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✂ INDUSTRIES

The Archaeological Evidence

P. R. S. Moorey

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PREFACE

When general histories of technology concern themselves with the civilizations of antiquity in the Old World, they direct attention to China and Egypt, to Greece and Rome, rarely to Mesopotamia: the land between the Tigris and the Euphrates. This neglect of the achievements of the Sumerians, the Babylonians, and the Assyrians in exploiting and managing the natural resources of the river valley and its highland periphery is explicable, if none the less regrettable. For over a century now students of ancient Mesopotamia, whether philologists, archaeologists, or ancient historians, have been relatively little concerned with systematic study of local crafts and industries. This is most surprising in the case of archaeologists, since the debris of manufacture is a primary source of information for them whether it be flint tools or pottery, copper weapons or faience ornaments. Traditionally, however, archaeologists working in Mesopotamia have treated the material evidence, above all pottery, not in technological or industrial terms, but typologically as the primary means for structuring chronological systems or for establishing the identities and relationships of the political and social groups taken to be defined by material culture.

In the last thirty years the growing impact of the social sciences on archaeology has directed attention elsewhere, notably to the elucidation of economic, political, and social processes. In Mesopotamia two such processes in particular, both pioneered locally, have attracted concentrated research: first, the development of controlled farming; second, the subsequent emergence of complex urban societies ('civilization'). At times this trend has increased rather than diminished the tendency to marginalize coherent studies of material culture. Even with the greatly increased use of scientific means of analysis and investigation in recent years, craft and industry have not attracted the attention paid to other aspects of the archaeological record. Yet technology, no less than administration or subsistence, is a vital part of past socio-economic systems, whilst being particularly open to observation and study through archaeological survey and excavations.

The nature of the evidence largely explains this relative neglect. Too often the material evidence is unavailable for serious study and, when available, scattered, sparse, and incoherent. At this stage it is not possible to do more than put readers in the way of answers to basic questions about materials and techniques, crafts and craftsmanship, and very much in that order of priority. Even when integrated with the relevant textual

sources (not attempted here), the extant material remains do not offer evidence for essays in economic history such as might be taken for granted in any study of medieval European crafts and might be attempted for those of the Graeco-Roman world. It is research on materials and methods of manufacture that conspicuously provides what consistency the following survey has. Even then it will be obvious even to the most casual reader that numerous significant subjects merely touched upon here await adequate research in depth.

This attempt to make sense of what information is already to be found in the archaeological and art-historical record for craft and industry in ancient Mesopotamia in as systematic a way as possible arises directly from thirty years' close involvement with the collection of Near Eastern Antiquities in the Ashmolean Museum, Oxford, one of the finest study collections of its kind outside the region. It might never have been made had I not also been responsible for the greater part of that time for the Museum's even more distinguished ancient Egyptian collection. In that capacity I recurrently consulted *Ancient Egyptian Materials and Industries* by Alfred Lucas (in the fourth edition prepared by J. R. Harris in 1962). This single book enabled me to answer easily numerous questions, both from the general public and from students, which I found were unanswerable when framed in relation to the crafts of ancient Mesopotamia without much private research. Some years ago I published an attempt to provide a Mesopotamian counterpart for metals and metalwork, glazed materials and glass (Moorey 1985). These essays, extensively revised, form parts of Chapters 4 and 6 and all of Chapter 5 here. In so far as the more restricted surviving materials allow, I have tried to match the range encompassed by Lucas. Like him I have aimed to meet the needs both of the general reader interested in early craft technology and the Near Eastern specialist, if only as a bibliographical resource, but ever mindful that I am neither a chemist, like Lucas, nor a philologist, like Harris.

Surviving artefacts reveal changes in technology once they have been tested and established. The springs of invention and the processes of innovation, the aborted technologies and the short-term experiments, which underlay the observable changes, usually remain as elusive as the prime mover. It is the variations in techniques and tools, the steadily increasing mastery of natural materials and the creation of artificial substitutes that are most evident. This, in short, is technology

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conceived as 'a collection of tricks of the trade drawn from the experience of craftsmen . . . accumulated and developed at a leisurely pace' (Braudel 1981: 431). In seeing the development of technology in ancient Mesopotamia in such terms I have sought to avoid the distortions which so easily follow from constructing the history of technology as if it were a sequence of discoveries conceived as instances of widespread radical change with a momentum of its own. Like all other aspects of human history, it has 'many actions and reactions, many changes of gear. It is not a linear process' (Braudel 1981: 334).

In small areas and in adjacent regions in the ancient Near East, different peoples, exercising the power of choice, did things in different ways. Technological innovation was a slow, continuous process through the time and area studied here, operating simultaneously at a number of levels and in a number of localities in society. Technological change was not a series of self-contained stages linked together in some chain of causality. As always, cultural factors were as important as practicality in determining whether or not craft practices were modified or changed. Any successful technology, in the broadest sense, is the result of a subtle combination of physical means (resources and tools) and social communication (diffusion and training). In ancient Mesopotamia traditional ways of doing things persisted side-by-side with newer ways, whilst traditional materials were continuously exploited alongside freshly discovered ones, especially when the familiar ones were locally available, relatively cheap, and easily processed. It is a commonplace in the history of technology that even an eventually acceptable invention may have to wait long before society has attained the required degree of receptivity; but it is usually impossible from the archaeological record alone to explain why in a specific case people were not yet capable of achieving, or fully utilizing, the potential of a new invention.

To the student of ancient technology, defined as the accumulating wisdom of successive generations of craftsmen, archaeology offers the great advantage of a long perspective through time and a vertical perspective through society, from the privileged to the impoverished, who are so often lost to the written record. For the purposes of this book the time-range extends from the earliest farming communities permanently settled in northern Mesopotamia by the eighth millennium BC through to the fourth century BC, when the region began to be absorbed into the much wider Hellenistic socio-economic system in which traditional local cultures underwent radical transformation. Although archaeology loses its monopoly of the evidence increasingly after about 3000 BC, it still provides information on craft and industry supplementary to that recorded by scribes as well as illuminating aspects of craft products and

procedures recorded not at all, or inadequately, in writing.

Time has inevitably overtaken such pioneer studies as the relevant parts of Meissner's *Babylonien und Assyrien* (1920; 1925) and such useful secondary works as Partington's *Origins and Development of Applied Chemistry* (1935), though both remain fundamental guides to early research. Forbes's *Bibliographie antiqua: Philosophia naturalis* (1940–50; supplement 1952) is a useful and enduring bibliography, but the Mesopotamian sections of his *Studies in Ancient Technology* (1955–72) share the acknowledged shortcomings of the rest of these volumes. Although they contain in easily accessible form much that is difficult to find elsewhere, they are often criticized with some justice for a number of serious deficiencies. The philological citations are notoriously unreliable; archaeological evidence, all too rarely used, is uncritically handled; and there is a marked imbalance in the historical evidence selected for inclusion. Moreover, many references are either misleading or so imprecise as to be merely irritating. Unfortunately, the 'revised' editions are little better. Landsberger (1965: 291 n. 27) said of one of them that '[it] is in a sense, up to date, but his results are so confused that they defy criticism'.

Until now philological studies of Mesopotamian crafts have been more common than archaeological ones. The modern dictionaries (*The Chicago Assyrian Dictionary* (CAD); *Akkadisches Handwörterbuch* (AHw)) are fundamental to these studies, superseding the specialist monographs of Campbell Thompson (1936; 1949) on the vocabulary of Assyrian botany, chemistry, and zoology, though his commentaries may still be selectively read with profit. The series of volumes on various aspects of daily life in Mesopotamia published by Armas Salonen between 1939 and 1976 (see bibliography) are potentially dangerous for any but specialist philologists to use. As Oppenheim (1978: 660 n. 151) remarked, 'Salonen's books in many respects constitute pioneering work that of necessity is word-orientated. They do not take into account the specific evidentiary value of the text types in which these words occur and the complexities of the socio-economic structures that created the documentation.' This may lead the unwary into serious difficulties.

The relevant articles in the continuing *Reallexikon der Assyriologie und vorderasiatischen Archäologie*, particularly since it was revived in 1957 at the letter F, are invaluable for their conjunction of archaeological and philological evidence and for their bibliographies; but they suffer from alphabetic isolation of related topics, from uneven quality, and from a general indifference to evidence from scientific analysis. In 1976 a distinguished group of Italian scholars produced very useful summaries (with good select bibliographies), primarily based on textual evidence, for the volume on

L'Economia in a three-volumed study: *L'Alba della Civiltà: Società, Economia e Pensiero nel Vicino Oriente Antico* (edited by S. Moscati; Turin).

Mesopotamia is taken here to embrace those parts of modern Iraq, Iran, Syria, and Turkey drained by tributaries of the Shatt el-Arab at the head of the Gulf, though the focus is primarily on the area of modern Iraq. The choice of this region rather than the Near East as a whole is simply to make an intractable subject as tractable as possible. It should not be taken in any way as indicating a particular cultural bias towards a view of Western Asia in antiquity immutably fixed on Mesopotamia as the one and only centre of inspiration. Indeed, that very point of view is recurrently challenged as each craft tradition is examined here.

Even within this area the balance of evidence is rarely, if ever, what might be hoped for. Within Mesopotamia the available material evidence is concentrated in the north, centre, and east of the region from the time of the earliest permanent villages until about 5500 BC. Thereafter, for some four thousand years, the centre and the south (Akkad and Sumer; Babylonia) are best known, until once again from about 1600 to 600 BC the north (Assyria) becomes the primary source of information. In other words, the earliest settlement of the south is barely understood; the nature of urban growth in the north is only just beginning to come into focus; and the material achievements of Babylonia from soon after the reign of Hammurabi (c.1792–1750 BC) to the accession of Nebuchadnezzar II (c.604–562 BC) are hardly known. This oscillation to some extent explains the lack of balance in discussions of developments in northern and southern Mesopotamia often evident in the following pages.

Each of the main sections of this book is a tentative, necessarily selective attempt to present the primary evidence and to assay its value as the basis for an understanding of the traditional crafts of ancient Mesopotamia so far as they are represented in the record currently provided by archaeology. There are vital crafts, primarily those using organic materials, unrepresented here, as they remain the territory of the philologist in Mesopotamia. It is possible from time to time, as Barber (1990) demonstrated with textiles, to offer archaeological information from unlikely regions even for these topics, but by taking a wider perspective and writing a different kind of study.

It is in the nature of the evidence that even for crafts illustrated by the surviving art-historical and archaeological data the following chapters are in no sense comprehensive surveys. They are essays in which the specific is always open to continuing enquiry and the general is recurrently elusive. The source material is always fragmentary, very often without a comprehensible context, and at times extremely difficult to summarize coherently. The crafts in which the technologies primarily involve mechanical modification, as when using animal products (bone, ivory, shell, etc.) or stones, are treated first. These are followed by those in which the technologies involve chemical and structural alteration to the raw materials used during manufacture, as with ceramics, glazed materials and glass, and metals. The role of the natural sciences in studying this group is naturally the greater. The crafts of the builder, embracing both these technologies and also organic materials which rarely survive, are then treated together. In so far as the literature of the subject is concerned, I have attempted to survey what was available to the end of 1991.

Illustrating a survey of Mesopotamian crafts is difficult. Unlike ancient Egypt (cf. Drenkhahn 1976), the imagery of Mesopotamia from earliest times to the Achaemenid period did not draw upon the activities of daily life on the great estates. Such exceptions as the craft activities shown on sealings of the Late Uruk period from Susa (cf. Amiet 1972: pls. 14–17), the very occasional genre scenes on Old Babylonian terracotta plaques (cf. Moorey 1975: 95), and rare glimpses on Neo-Assyrian reliefs (cf. Hrouda 1965; Madhlum 1970), only emphasize their rarity. These sources are drawn upon here as appropriate, supplemented from the equally meagre body of material evidence for certainly identified craft tools and equipment. For the craftsmen's repertory the reader is directed to the standard and fully illustrated books on Mesopotamian art and architecture. An easily accessible range of good maps and coloured illustrations will be found in Roaf's *Cultural Atlas of Mesopotamia and the Ancient Near East* (New York and Oxford, 1990).

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Ashmolean Museum, Oxford.
December 1992.

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Any author who attempts to summarize information obtained through multidisciplinary research is particularly conscious of his dependence on the advice of specialists among his colleagues. When he is also a museum curator and a university teacher he is no less aware of how much he owes to the questions and conversations of innumerable people over many years, whose assistance has imperceptibly and anonymously become part of the way he approaches particular problems. It is only possible here to name those whose contributions, as the bibliography often makes clear, have brought me to this point, when along the way I have sometimes despaired of making any sense of it all. As I have constantly trespassed into fields of study well beyond my academic competence, I am more than usually sincere when I say that I alone am to be held responsible for the persisting errors and misconceptions from which even the most learned of friends could not protect me.

My study of stoneworking crafts owes much to discussions with my former research student Dr Timothy Potts, to conversations with Drs Gorelick and Gwinnett, and to Dr Carol Meyer (Chicago) for kindly allowing me access to her unpublished doctoral thesis in 1985; of metals and metalworking to Mrs Judy Bjorkman, Dr Paul Craddock, Dr Stuart Fleming, Professor Robert Maddin, Professor James Muhly, Dr Peter Northover, Dr Vince Pigott, Dr Tamara Stech and Mr J. E. Rehder; of ceramics to Miss Mavis Bimson, Dr Robert Hedges, Professor Alex Kaczmarczyk, Professor Mark Pollard, Professor Michael Tite, and Dr Pam Vandiver; of ivories to Dr Georgina Herrmann; and of shells to Dr David Reese.

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I am very conscious of the absence of the philological aspects of my subject save through cross-reference to standard sources; with many points of translation I have been generously assisted over many years by Dr Jeremy Black, Dr Stephanie Dalley, and Professor Oliver Gurney, to whom I am most grateful. It was Professor Sir John Boardman who suggested that I should gather these studies together rather than continue to publish them in separate monographs. I trust that the result justifies his encouragement.

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✧ NOTES FOR THE READER

1. Chronological Terminology

(a) Prehistoric

Aceramic Neolithic	c.8000–6500 BC
Hassuna/Samarra/Halaf	c.6500–5500 BC
Ubaid	c.5500–4000 BC
Uruk (Early/Middle)	c.4000–3500 BC
Uruk (Late/Jamdat Nasr)	c.3500–3000 BC

Absolute dates before 3000 BC are still insecurely based. The figures given above are broad approximations to a greater or lesser extent based on Carbon-14 determinations (cf. Aurenche *et al.* 1986).

(b) Historic

Early Dynastic I	c.3000–2750 BC
Early Dynastic II	c.2750–2600 BC
Early Dynastic III	c.2600–2350 BC
Akkadian (or Sargonic)	c.2350–2100 BC
Ur III	c.2100–2000 BC
Isin-Larsa/Old Babylonian/Old Assyrian	c.2000–1600 BC
Kassite/Mitannian/Middle Babylonian/Middle Assyrian	c.1600–1000 BC
Neo-Assyrian	c.1000–612 BC
Neo-Babylonian	c.612–539 BC
Achaemenid Persian	c.539–330 BC

The absolute dates before 612 BC given here are approximations. The chronology for individual kings cited in this book is that given by J. A. Brinkman in A. Leo Oppenheim, *Ancient Mesopotamia* (revised edition; Chicago, 1977), 355 ff. This is based, for convenience (as is the chronology of the revised volumes of the *Cambridge Ancient History*), on the 'Middle' chronology for the First Dynasty of Babylon (c.1894–1595 BC). The primary alternatives are the 'High' (c.1950–1651 BC) and the 'Low' chronologies (c.1830–1531 BC). Recently the 'High Chronology' has become more popular, but dendrochronological studies have begun to raise fresh doubts about its validity.

Elsewhere in the Near East, where historical terminology is not usually used, the main chronological horizons are: Aceramic/Ceramic Neolithic (c.8000–4500 BC); Chalcolithic (c.4500–3300 BC); Early Bronze Age (c.3300–2000 BC); Middle Bronze Age (c.2000–1550 BC); Late Bronze Age (c.1550–1150 BC); Iron Age (c.1150–550 BC). The chronology of Iran is still basically

site-focused and complex (for Susiana (Khuzistan), see Carter, in Carter and Stolper 1984). Until the long-promised third edition appears, the second edition of R. H. Ehrich, *Chronologies in Old World Archaeology (COWA)* (Chicago and London, 1965) remains the standard survey of archaeological chronologies.

2. Problems in Historical Geography

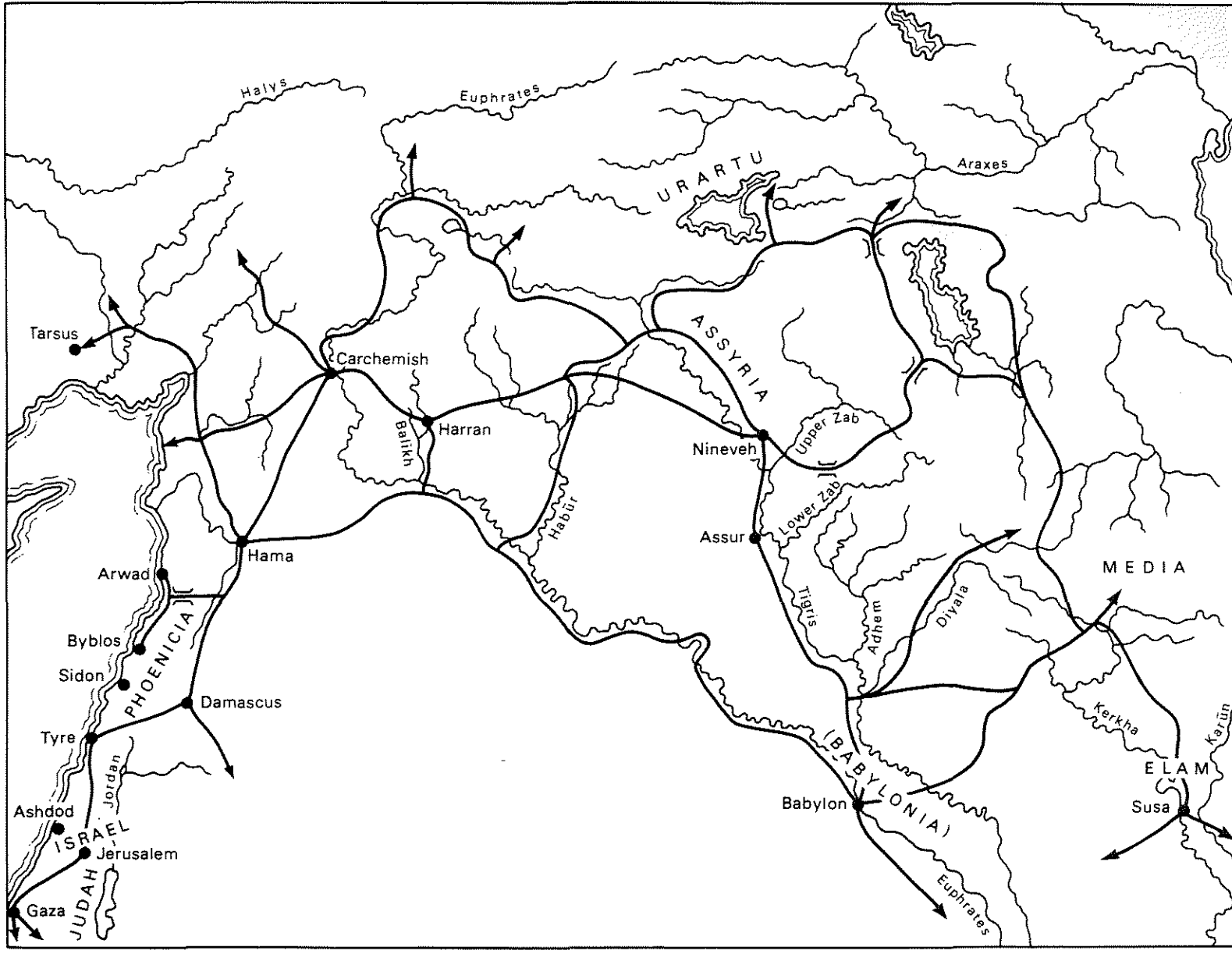
This is clearly not an appropriate place for lengthy discussions of historical geography, but in order to avoid cluttering the main text with recurrent annotations, a few regions constantly cited by their ancient names are briefly reviewed here:

(A) Within Iran (primarily third millennium BC)

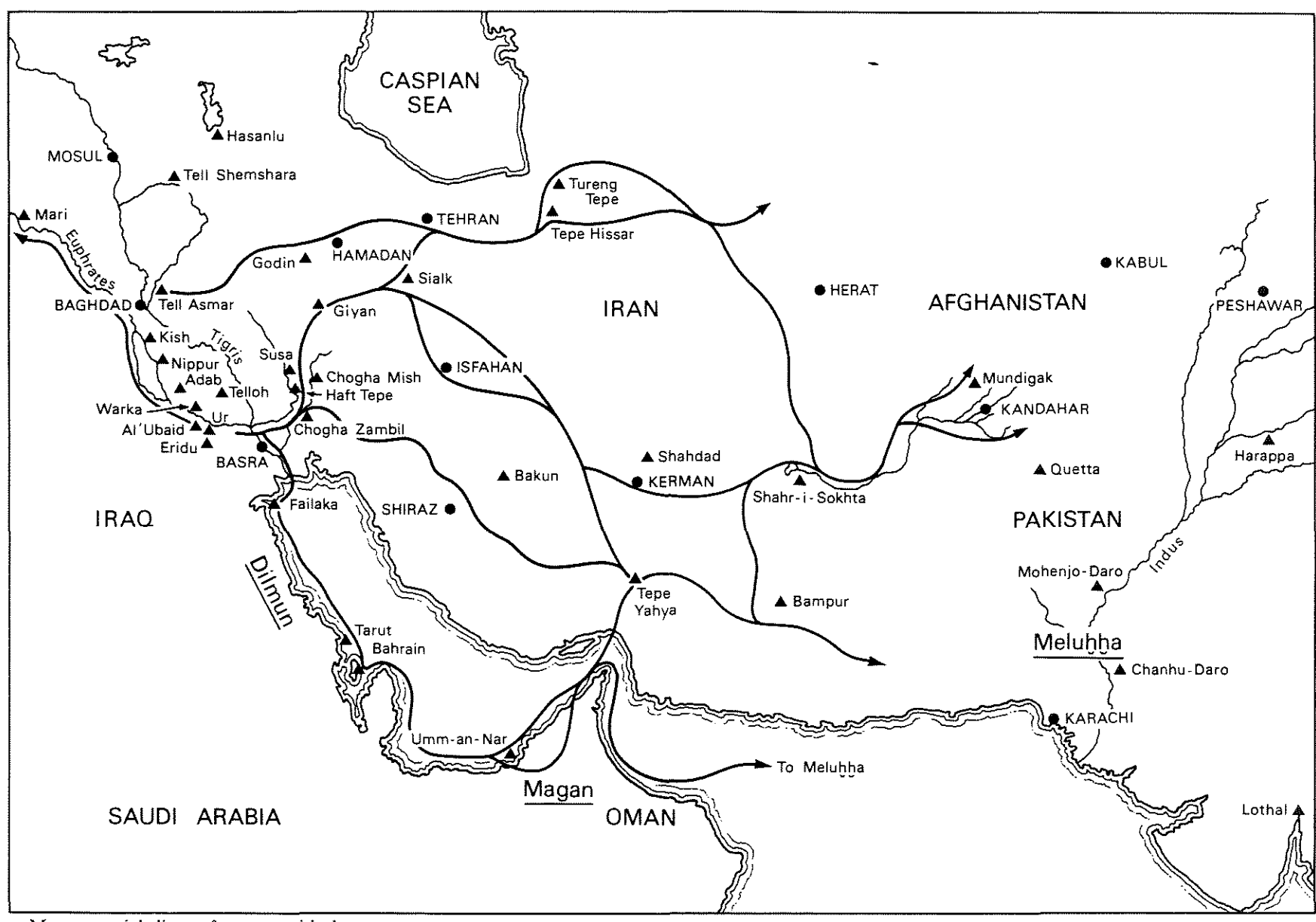
(a) *Aratta* immediately raises the critical issue. Many scholars regard it as a real location (see below), whilst Michalowski (1986: 132–3) has assembled cogent arguments in favour of a mythical 'El Dorado' of remote antiquity. So far there is no certain reference to *Aratta* in a non-literary text (but see Michalowski 1988); possible references, if indeed toponyms, may be to Shurupak (Fara; cf. Green 1980: 17). *Aratta* appears with consistency in literary texts describing mythical Early Dynastic rulers of Uruk and their encounters with peoples to the east in tales designed to emphasize the superiority of Sumerian culture. If *Aratta* is to be taken as a real location with rich resources including 'gold, silver, copper, tin, lumps of lapis lazuli' (Cohen, S. 1973: 112, lines 18–19), then the literary references place it deep into Iran or beyond, east of Anshan (Tepe Malyan) (cf. Majidzadeh 1976; Hansman 1978). The name became an epithet for abundance and glory (Cohen, S. 1973: 55 n. 67).

(b) *Marhashi*, sometimes *Barhashi* or *Parahshum*, has long been conventionally located in the mountains north-west or north of Elam and east of the Diyala river. Steinkeller (1982; 1989) has advanced a case for regarding it as an important part of central southern Iran, to the east of Anshan (Tepe Malyan) in Fars. It was a source of plants, animals, and semi-precious stones, including agate and cornelian.

(c) *Shimashki* appears in an inscription of Shu-Sin (c.2037–2029 BC) as a region comprised of six named lands, *Zabshali* conspicuous amongst them (Edzard 1959–60: 9). Arguments for locating it south and east of Kermanshah in the provinces of Luristan and Fars (Steinkeller 1988: 201; 1990) are more persuasive than



1. Lines of contact within Mesopotamia and her periphery.



2. Mesopotamia's lines of contact with the east.

Vallat's (1980) suggestion that it might have been in eastern Fars or in Kerman.

(d) *Tukrish* is not clearly located in any published text. It lay somewhere east of the Tigris in western Iran, more probably north of Luristan than in that province itself. References to *Tukrish* are not common and are scattered through sources of the second and first millennium BC, with possible earlier references. In myths it is known as a source of gold and lapis. At Mari and Qatna its name is used to describe vessels in precious metals, elsewhere to describe particular types of garments or textiles, as if they were renowned products of the area (Michalowski 1988: 162).

(B) *The Gulf and the sea-route to the Indus Valley*

(a) *Dilmun* is often referred to both in economic and in literary texts, where it need have no reference to reality (Michalowski 1986: 133–5). When it does refer to a particular place, no one has subsequently overthrown Sir Henry Rawlinson's (1880) arguments in favour of the island of Bahrain, though scholars remain undecided how much else may or may not have been involved at various periods (cf. Bibby 1972: 62; Carter, T. H. 1981; Potts, D. 1990: i. 85 ff.).

The following items are listed as reaching Ur from *Dilmun* in the late third and early second millennium BC: lapis lazuli, cornelian, and various other unidentified semi-precious stones; ivory and ivory objects; copper; silver; 'fish eyes' (pearls or agate); red gold; white corals; various woods; dates. Except for the dates and the 'fish eyes', if they were indeed pearls, all these commodities came to *Dilmun* from elsewhere for onward shipment (cf. as *Tilmun*: Edzard *et al.* 1977: 157–8; Edzard and Farber 1974: 193; Groneberg 1980: 237).

Any summary of the evidence for the locations of *Magan* and *Meluhha* must begin with a general assessment relevant to both. It has been held in recent years that these terms changed their meaning in the first millennium BC when, rather than referring as before to Oman and the Indus Valley area, they came to denote Egypt and Nubia/Ethiopia. Two distinguished Sumerologists, Jacobsen (1960: 184, n. 18) and Kramer (1963: 276) believed that the two names always referred to regions in Africa. Salles (1989) has recently argued with some force that even in the first millennium BC these terms were still at times used in Assyria and Babylonia in the traditional way. Then they came additionally, not exclusively, to denote regions in southern Egypt and the horn of Africa newly in contact with Mesopotamia whose exotic traded goods (ivory; ebony; tortoiseshell; perfumes and spices) were the same as those coming also from or through Oman and the Indian sub-continent. Michalowski (1986: 134) has observed, of the earlier period, that 'places such as *Aratta* and *Dilmun*, whether real or imaginary, are the subject of myth and

legend while more distant locations documented in administrative records, e.g. *Magan* and *Meluhha*, are not'.

(b) *Magan*, when mentioned in early texts, is now usually believed to have been a region at the mouth of the Gulf, embracing much of modern Oman and possibly part of the opposite coastal regions of Iran (cf. Potts, 1990: i. 133 ff.). *Magan*'s boats reached Sumer in the later third millennium BC and the Akkadian kings claimed to have campaigned there and taken booty, which included stone vessels bearing inscriptions to that effect (Hirsch 1963: 18; Potts, D. 1986; Potts, T. F. 1989). Timber and wooden objects, a type of onion(?), copper, ivory, gold dust, cornelian and other semi-precious stones, diorite, red ochre, as well as goats, were all said to come from *Magan*, but never lapis lazuli. Some of these goods, notably cornelian and ivory, were being shipped from further east, some, like copper and diorite, were local. Men from *Magan* are occasionally mentioned in Sumer in Ur III texts.

(c) *Meluhha* is now usually located in the Indus valley region when mentioned in early texts, though it might be of wider reference covering the shores of what in modern times has been called the Indian Ocean. It was a land of seafarers whose boats are mentioned in later third-millennium BC Mesopotamian texts. Its exports included timber and wooden furniture, copper, gold dust, lapis lazuli, cornelian, birds (including the peacock), and such manufactured objects as multi-coloured ivory birds, a cornelian monkey, and a 'red dog'. People from *Meluhha* were also settled in Mesopotamia (Ratnagar 1981: 68 ff.).

(C) *Within Syria, eastern Turkey, and Iran* (primarily first millennium BC)

There are a series of regional names, largely in Neo-Assyrian texts, which require elucidation to understand references to the sources assembled by Jankowska (1969) cited in the following pages under her name (cf. especially for the historical geography, Hawkins 1982).

Bit-ḫalupe: the region between the Euphrates and the lower Habur, north of Tell 'Ashara, in Syria.

Bit-Zamani: the region north and north-east of Diyarbakir in Turkey.

Hamath: the region of modern Hama in Syria.

Ḥattina (correctly *Pattin*): the Amuq region of Syria, otherwise known in antiquity as *Unqi*.

K(Q)ummuḥ: the region north of Samsat, to the west of the Euphrates, in Turkey.

Laqe: region to the south-west of *Bit-Ḫalupe* on the other side of the Euphrates in Syria.

Muṣaṣir: the religious centre of ancient *Urartu*, south-west of Lake Urmia near Rowanduz in Iraq (cf. Boehmer 1973).

Nairi: a region, between the Upper Euphrates and

Lake Van in eastern Turkey, so named in second-millennium and later sources, when this area is better known as the kingdom of *Urartu*.

Que (Hume): in modern Cilicia, Turkey; the region of modern Adana.

Shubria: region south of modern Mus, in Turkey, northwards to Lake Van.

Tabal: south-east corner of the Turkish plateau.

Zamua: near the headwaters of the Diyala river in the Zagros mountains.

✕ INTRODUCTION

1. The Agricultural Foundations

Very little rain falls in the land of Assyria, and this little is what nourishes the root of the crop; but it is in its watering from the river that the corn (*sitos*) crop wins its ripeness and the bread grain comes into being. It is not as in Egypt, where the river itself rises over the fields; in Babylon the watering is done by hand-operated swing beams. For all the Babylonian country, as in the case of Egypt, is cut up with canals . . . Of all the lands that we know, this is far the most fertile for Demeter's crop . . .

(Herodotus, i. 193; Grene 1987: 121)

THROUGHOUT ANTIQUITY THE PEOPLES OF Mesopotamia depended for sustenance and prosperity upon agriculture. As Herodotus points out, it was rain-fed in the north, where the earliest farming communities were established by the eighth millennium BC, and entirely dependent in the south upon irrigation systems first developed there in the sixth millennium BC. The economic prosperity of the towns which flourished in the south from the middle of the fourth millennium BC, and in the north from some five hundred to a thousand years later, was dependent on the products of a rural hinterland and upon raw materials brought in by coercion (booty or tribute) or by some form of reciprocal exchange.

Urban life in the north (Assyria) and in Syria was much more stable than in the south of Mesopotamia (Sumer and Babylonia), where so much depended upon a delicate ecological balance. In the south, floods and devastating droughts might bring major changes in watercourses so that towns would be suddenly eclipsed or survive only by virtue of their cult status. Although their hinterland might remain largely unchanged, trade went. The brief, glorious life of Mashkan-shapir in the earlier second millennium BC and the survival of Ur only as a cult centre after the same period illustrate the fundamental significance of waterways as lifelines in Babylonia. In north and south, agriculture not only fed the population, but from an early date provided the surpluses which sustained internal exchange systems and whatever long-distance commerce brought in the many raw materials upon which craftsmen exercised their skills at any particular time (Oates and Oates 1976; Postgate 1992).

The absence of agriculture from the industries con-

sidered in detail here is in part explained by its conventional omission from studies of craft and industry, in part by the nature of the present evidence, which still depends predominantly upon written sources. Even current understanding of prehistoric farming owes as much, if not more, to projection backwards from text-based evidence than to field research. Mesopotamian archaeology is still overwhelmingly urban in emphasis. The remarkable series of surface surveys, initiated by Jacobsen and significantly extended by Adams (1981) and others more recently, have laid the foundations for reconstruction of the courses of major ancient waterways and for the comparative study of settlement patterns in the Pre-Islamic period. But when it is realized that this information constitutes the only body of systematically retrieved data currently available relating to the rural hinterland of Mesopotamian towns, it will be evident how much still needs to be done to begin the complex process of reconstructing the rural economy. The marked limitations of information from archaeological field surveys are now well known, even at the most general level of synthesis, whilst there is some justice in Brinkman's (1984: 180) conclusion that this is a case in which 'we have subjected our data to rigorous interpretation but have not applied comparable rigor in collecting and criticizing our information.'

Information from archaeological sources on methods of farming, on the creation of irrigation systems, and on village life is minimal. Nor is it known what the hierarchy of settlement was in rural areas or precisely how town and country interrelated in economic terms. Scientific evidence for climatic patterns, for environment, and for crop preferences is now becoming available, but not yet in quantities appropriate for generalization. Textual data on agriculture is indispensable and it is increasingly well exploited, with the assistance of natural and social scientists, to reconstruct processes and technologies in historic periods and, by inference, earlier (cf. *Bulletin on Sumerian Agriculture* (Cambridge, 1984-; Hruška 1990; Galvin 1987; Zeder 1991).

The most intellectually adventurous attempt to come to grips with this problem highlighted the limitations of fieldwork as much as its potential. Henry Wright's pioneering study, *The Administration of Rural Production in an Early Mesopotamian Town* (1969), stands alone as an enterprise directly combining field archaeology and textual analysis in order to elucidate the rural economy of a particular area, in the vicinity of Ur, at a specific

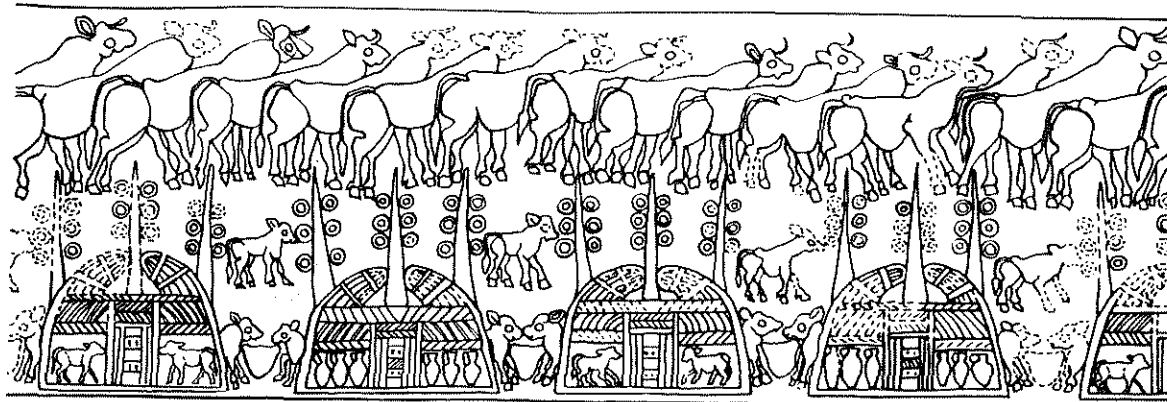


Fig. 1. Cattle and cattle byres in Southern Mesopotamia, c.3500 BC. Drawing of an impression from a Uruk period cylinder seal (5.3 cm. high).

time, early in the third millennium BC. His summary is as precise as it is challenging:

These families [in the small settlement excavated at Sakheri Sughir] utilized a simple technology whose imperishable parts were made of ceramic, flint, or bitumen. Some of these tools were used in production, but most were used in food preparation. Tools were repaired or manufactured and food was prepared in such limited confines that the debris of these activities could not be statistically isolated with my limited samples of refuse. Thus there was little specialization of activities. When larger random samples at sites like Sakheri Sughir are excavated, it will be possible to estimate the rate at which materials and goods were brought from the towns to a rural domestic unit, and consumed in domestic activity and in production.

(Wright 1969: 87)

Rare text-based studies of the rural economy (cf. Zaccagnini 1979) serve to indicate how little light the written sources of any historical period throw upon the role of craft and industry in ancient Mesopotamian rural society. In the Achaemenid period Xenophon, who was familiar with Mesopotamia, provided a succinct description of a small-town or rural craftsman, applicable to all the periods and regions surveyed here:

For in small towns the same workman makes chairs and doors and ploughs and tables, and often this same artisan builds houses, and even so he is thankful if he can only find employment enough to support him . . . In large cities, on the other hand, in as much as many people have demands to make upon each branch of industry, one trade alone, and very often even less than a whole trade, is enough to support a man . . .

(*Cyropaedia*, viii. ii. 5)

Modern archaeological research has dispelled traditional ideas of an evolutionary progress from hunters to pastoralists to farmers. Farming, it has been shown in the Near East, developed from foraging, with plant domestication as its primary goal. Animal domestication, the basis of pastoralism, developed within the orbit of agriculture not outside it, since early farming

was plant-oriented and meat-based, exploiting a steadily widening range of animals from goat through sheep and pig to cattle (Galvin 1987). Pastoralism, like plough and irrigation agriculture, was a later specialization from a common core of early plant and animal domesticates, with the pastoralist species (donkey; horse; camel) emerging from about 4000 BC along with secondary uses for existing domesticates (wool; traction). Then there began that complex set of interactions between sedentary and mobile societies long distinctive of the region. The two were economically interdependent, with important implications for the procurement of raw materials and the distribution of manufactured commodities.

In the earliest village settlements of northern Mesopotamia from the later ninth millennium BC, pioneer animal husbandry and rain-fed cereal cultivation were successfully combined with traditional hunting and gathering of various wild species to provide a mixed subsistence economy of proved resilience. This became more and more dependent upon domesticated animals and cereals as time went on. The earliest agriculture was restricted to areas of seasonally moist dark brown soils requiring extensive preparation with stone hoes and crop harvesting with chipped stone tools: an inherited technology of considerable antiquity. The first clear indication of the existence of ploughs in Mesopotamia only appears with the Uruk IV pictographs in the second half of the fourth millennium BC (Green and Nissen 1987: 176, no. 33) when it is a beam-ard, a simple machine which scratches a furrow without turning the sod. This type of plough was to remain standard in ancient Mesopotamia (cf. Vértessalji 1983; Hruška 1988). Ploughs with seeder funnels are first illustrated on seals of the third quarter of the third millennium BC (Frankfort 1939^a: pls. XIXe, f, XXd). In the manufacture of these ploughs, as in the production of all other routine agricultural tools, locally available clay, stone, and timber were enduringly used as the preferred

materials for communities operating on minimal resources. Workers on palace and temple estates alone were more commonly equipped with copper-alloy tools from the third millennium BC, though they were always subject to close controls (cf. Moorey 1971^a), and with iron equipment from the earlier first millennium BC. Even then cheaper materials would always have complemented the more costly metals.

Earlier indicators of the introduction of ploughs are oblique. Plough marks have been reported in the fifth millennium BC (Susa A) at Tepe Sharafabad in Khuzistan, indicating that true ploughing, rather than cultivation with digging sticks or hoes, was already practised by the time that irrigation farming was introduced (Wright *et al.* 1980: 275). This is not surprising, since bovines, the earliest recorded traction animals in the region, are represented among faunal remains from pioneering communities of farmers in northern Mesopotamia. By the fifth millennium BC, domesticated bovines are recorded at Ras al-Amiya in central Iraq (Flannery and Cornwall 1969: 436). Osteoarthritic indications in bovid skeletons are the most likely fresh source of evidence for the emergence of ploughing as also of the use of threshing sledges, which are first illustrated on seals in the later fourth millennium BC (Lit-tauer and Crouwel 1990).

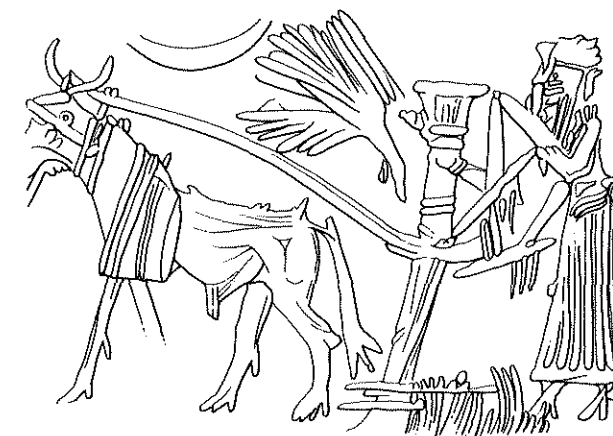


Fig. 2. Plough with a large seeder c.2200 BC. Drawing of an impression from an Akkadian period cylinder seal (3.2 cm. high).

The surpluses generated by early agriculturalists in northern Mesopotamia have been consistently underestimated in the past. Marked signs of communal economic activities are now evident in the seventh millennium BC storehouses at sites like Yarim Tepe and Umm Dabaghiyah. Indeed, if Umm Dabaghiyah is rightly interpreted as a whole community of specialized hunters and tanners processing onagers, conventional views of early village self-sufficiency have to be reappraised since it suggests interdependent villages (cf. Voigt 1990). Earlier, in the aceramic Neolithic

settlement at Çayönü in southern Anatolia, there is evidence both for discrete areas devoted to craft specialization ('workshops') and a pattern of inter-household exchange. At the same time considerable social organization is implied by the creation and maintenance of such structures as the 'Terrazzo' and the 'Skull' buildings (cf. Redman 1983).

Circulation of goods is also evident as early as the appearance of controlled food production, along lines established much earlier (Runnels and van Andel 1988). The multiplicity of stones used for ornaments and tools reveals the existence of surplus wealth to be devoted to the acquisition of luxuries, some obtained from far away. They and other raw materials such as copper, lead, and shell circulated widely, whilst manufactured goods, including pottery, were no less subject to exchange. The possible existence of nascent redistribution agencies from as early as the eighth millennium BC has been postulated from the emergence and steadily increasing use of stamp seals (cf. Wickede 1990). Sealings, however, are not necessarily indicative of large public controlling institutions in Mesopotamia, since they played a role in household management in the third millennium BC (cf. Martin 1988: 64 ff.).

By the early fifth millennium BC a growing degree of social stratification in the rain-fed agricultural villages of northern and central Mesopotamia is indicated by clear distinctions of size and complexity in architecture, an ever wider circulation of luxury materials and goods, and marked variations in the equipment of burials, notably at Tell es-Sawwan. There some of the richly equipped graves were for children, their wealth perhaps illustrating inherited high status. Evidence of this kind has been taken to indicate the presence by the Halaf period of well-established networks of chiefdoms in this area (cf. LeBlanc and Watson 1973: Watson 1983^a: 241-2; Patterson 1989: 310-16).

One particular structure may illustrate an increasing concentration of power and wealth in the hands of individuals or controlling institutions. The TT6 'burnt house' at Tell Arpachiyah (Mallowan 1935: 16-17, 105 ff.), directly underlying the *tholoi* uncovered on top of the mound, yielded an unusual concentration of fine manufactured objects in baked clay, stone, and metal, as well as raw materials. There is no compelling evidence here in favour of identification as a potter's or a stoneworker's workplace, as Mallowan originally proposed, nor for the hypothesis argued more recently by Munchaev that the area had been burnt in an act of ritual cremation. Its location in relation to the subsequent *tholoi* and its richly varied contents prefigure accumulations which in later contexts have come to be known as 'treasuries'.

It was, however, in the south that distinctive circumstances promoted the fuller development of trends

already evident in the richer villages of the north. The emergence of urbanism in Sumer was not as 'revolutionary' as Childe famously proposed. As Joan Oates has cogently pointed out more recently: 'to the Sumerians there was no distinction between village and city, and the word URU signified any permanent settlement, whatever the size. To a large degree this must reflect the fact that the city in Sumer grew naturally . . . the social and technological background of this early but *unconscious* urbanism can be traced at least as far back as the 7th millennium BC (uncalibrated dates), to the *industrial* advances of the early farming settlements of northern and central Mesopotamia, and in particular to the 5th millennium BC villages of Sumer itself, such as Eridu, where the pattern of town and temple, so characteristic of the Sumerian city, was already established' (Oates, J. 1983: 81; cf. Wright, H. T. 1984).

The known history of permanent agricultural settlements in southern Mesopotamia (Sumer) opens with the creation of simple gravity-fed irrigation systems which for the first time allowed for the agricultural exploitation of the river valley. Channel irrigation among the braided streams which flowed down alluvial fans on the eastern margins of the lowland plain was the earliest to be established in villages such as Choga Mami (Oates, J. 1983²). It had been realized that a simple and effective way of using the natural gradient to maintain the necessary flow of water could be obtained by cutting transverse trenches. The wooden beam-and-plough was vital to the full development of the system of farming which now became possible in the south. Whether it was introduced from the north or invented at this time is not yet certain.

Field survey in Sumer has revealed a pattern of initial settlement following small meandering streams in an unmodified alluvial plain. Cultivation at this stage was confined to zones where irrigation water might be easily obtained through village-based and locally managed systems (cf. in general Postgate and Powell (eds.) 1988). Evolving irrigation networks are likely to have been a powerful stimulus to innovation in related technology. As the necessary technical devices were made of organic materials and very rarely appear in art, their development is largely a matter of conjecture. Apart from the screw, which is a development of the Neo-Assyrian (?) period, it is known that the four basic technical devices for the redirection of muscular effort—the lever, the wedge, the windlass, and the pulley—were inherited by the Greek world from the East (cf. White 1984: 10). In all likelihood the lever and the wedge had emerged there in remote prehistory; but it is possible that a particular application in irrigation popularized the lever. It is vital to the shadoof, an extremely versatile water-lifting device easily constructed from locally available timber (PLATE IIB). Although this machine is not illustrated until it appears

on a cylinder seal in the third quarter of the third millennium BC (Boehmer 1965: no. 716), it is a device so necessary to irrigation in southern Mesopotamia that its invention has been assumed to be much older. The shadoof was generally made of a long wooden pole secured at a fulcrum to a horizontal beam of wood, supported at each end by a timber pole or by a mud-brick column. The short end of the lever was counter-weighted with a stone or a lump of clay, with the bucket attached by a rope to the other end. The best surviving illustrations are on a relief of the reign of Sennacherib in the seventh century BC (British Museum: WA 124820; Layard 1853^b: 15 (drawing)).

Well technology, evident from at least the Halaf period in the north, depended at first only on the rope and bucket, perhaps with the use of animal traction (PLATE IIA). The windlass is most unlikely to have preceded the general use of the wheel, evident from the second half of the fourth millennium BC, and may indeed not have been used until after the introduction of the spoked wheel to Mesopotamia in the early second millennium BC (cf. Littauer and Crouwel 1979). The windlass could have been preceded by simple spindles, converting the upward lift into the downward pull. For a windlass proper, a wooden cylinder is fixed horizontally over a well so that it may rotate freely with the bucket rope wound round the cylinder. Before the use of the crank, which does not appear until the Middle Ages, it was commonly turned by a large spoked wheel attached to one end. The oldest well-heads so far excavated are those of mulberry wood from Mallowan's excavations at Nimrud in the Neo-Assyrian period (Mallowan 1953: 25). A ninth-century BC fragmentary relief of Assurnasirpal II shows a well-head within a fortified town (Gadd 1936: 144, pl. 4 (lower left); British Museum: WA 118906). Nearly two centuries later Sennacherib claimed innovations in water-lifting techniques, one of which may have anticipated the principle of Archimedes' Screw (Luckenbill 1924: 110, 45–9; Stephanie Dalley: personal communication). In the material record the pulley is first evident in an enigmatic series of small decorated bronze fittings in the earlier second millennium BC (cf. Moorey 1977).

It is possible that more sophisticated water-lifting devices were in use by the first millennium BC, but the evidence is both sparse and equivocal. Classical descriptions of the 'Hanging Gardens of Babylon' refer to installations, notably screws, which may be Seleucid in date (Strabo: *Geography*, xvi. i. 5). A description by Koldewey (1914: 91) is conjectural: 'mechanical hydraulic machine . . . which worked on the same principle as our chain pump, where buckets attached to a chain work on a wheel placed over the well. A type of windlass works the wheel in endless rotation.' This is an ingenious attempt to explain a unique set of adjacent triple well-shafts in the 'Vaulted Building' at Babylon

of the Neo-Babylonian period. It alone cannot be taken as firm evidence for the use of such a device as early as the sixth century BC.

Whatever its precise role in stimulating technological innovation may have been, irrigation opened up fresh regions to highly productive agricultural exploitation from the fifth millennium BC, whilst intensifying social cohesion in the settlements it sustained. In a landscape where the productivity of the land varied so markedly with the availability of irrigation water for farming, inequalities in agricultural landholding were likely to have had a marked accelerator effect on the transition to stratified urban societies in the fourth millennium BC. At the same time, the notorious insecurities of farming in southern Mesopotamia, the unpredictable floods, the dust storms, and the diseases, encouraged a more rapid development of already established institutions of social integration to support self-preservation.

It is commonly said that the timing of the flood of the Tigris, even more than that of the Euphrates, coming during the grain harvest, was a threat rather than an asset to ancient farmers. It is then usually assumed that it was only after advanced technological changes in the Seleucid period that the unpredictable river Tigris was fully harnessed for large-scale irrigation (Adams 1981: 6 ff.). There are, however, indications in the Sumerian literary text known as *Lugal* and in Gudea's Cylinder A inscription that Lagash was irrigated by water from the Tigris and that this was the source of the city's prosperity (Heimpel 1987^b: 316–17). Excavations long ago at Telloh (*Girsu*) revealed one of the few irrigation installations yet excavated. This 'construction énigmatique' has been convincingly identified as a regulator on a canal system (Pemberton *et al.* 1988: 218–21).

By 3000 BC, after which in the south texts become the primary source for the reconstruction of agricultural activity, the patterns of farming had been established that were to endure substantially unchanged as the basis for Mesopotamian prosperity until the second half of the first millennium BC. Generally, cereal cultivation flourished beyond subsistence levels, and pastoralism was maintained with equal success in the areas between irrigated crops. This ensured ready supplies of secondary animal products and sustained the bovinds vital for traction. The shift to extensive irrigation agriculture involved increasingly successful production not only of grain varieties adapted to drought and salt in the soil, but also those plant species vital for oil production and for textile manufacture, similarly grown through irrigation.

Although the process of urbanization within the dry-farming zone of northern Mesopotamia is only now being intensively studied (cf. Lebeau 1990; Weiss (ed.), forthcoming) there seems little reason to doubt that

its agricultural basis was in place by the early third millennium and, as in the south, the means and the methods of farming established by then were those that endured into the first millennium BC. In the north the marked variability of annual rainfall offered risks no less threatening than those of drought and flood in the south, for which effective planting strategies and storage facilities had to be devised to support substantial urban populations at all times. It was, moreover, in the north that pastoral nomads played a significant, if still little-understood, role in the mutually supportive relationships of towns and villages.

2. Resource Procurement

In the archaeological record, urbanization, particularly in Sumer, is marked by a conspicuous increase in the demand for exotic materials and in the range of goods manufactured from them; craft and industry were transformed. Advances in agrarian productivity and the new organizational relationships involved in the change from a society of tribal units to one of city-states brought with it not only the means for commercial enterprise on a more extended basis, but also the incentive to expand it to an unprecedented degree. Within the emerging city-states, the privileged ruling group sought goods with unambiguous social significance as ostentatious status-markers. But even now, and subsequently, the quantities of semi-precious raw materials and manufactured goods which travelled over long distances were almost certainly very small by modern standards in proportion to total production, not least because transportation in bulk was so rare for practical reasons (see below).

The metals, stones, and timber sought by the Mesopotamian palace and temple organizations were exchanged, when not seized as booty or received as tribute or gifts, not so much for agricultural produce as for manufactured goods, most notably textiles (cf. Adams 1974; Yoffee 1981). In the ancient Near East, differences in technology were relatively small and the problems of long-distance travel unaided by water were so great that significant economic differentiation and exploitation were relatively rare. But, when they existed, their importance was proportionately greater. The contrast between Mesopotamia and her highland neighbours was not just one of unequal access to raw materials, but also of unequal degrees of socio-economic organization and complexity. The urban crafts and industries of Mesopotamia were as dependent on the highly organized labour of those who produced but did not participate in the consumption of what was traded as they were on sustained access to foreign materials.

This is not the place to enter into the notoriously

complex question of the relationship between centralized administrative systems and individual entrepreneurship in the procurement of raw materials, their manufacture, and the distribution of goods in historic Mesopotamia. But it is necessary to draw attention to it, if only to emphasize that they were not homogeneous at any time. The three modes of exchange conventionally distinguished as reciprocal, redistributive, and commercial coexisted. They were not mutually exclusive, as is too often assumed. It is the very complexity of their interaction and the uneven nature of the surviving textual record that has led to the long-standing controversies over the operation of the domestic economy and the role of foreign trade (cf. Adams 1984: 91-4; Postgate 1992: 191-222). These are matters upon which the texts throw the most significant light. Archaeology may most readily be expected to illuminate the ways and means of procurement rather than their administration.

It would be difficult to overestimate the role of transport by water in the sustenance of Mesopotamian crafts from an early date. River transport extends back deep into prehistory. Already by the fourth millennium BC, at the latest, there is some indication of the use of sail and a primitive capacity to exploit sea-transport in the Gulf. Even if fundamental questions about the character of Mesopotamia's import and export systems remain to be answered, something may already be said about the physical means and the routes through which they operated. As has already been pointed out, a rich diversity of natural resources in the Near East and their unequal distribution had encouraged a degree of exchange, however organized, from the earliest phase of controlled farming in the north of Mesopotamia. A series of contrasting ecological zones within Mesopotamia made her in general well suited to the production of vital consumables, both animal and vegetable, but left her seriously deficient in minerals, metals, and stones, as well as good timber. To a greater or lesser extent these were to be found in the adjacent highland regions extending from the Amanus/Taurus mountains of Syro-Anatolia through the Zagros into southern Iran, whilst other sources further afield were at times accessible overland through Iran or by sea along the Gulf. This meant that if a particular source area was for some reason inaccessible, alternative suppliers might well be available elsewhere for the required raw material.

(i) ROUTES

(a) *To the west and north-west*

The river Euphrates provided Mesopotamia not only with a western frontier, but also with its primary corridor of communication with Syria and Anatolia from a very early date. The river and its banks offered scope

for a combination of land and water transport vividly described for the Achaemenid period by Herodotus (i. 94):

The greatest wonder of all this region, after the city itself, I will now tell you: it is the boats that travel down the river to Babylon. They are circular in shape and made all of skins. They build them higher up, beyond Assyria, in Armenia, and they cut ribs of willow to make them. Then they stretch, over these, hides to cover them on the outside, like a kind of hull. They do not broaden the stern or narrow the prow but leave the boat round, like a shield. They fill it downstream, to travel with the current. What the boats carry down mostly are palmwood casks full of wine. They are steered by two paddles, with the two men standing upright in the boat; the one pulls his paddle towards him, the other thrusts his out. The boats are made, some in very large size, and some in small. The biggest of them are up to one hundred and twenty-five tons burden. In each boat there is a live donkey, and in the bigger boats more than one. When in their voyage they come to Babylon and dispose of their cargo, they auction off the ribs of willow from the boats and all the straw, and they pack up the skins on their donkeys and drive off to Armenia. For it is in no way possible to travel upstream, because of the quickness of the current; that is why, also, the boats are made of skins instead of wood. When they have come back to Armenia, driving their donkeys, they make other boats again in the same way.

Although the Euphrates presents hazards to the navigator in its upper course, particularly in the low-water season, it seems nevertheless to have been much used in antiquity as a waterway. Graeve (1981: 15 ff.) has assembled some of the texts which illustrate how a variety of craft passed backwards and forwards from Babylon to at least the great westward bend in the river. Evidence from the palace archives at Mari (cf. Dalley 1984: 168 ff.) particularly well illustrates how water transport was fundamental to the economy of this major city-state in the earlier second millennium BC in a system embracing the Euphrates, the Habur, and related canal networks. Information from royal itineraries of the Old Babylonian period at Mari may be read to suggest that the stretch of the Euphrates from the mouth of the Habur river, just north of Terqa, to the mouth of the Balikh, near Tuttul, was avoided at times of intense heat and by those fearful of its less predictable sections (cf. Villard 1986: 397). How early land routes were established along the banks of the Euphrates is debatable. Buccellati (1990: 27), for instance, believes that it was not until large-scale pastoralism developed in the Middle Euphrates region in the Bronze Age.

The Euphrates played no less significant a role in linking the maritime trade of the eastern Mediterranean with that of the Gulf, perhaps from as early as the middle of the fourth millennium BC. The Sumerian 'colonies' on the northern bend of the Euphrates were not only links in a chain of communication ultimately reaching from the head of the Gulf to the Egyptian



3. Mesopotamia: main sites mentioned in the text.

Delta through Syrian ports, but may also have been the source of immigrants who took the culture of Uruk to Egypt (Moorey 1990), presumably for raw materials, possibly above all gold. The riverine setting of at least one of these settlements, that at Habuba/Qannas, with its port area, demonstrates the combined importance of location and means of bulk transport. From the middle of the third millennium BC, if not earlier, the importance of this route for long-distance trade and cultural contact is increasingly evident. It now seems likely that a famous bilingual inscription of Sargon of Akkad (c.2334–2279 BC) sets out in geographical order from south-east to north-west the major trading posts on the route marked out by *Meluhha*, *Magan*, *Dilmun*, *Mari*, *Yarmuti*, and *Ebla*: from the Indus, itself linked overland through the region of modern Afghanistan with central Asia, to the Taurus (Hirsch 1963: 37–8).

It was the river valleys, as much as the rivers themselves, which allowed for the passage of goods; ways across intervening steppe and semi-desert were, until camel caravans, dictated by the regular availability of drinking-water along the way. Westwards of the Euphrates stretched the Syrian Desert, forcing traffic either up or down the river valley until such time as more direct routes opened up through use of camels. By the earlier second millennium BC, if not before, a western route left the river near Mari, passed through Tadmor (Palmyra) to Qatna (Homs), and thence southwards to major towns in Palestine. It is not clear how early this was opened up nor, until the general use of camels, how exploitable it was for regular traffic. Other desert routes belong to Hellenistic and later history (cf. Grant 1937).

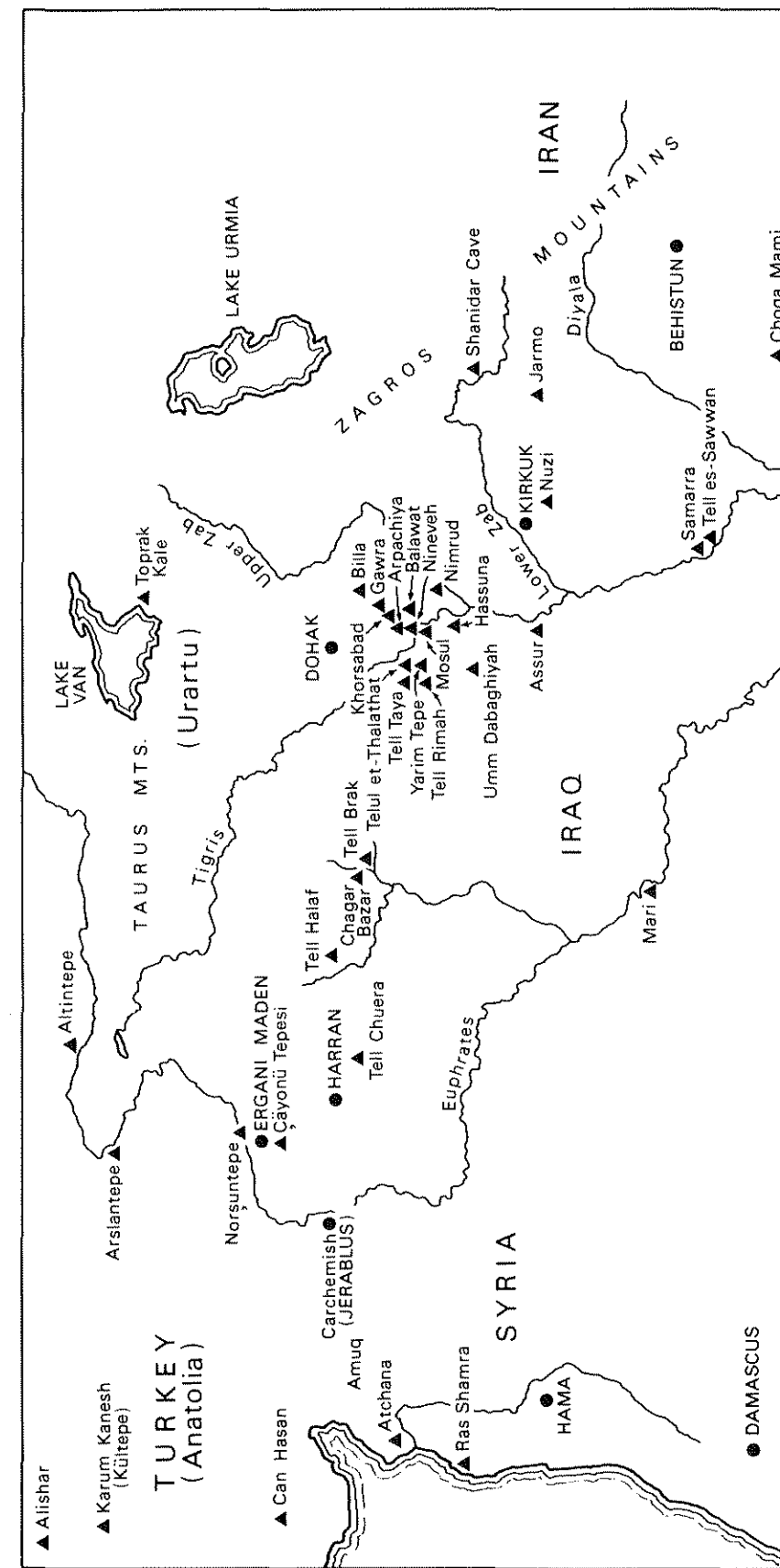
Many routes, combining land and water, linked the Euphrates and the Tigris in south and central Mesopotamia. In the north, land routes across the steppe from Assur to the great westwards bend on the Euphrates gave Assyrians direct access to the network of routes linking Syria with Anatolia (cf. Mellaart 1982). Routes described in Old Babylonian itineraries, passing westwards from Mesopotamia, refer to special diplomatic or political circumstances, so may not be used to draw general conclusions about commercial routes and journey times. But it has been argued that 'the figure of 25–30 airline km/day which emerges agrees well with what is known of the speed of travel on foot (or upstream by boat) in Old Babylonian times' (Hallo 1964: 63). It is likely, on such a calculation, that the longest land distances regularly covered within this extended network involved something like a half-year round trip for men and asses.

(b) To the east and north-east

The Tigris and its tributaries are, and seem likely always to have been, rather less congenial to transport than the Euphrates and its tributaries, and thus in general less used for this purpose. In recent times the situation has been summarized thus: 'as far as Baghdad the Tigris is navigable by river steamers with draughts of 4 feet 6 inches in the high-river season and 4 feet in the low river season. Above Baghdad small steamers of 3 feet draught can reach Mosul with great difficulty between December and May, but British steamer owners regard the section as unsafe for navigation. During the rest of the year all traffic is downstream by rafts, which are often damaged by rocks. Small craft can reach Ba'qubah on the Diyala during the high-river season. Above Mosul downstream raft navigation is difficult and dangerous' (Mason 1944: 559). Thus Nineveh developed as a major transshipment point where western overland traffic was funnelled downstream (cf. Oates, D. 1968^a: 21).

Whereas the Euphrates, with a desert barrier to its west, had always been a vital link between Sumer and her western and north-western neighbours, the Tigris and its eastern tributaries were not called upon to play a comparable role, since penetration on to the Iranian Plateau, through the formidable Zagros barrier, was possible for land transport. In the north-east, although there are routes leading from Assyria into the region round Lake Urmia, passage is difficult and commerce has always been somewhat restricted by the natural conditions. The most frequently travelled land route (the 'Great Khorasan Road') between lowland Mesopotamia and highland, inner Iran has always been that now marked out by Baghdad, Kermanshah, Hamadan, Tehran, and Meshed, where, despite many parallel mountain ranges, the frontier with Asia is relatively unobstructed. However, nowhere along this route has there yet been discovered an early settlement which served as an intermediary between east and west as Susa did further to the south in Khuzistan.

The inhabitants of the plain of Susa in Khuzistan held a unique position as middlemen, for upon their homeland in the extreme south-east of the Mesopotamian plain focused overland routes from the Iranian plateau (notably Fars: ancient Elam), from the maritime lands of the eastern Gulf, from heartland Sumer, and from the eastern periphery of Mesopotamia in the Zagros foothills. Susa was particularly linked with central and northern Mesopotamia by routes running northwards and then turning west to join up with arteries connecting Assyria (Assur) with Anatolia and Syria (Carter and Stolper 1984). Susiana's role as a frontier zone between a vast region rich in raw materials and one largely devoid of them was critical for Mesopotamia at many periods and goes far to explain the complex history of political relationships



4. Northern Mesopotamia and Syria: main sites mentioned in the text.

between Sumer/Babylonia and Susiana/Elam (cf. Amiet 1986), which were linked both by land routes and by water through river and canal networks.

(c) *To the south*

Ratnagar (1981: 157 ff.) has given a thorough account of the mechanisms of trade from the Gulf to the Indian subcontinent in its prime from the mid-third to the mid-second millennium BC. She has documented a vigorous maritime commerce, whose earliest phase remains largely a matter of speculation. There was a basic pattern in which ships from the east penetrated at least the southern Gulf. Mesopotamian boats reached southwards at most to *Magan* at the entrance to the Gulf or perhaps more often no further than *Dilmun*. When and to what extent there was direct contact between Mesopotamia and the Indus remains debatable. Indian maritime enterprise in antiquity was characterized as much, if not more, by the distribution of Indian products as by a drive for vital commodities unobtainable on the subcontinent (Ratnagar 1981: 235). It is arguable that in Mesopotamia the reverse always applied. There is increasing evidence for vigorous maritime trade within the Gulf itself, with bulk transport of copper and stone to Mesopotamia from as far afield as Oman; but very little is yet known about the methods employed. In the later nineteenth century Pelly calculated that in the Gulf region a 500-ton boat can carry as much cargo as a 3,000-mule caravan (cf. Ratnagar 1981: 158).

(ii) MEANS OF TRANSPORT

Although it is possible within the constraints of nature and with references scattered through the documents of historic times to reconstruct the primary routes to and from Mesopotamia, the date of their earliest use and their continuing role depended ultimately upon the carriers. Until the general use of camel caravans in the first millennium BC, passage across deserts for goods was greatly restricted, if not virtually impossible. Until the general use of the pack donkey in the fourth millennium, man alone may have acted as general carrier and he should never be overlooked as a pack or even as a traction animal at all times.

(a) *By water*

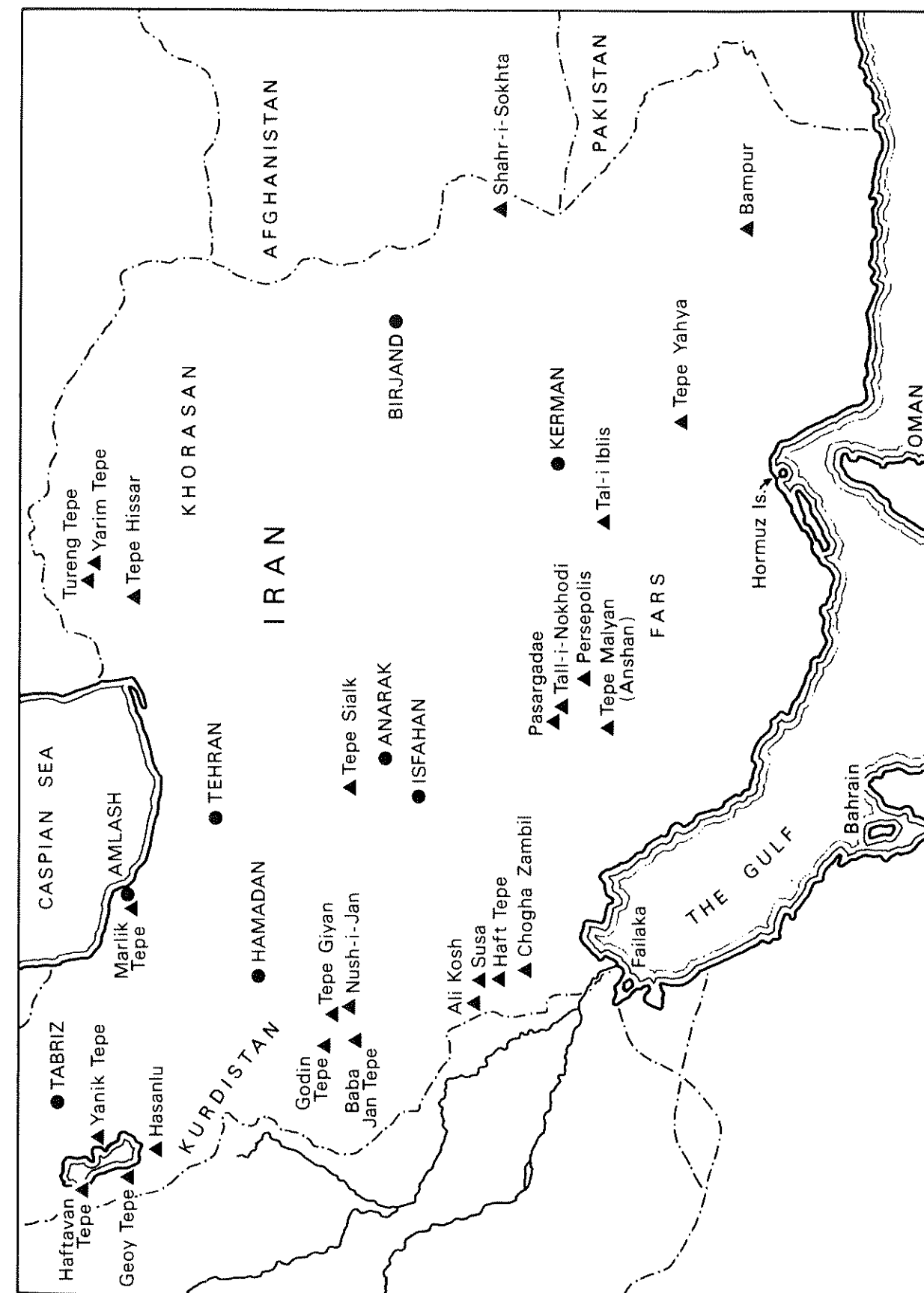
In antiquity bulk transport was only really possible by water, and for a region particularly concerned with the import of metals, stones and timber this is always important. It was also considerably cheaper and faster. Even where it is possible to use overland transport, men and animals need sustenance, whilst account needs also to be taken of the wear and tear to which animals and vehicles were subject. Mesopotamia was fortunate in its access to riverine transport, and thence to the sea

in the south, and to a growing network of canals from the fourth millennium BC (Margueron 1989). The vessels suitable for Mesopotamian waterways were small craft, made of local materials, which varied little in form through their long recorded history and may be assumed to go back ultimately to the earliest settlements on river banks. Archaeologically, they may only be studied from models, mainly of baked clay or bitumen, first appearing in the south in the Ubaid period, and from representations in art (Göttlicher 1978: nos. 3 ff.; Graeve 1981), which begin with the earliest cylinder seals in the mid-fourth millennium BC. Punted or paddled reed rafts, boat rafts, and canoes with upturned prows were commonest in the extreme south; buoyed rafts or basket-like boats of willow and hides or basketry were used further upstream; and larger boats with straight, upturned ends were preferred on the more navigable stretches of water. At Eridu a clay model boat, with prow and stern curving upwards, was found near the surface at the Ubaid cemetery above burial no. 57 (Safar *et al.* 1981: 230–1). It had a socket for a mast and holes in the sides for securing the mast with ropes. It is not clear whether this is a seagoing vessel. Stone anchors and a sailing boat(?) scratched on a model chariot wheel have been found in the third-millennium BC trading centre at Tell 'Atij on the Habur river (Fortin 1989: fig. 5, 18–19).

In the early part of this century the primary means of bulk transport on the middle Euphrates was by rafts, made of timber and brushwood lashed by tamarisk or willow bark and buoyed by inflated sheepskins, the necks secured with hemp or liquorice fibre. The smallest, of two hundred skins, supported about five tons; the largest, of some eight hundred skins, took a load of about thirty-six tons (cf. Yener 1983: 5 n. 25). There is virtually no textual evidence about methods of construction. Casson (1967) interpreted two texts from Umma listing the wood for boat-building as evidence for the shell-first construction, with wooden planks held together by mortises and tenons.

Very little is known of the boats involved in the Gulf trade. It is not even known whether these boats were able to beat to windward as the later lateen rig allows them to do. In more recent times Iraqi river boats were unable to do so and manpower was used against stream and wind. It is, however, usually assumed that at sea rowing was only a secondary means of propulsion (cf. Ratnagar 1981: 160 ff.; Graeve 1981: 176 ff.) and that sails were widely used. Seals from Failaka confirm this and illustrate vessels rigged with a single square sail (Kjaerum 1983: nos. 162–6), though the materials and methods used in the manufacture of seagoing craft is still largely a matter of speculation.

On water as on land packaging was largely organic (leather, textiles, or wood), but some was ceramic. It has been suggested in studies of sea-borne trade in the



5. Iran: main sites mentioned in the text.

eastern Mediterranean that the emergence of large-scale production for export is best indicated in the archaeological record by the appearance of specially designed pottery containers: sturdy, reasonably large, easy to manhandle, and suitable for stacking on land or in water transport. The classic example is the 'Canaanite Jar', large ovoid or piriform vessels with handles and pointed bases used for the storage and transport of oil and wine, fruit and fish, which first appeared in the Levant at the outset of the second millennium BC. Although Egyptian pottery jars of the third millennium BC may have been decisive in the evolution of the 'Canaanite Jar' in coastal Syro-Palestine, Parr (1973: 178 ff.) has called attention to similar, handleless prototypes in southern Mesopotamia from the Ur III period which might have been similarly used (cf. Ayoub 1982: types 52-3). As the 'Canaanite Jar' did not spread eastwards, it must be assumed that adequate substitutes were locally available. It was not until Neo-Assyrian times that large ceramic and stone containers of western origin regularly penetrated Mesopotamia, perhaps as often by then on the backs of camels as in boats (cf. Mallowan 1966: 170-1, figs. 103-4).

(b) By land

In the Near East the terrain and the absence of constructed roads, in all but exceptional circumstances, always made pack-animals the best bearers on land, apart from man himself, who appears occasionally in art, either alone using a headstrap or in pairs carrying large vessels or sacks suspended from poles (cf. Woolley 1934: pl. 91: lowest register; Boese 1971: pls. I: AG2; V: CT2; IX:CS7; XVI:N5). This use of manpower is likely to have been much more important than the sources at present make clear, since it is a subject neither for art nor record. Men might also have been involved in hauling boats, as they were in more recent times for journeys up the Tigris from Basra to Baghdad, or marshalled in hundreds to drag large sculptures on rollers, as for Assyrian kings (cf. Orthmann *et al.* 1975: pl. 234a, b).

From the later fourth millennium BC simple country carts (or land sledges) of conservative design served local purposes in quiet obscurity, particularly in Anatolia and on the north Mesopotamian steppe, where terrain favoured them and bovids may have pulled them. Elsewhere the ass and camel served as the primary carriers (cf. Littauer and Crouwel 1979; Bulliet 1975) from dates that remain to a degree open and controversial.

The history of the Near Eastern deserts began with the beasts of burden which enabled man to lead a nomadic life (Margueron 1989). First, from at least the fourth millennium BC, there was the donkey or ass. Then, from some time in the third millennium BC, the

domestication of the horse in the region brought the mule, an ass-horse hybrid. The camel does not appear to have been used as a pack-animal before the first millennium BC outside eastern Iran (Compagnoni and Tosi 1978). Before widespread camel domestication in the mature Iron Age, no significant populations lived deep in the desert (cf. Garvin 1987: 127-9 for the impact of the camel on specialized livestock management).

Modern scholarship has recurrently emphasized that coexistence, indeed a marked degree of interdependence, rather than confrontation characterized relationships in antiquity between nomads of all kinds and permanently settled peoples. As the early history of nomads is still very obscure, it is extremely difficult to establish when and precisely how they entered early exchange networks. In medieval and early modern times nomads undertook vital transport functions, ensuring the survival of some towns as well as many villages. It was often upon the beasts of burden bred by nomads, and under nomad protection, that manufactured goods were circulated. In some areas the co-operation of nomads was vital both to local and to long-distance trade. Moreover, the ability of nomadic peoples to pass through inhospitable regions and the need to secure their protection was fundamental to opening up remote resource areas to exploitation by primarily urban-based crafts and industries. Wright (G. A. 1969) saw a role for nomads and transhumant peoples in the distribution of obsidian. Crawford (1978) sought to refine this suggestion by invoking transmission through 'sheep and goat herders or *petits nomades*', as the Neolithic exchange-system was established before the use of pack asses or camels.

Before the camel the ass was the pack-animal *par excellence*, even if rarely shown in art and not yet common among the osteological evidence from excavated settlements. The earliest clear representation of a pack donkey is from a Chalcolithic tomb in Palestine, early in the fourth millennium BC (Kaplan 1969: pl. VII). The best textual evidence for such transport remains that from Kültepe (Karum Kanesh) (Veenhof 1972: 13 ff.) in the early second millennium BC. There each ass or donkey (more rarely horse or mule) carried its harness; about 130 minas (c. 130 lb.) of tin, wrapped in four textile containers, packed in two half-packs; 10-12 minas of loose tin and 4 to 6 textiles, probably together in one top pack; some private property of the freighter and some food. This load of at least 90 kg (180 lb.) corresponds well with more recent requirements of the pack ass. When such animals were still used by the British Army, 100 lb. (50 kg.) was the maximum for an ass, in two packs; 160 lb. (77 kg.) for a mule. Carrying a full load the ass goes about 2.5 m.p.h. for 6 hours daily (15 miles a day). The mule goes at 3 to 4 m.p.h., covering about 20 to 25 miles a day loaded. Peoples using

the ass moved around the water sources and did not venture into the desert. Asses could only be used on desert tracks during exceptionally rainy winters and then only on a few of them.

Current evidence indicates that the one-humped camel was not a factor of importance in the Syrian and North Arabian deserts until the beginning of the Iron Age. The camel had long been domesticated elsewhere, notably in southern Arabia (cf. Bulliet 1975; Zarins 1978^a), so its isolated appearances in the Near East before about 1000 BC may best be explained as the result of trade with Arabia. It is not until about the reign of Tiglath-Pileser III (c. 744-727 BC) that camels are mentioned in large numbers in Neo-Assyrian texts. By then there was a substantial expansion of camel breeding in the Arabian desert, closely correlated with an expanding incense trade. At the same time the pictorial evidence increases, with the camel shown as a baggage animal on Assyrian military expeditions. The entry of the one-humped camel into the transport economy of the ancient world as a draught animal was precluded by inadequate development of harnessing technology based on the principle of the yoke. Modern use of the one-humped camel for draught is a result of European influence and more recent developments in horse-harnessing.

The one-humped camel has a number of marked advantages over the ass and the mule as a baggage animal. It has greater powers of abstinence from food and water, as it can go ten to fourteen days without water according to season; it carries double; it requires fewer drivers, goes unshod, and costs less to maintain. A laden camel moves at about 3 m.p.h. It also has great advantages over ox-drawn carts. It can carry twice as much for twenty to twenty-five miles at a stretch over terrain impossible for wagons and has no trouble in fording rivers. It will make more journeys in a year and in a respective lifetime, living and working four times longer on average; it has greater tenacity and endurance.

The two-humped camel was probably domesticated in north-east Iran and Soviet Turkmenistan. Unlike the south Arabians, the Persians did not need the camel for subsistence. It is a big strong animal, surer footed than the one-humped camel; but it does not tolerate heat so easily. The most explicit early evidence are clay model wagons drawn by camels (Namazga IV) in the mid- to later third millennium BC. This early use for traction may explain why it was always controlled by a nose-peg, whilst its one-humped cousin has a nose-band. There are isolated Bronze Age pictorial representations, as on the Khurab copper pickaxe (Lamberg-Karlovsky 1969) and a Syrian style seal of the earlier second millennium (Porada 1977^a); but it is not until the Neo-Assyrian period that two-humped camels are usually mentioned or illustrated in connec-

tion with regions east or north-east of Assyria. In the fifth century, on the Apadana reliefs at Persepolis, the one-humped camel is shown only with Arabians; the two-humped appears with various east Iranian peoples (Schmidt 1953: pls. 30, 33, 39, 41, 46).

3. Craft and Industry: Methods of Study

(i) TEXTS AND ARCHAEOLOGY

Any separation of sources is artificial and arbitrary, but there are certain basic differences which mark the individual contributions of documents on the one hand, and material evidence on the other, to the study of Mesopotamian crafts. Texts relate principally to the role of craftsmen in social and economic life; the information provided by field archaeology and art history more often illustrates the crafts themselves and the processes of manufacture. Economic and sociological studies of crafts and industries are consequently better served by textual information, technological studies by art and archaeology. Moreover, the available textual evidence is largely concerned with social élites and those who serviced them, whilst archaeological data are often the debris of the less privileged parts of the community.

As the majority of surviving texts come from the archives of palaces or temples they exhibit the timeless tendency of bureaucratic documentation to stress the significance of large-scale public labour forces, whose control generated the texts, over the activities of private labour. Although documentary darkness is not complete outside this public sector, activity in the private domain is still so much a matter of conjecture and controversy, often over fundamentals, that any precise statement of general significance is hardly possible at present (cf. Archi (ed.) 1984; Powell 1987). In historic, as in prehistoric, times, many craft services were rendered to dwellers in towns and villages, occasionally or seasonally, by expert craftsmen. Some were resident, some itinerant (especially, perhaps, potters and smiths), working outside the great organizations to a greater or lesser extent. Within towns more variety of skills was available, with a marked division of labour, so the exchange of goods and services was more significant than in villages. The more specialist the craft and the rarer (and thus costlier) its raw materials, the greater the likelihood that its products were made and distributed from particular centres rather than being generally available, as ordinary pottery and textiles are likely to have been. Who, if anyone, controlled workmen in the private sector and how is all too often wholly obscure. Only the wealthier families in any age or place are likely, following the pattern of the local palace, to have maintained industrial workshops sufficient to service their own residences and estates.

As in ancient Egypt, it was usually the customers or

the patrons who provided the raw materials from which the products were made: 'the conclusions to be drawn suggest that villagers would come individually to towns and cities as the natural central place to obtain objects and goods made by persons with special skills. As for goods which came over long distances, a central location would also be the obvious place for obtaining them. The role a "central place" played in the exchange of goods and services should, however, not be over-emphasized in the Mesopotamian context. As long as urban centers produced a considerable part of their own staple food supply and villagers most of their clothing, tools and implements, a "central place" is denied an exclusive role in the exchange between food producers and non-food producers' (Renger 1984: 72).

Zaccagnini (1989: 50-1) has recently argued that typical second-millennium BC Mesopotamian villages had a subsistence economy based on non-specialization of labour, with low-level technology and no specialized full-time activity; exchanges between villages were rare or non-existent. 'Craftwork is limited almost exclusively to the palace or (temple) workshops, where full-time specialists are maintained by the administration . . . A quite different problem is of course the decentralization of certain specialized crafts away from the headquarters of an administration (= the palace/temple with its workshops) . . . this is not specialized work performed by village communities but forms of decentralized technological activities performed by the palace.' Zaccagnini suggests that the spread of elitist technologies beyond palace and temple organizations was a development of the first millennium BC (Iron Age). This may not have been the whole story. Adams (in Henrickson and Thuesen 1989: 443-4) has called attention to an unpublished Middle Assyrian text from Assur which describes 'groups of specialized craftsmen travelling with extensive trains of animals, wagons, families, including much baggage and many slaves, and never settling down and carrying on their craft activity in response to commands of the king or whatever it was'.

It has long been hoped that the innumerable archival texts and the 'list literature' of Sumer, Babylonia, and Assyria would yield information on crafts and technology. But for the moment too many words for materials and objects remain untranslated. Numerous words are known only from lexical lists, where there is little, if any, evidence for their precise meaning. Indeed, scribes may often have known little about the words they copied (Civil 1980). Although any text, historical, poetic, or private, may offer a clue to the activities and resources of craftsmen, the prime textual sources for them are lexical lists, administrative documents, and legal texts. From the earliest texts, of the later fourth millennium BC, they encompass a great variety of crafts and trades. However, presence or absence at any par-

ticular time or place in the extant record is more a matter of chance than any indication of the real situation. Salonen (E. 1970) collected the information from texts on craftsmen, but his monograph is essentially a checklist without any socio-economic analysis from a historical perspective. Tablets from palaces and temples recording the issue of raw materials and the delivery of finished goods constitute the bulk of the relevant written evidence. They reveal much about accounting procedures, but little or nothing of technical processes, whilst specialist vocabulary regularly eludes accurate translation. Nor is much revealed about the ultimate origin of raw materials, since if any such reference is made, it is usually to the immediate point of acquisition or storage. The role of women in Mesopotamian craft and industry is generally obscure, though some information is scattered through the texts (cf. Lesko 1989: *passim*; cf. Adams 1984: 114-7 on textile production).

The most numerous administrative archives to have survived are those from the IIIrd Dynasty of Ur at the very end of the third millennium BC; but even they provide an insecure basis for generalization at this stage of research. Little more than a quarter of a key archive, at best, may be available for integrated study. Neumann's (H. 1987) review of the written information on Ur III crafts concentrates inevitably on their organization, since his texts come almost exclusively from the state bureaucracy as represented in five royal centres: Drehem (Puzris-Dagan), Lagash, Nippur, Umma, and Ur. His primary themes are therefore predictable: the organization of personnel into workshops; the hierarchy of control from the delivery of raw materials through to the distribution of finished goods; the supervision of the work; the destination of the products, predominantly to the palace; and the payment of workers. The craft range is relatively restricted, since the texts concern workers processing goathair, leather (cf. Sigrist 1981), stone, base and precious metals, reeds, and wood. Neumann's study is a significant contribution to administrative history rather than to the elucidation of craft organization. The intermittent nature of the database hardly allows for study of the transactions linking production through distribution with consumption.

At present only two Mesopotamian workshop archives are readily available in specific studies. One is from Ur, where Woolley recovered many late Ur III tablets, from the 'Registrar's Office' (Room 8 of the *E-dub-lamah*). These were at first assumed to be the remains of an archive *in situ*. Subsequently they were shown to be part of debris brought in from elsewhere as build-up on the site during the Kassite period (cf. Jacobsen 1953: 128 n. 1). Four activities are represented in this archive, two of them of particular interest for the study of crafts. One allows for reconstruction

of key steps in textile manufacture (Jacobsen 1970), though several institutions are involved. The other relates to a single workshop, whose activities have been reconstructed largely on the basis of one extended inventory list (Legrain 1947: no. 1498) recovered from outside the 'Registrar's Office' (Loding 1974). It is unclear whether these texts were generated by royal or by temple administrators. Jacobsen favoured the former, Loding the latter; but both are agreed decisive evidence is still needed. The major inventory text has been especially exploited not only by Loding (1974) and Neumann (1987), but also by Limet (1960: 166 ff.), who used it for his pioneering study of metal workshops in the Ur III period. As individual texts in this group have not yet been systematically integrated with the information provided by the inventory list, it is still not possible to describe fully the workshop's structure and activity.

One aspect of its structure is of particular significance for students of the archaeological record, since it reveals the intimate working association of different crafts. Eight types of craftsmen are listed in the inventory: blacksmiths, carpenters, felters, goldsmiths, leatherworkers, metalworkers, reedworkers, and stonemasons. Modern craft practices tend to separation rather than to association, as for obvious pragmatic reasons does modern research on ancient crafts (including this study). But there is every reason to suppose that craftsmen worked closely together in many urban communities in Mesopotamia, whether for the great institutions or for rich and powerful individuals, and that individual master craftsmen had diverse skills. Production of many artefacts, especially in the luxury range, involved the skill of a diversity of craftsmen.

The other well-published workshop archive is from Isin, but this time it was reconstructed from tablets scattered on the antiquities market (Mieroop 1987). Although it deals with organic materials and thus falls outside the range of crafts studied here, it elucidates certain points of general reference. This craft workshop was active about 2000 BC and seems to have been one in a network under government control. Materials were delivered to it from the central store of the city, which was variously supplied, but some came direct from source. Four groups of craftsmen were active in the workshop: carpenters (wood and glue), felters (wool), leatherworkers (leather, catgut, tanning materials, dyes, and oils), and reedworkers (reeds, bitumen, gypsum). All were apparently specialists, as no transfers are recorded. The association of these particular craftsmen appears to have been deliberate as many of the workshop's products combined their skills. Some work was sent elsewhere for embellishment, as by goldsmiths. The products were widely distributed within Isin, to the palace, to temples, and to the military. Some were sent further afield as official presents. At

all stages the work was carefully checked and recorded by officials.

Renger (1984: 86 ff.) has scrutinized documents of the first half of the second millennium in Babylonia in search of evidence for non-institutional trade and industry. At this time, as usual, documents indicate that skilled and specialized craftsmen, with rare exceptions, were integrated into the households of palaces and temples. Tablets from the Old Babylonian period in the palace at Mari provide an unusually rich source of evidence for crafts and craftsmen (Dalley 1984: 51 ff., for summary). Much of it is provided by lists of goods, records giving names of craftsmen and their rations; by letters giving orders and instructions, accepting deliveries and registering complaints. These data are now being systematically published, but not yet in easily accessible syntheses, which would make the operational activities of specialist palace craftsmen and their repertory of manufactured goods readily available. The information on technology is even more scattered and often obscured by technical terms whose meaning is not yet fully understood.

Sasson (1968; 1990) has summarized some of the information to be found in the Mari texts relating to the role of craftsmen (or 'artisans'). They were assessed for their technical rather than their imaginative skills as 'competent' or 'reliable/experienced', very occasionally as 'clever' (leatherworker), 'possessed of a secret skill' (reedworker), or 'clear-sighted/imaginative' (architect/city specialist). Their work was not assessed for its artistic worth, but for the quality of its production, for its utilitarian and functional adequacy or inadequacy. The artisans at Mari lived together in their own quarter, subdivided first into wards, then into 'cells' of one or two craftsmen with their apprentices and the male and female slaves allotted to them. At Mari, although artisans were organized into palace or temple workshops for life, there was a degree of mobility. Some were allotted to caravans or visiting dignitaries. When permitted by their overlords, particular specialists moved further afield, but under close regulation. They worked under strict instruction on raw materials issued for specific purposes and carefully checked to forestall any kind of sharp practice. They were expected to be versatile, and many different experts might co-operate in producing a single elaborate object.

Until now study of the documentation from first-millennium BC Neo-Assyrian sources has yielded a meagre harvest of information on craft and industry (cf. Postgate 1987). Nor is there a systematic study of the potentially very informative Neo-Babylonian sources (cf. Zawadzki 1991). Weisberg (1967) provided introductory material, compromised by a misleading use of the term 'guild' for which there seems to be no certain evidence in Assyro-Babylonian society. Docu-

ments may indicate a degree of collective bargaining by craftsmen with their employers within the great organizations; but there is no hard evidence that their association was formalized and constituted like a medieval guild, even if craftsmen of a particular following lived in the same city quarter, as they had done in Mesopotamia for centuries. Neo-Assyrian and Achaemenid texts in particular provide evidence for the considerable presence of foreign craftsmen of diverse origin, at least in court workshops (Oded 1979: 101–2). They were either captives or specialists sent by foreign rulers as diplomatic gifts in a pattern of artisan mobility long evident in the Near East (Zaccagnini 1983). Zaccagnini (1983: 264) has argued that 'what presumably existed at this time [Iron Age and Persian period] was a transitional stage between the all embracing state organizations which centralize and monopolize all available specialized skills within the realm of permanent dependence links, on the one hand, and a situation where (highly) specialized craftsmen offer their skills and bargain with the most suitable employer for a defined span of time and/or for specific professional tasks, on the other'.

In his posthumous study of *Man and Nature in Mesopotamian Civilization* (1978), as in a number of his earlier papers, Oppenheim was in no doubt that 'the best source of meaningful information bearing on Mesopotamian man's technical know-how is contained in a special text category that I call "procedural instructions"' (Oppenheim 1978: 649). He had written earlier of 'the cuneiform texts in which Mesopotamian craftsmen handed down their methods in writing. Such techniques are unique in cuneiform literature: only the perfume makers and the glass-makers thought highly enough of their professional work to seek to preserve in writing the tradition of their crafts' (Oppenheim 1977: 324).

It is not just pedantry to emphasize that it was, of course, scribes not illiterate craftsmen who composed and wrote these texts. If there was a value judgement implied, and this is by no means self-evident, then it was one made by the scholars not by the artisans. This distinction is of the greatest importance in assessing the value of such texts for any reconstruction of the history of ancient technology. Scribes were not interested in the practical processes of manufacture, as craftsmen would have been, but simply in systematically cataloguing the technical vocabulary for the equipment, the materials, and the procedures used in any specific craft. These texts are an integral part of the Mesopotamian scribal tradition's obsession with lists of words, with lexical texts and lexicography. They may not in any sense be regarded as originating in craftsmen's coherent oral accounts of their own craft, conceived as contributions to a fully descriptive encyclopaedia of crafts written by experts. Thus they should not be taken as

primary sources for the study of ancient technology, only as significant secondary ones. As secondary sources they are useful only so long as they are understood in their own terms. They are part of a complex literary tradition of great antiquity, with its own, largely obscure, history of transmission, which even in Oppenheim's account may go back into the early second millennium BC.

If the organization of crafts and craftsmen in workshops is a subject only to be elucidated by texts, then the character and location of such workshops might seem to be a topic particularly well suited to the combination of textual and archaeological evidence. Terms like 'workshop' and 'factory', reflecting the impact of the industrial revolution in Western society, can be seriously misleading with respect to the ancient Near East, where it was the workers with their tools which mattered more than any location and its fittings. It is particularly dangerous to be inhibited by modern urban distinctions between domesticity and work, since the range of activities in and around houses in ancient towns as well as in ancient villages was many and varied. Many crafts may have been household enterprises, with only the more difficult in the hands of specialists, whether full-time or part-time.

One of the few settlements in the Near East yielding evidence on this question is Kültepe (Karum Kanesh), in the early second millennium BC, where Özgüç (T. 1986: 39–40) has reported that:

The workshops are in various parts of the residential areas, not concentrated in a separate district. In technique, plan and ovens they resemble houses, but fireplaces, although of simple type, are larger, sturdier and have stone floors . . . In private houses we may occasionally find a stone mould or two and a crucible . . . Occasionally we find an unfinished seal, a weight, a stone axe, a hammer or polishing stone . . . These are small scale workshops. We cannot tell if such modest establishments were just meeting private needs or offering public service.

'Workplace' is the best generic term to use. The physical setting for a craft might be extremely simple, equipped with no diagnostic architectural features or built-in equipment. As in the Near East today, craftsmen may generally have worked in rooms, on flat roofs, or in courtyards otherwise undistinguished, often with fire-installations no different from those used for routine domestic purposes. Thus, when studying the archaeological record, it is important to keep clearly in mind the difference between the discovery of collections of tools and implements of the type used in specialized crafts (in itself a rare occurrence), which may well leave the location of the actual workplace an open question, and the discovery of industrial debris which fixes the working site more certainly. Skilled workers may well have been socially and economically

indistinguishable from the rest of the community, as elusive in texts as in material evidence.

With some of the best documentation for ancient Near Eastern crafts coming from palace archives, there has been a tendency to scrutinize excavated palaces for workshops. But it is more likely that they lay outside the architectural core of a palace somewhere on the periphery or in the surrounding town or, in the case of anti-social procedures like tanning or kiln and furnace firing, much further afield, where archaeologists until recently have hardly ventured (cf. Margueron 1979: 25; Dolce 1988: 41 n. 34). Facilities for processing food and other regular household services are alone likely to have been accommodated near or in palace domestic quarters. Store-rooms within palaces may well have housed raw materials, especially luxuries, issued for manufacture under close supervision, but for processing elsewhere.

A general absence of unequivocal archaeological evidence for workplaces in the urban and, more rarely, excavated rural settlements of Mesopotamia should, then, not cause undue surprise. Together, the nature of the evidence and traditional archaeological procedures conspire against their ready recognition. Moreover, as Nicholas (1981: 47) pointed out in assessing the multi-purpose land-use pattern of the suburbs she excavated in third-millennium BC levels at Tepe Malyan (Anshan) in Iran: 'Large sectors of a preindustrial city often may be characterized as distinct quarters (temple quarter, craft quarter) but at the same time relatively little cultural importance is attached to *unique* functional specialization for any plot of ground within the quarter.' No single house, area, or suburb is likely to yield the best information if taken in isolation. As the nature of each residential region of a town may only be understood relative to the whole, so craft activities within neighbourhoods and suburbs have to be viewed in the context of the whole settlement. Ideally, statistical analyses should be undertaken of material evidence for crafts both in localities and across the whole site to provide an acceptable view of their place in the life of a community.

It is archaeologists pioneering the surface surveys of mounds in Iran who have so far been most concerned with their potential for the study of craft and industry (cf. Mariani 1984; Nicholas 1981). Tosi (1984) has isolated six diagnostic features: fixed installations for processing raw materials (e.g. kilns and furnaces); specific working tools; residues or wasters; raw materials in convenient form for manufacture (flint cores; ingots); concentrations of finished commodities stored for their own sake as if awaiting distribution; materials held for recycling. When isolated, such criteria may be equivocal; a combination of two or more will be most illuminating.

It is too early to assess the potential of comparable

methods in Mesopotamia, though signs are already propitious. Long ago Woolley isolated the area at Ur known as Diqdīqqah as 'an outlying quarter of Ur given over to the minor crafts and manufactures and, probably, to the business of the merchants trading in goods from overseas. It came into prominence in the Third Dynasty, with the elaboration of the canal system by Ur-Nammu, and it continues as an industrial centre apparently into the Persian Period' (Woolley 1976: 81 ff.; Mieroop 1992: 1–12). Neither he nor anyone else has yet tested this suggestion by a thorough investigation of the area. Stone and Zimansky's more recent work at Old Babylonian Tell Abu Duwari (ancient Mashkan-shapir) indicates that modern methods of field survey open up very important perspectives for analysis of workplace distribution: 'an examination of the distributions of the concentrations of waste products suggests that copper-working and the firing of ceramics were generally carried out together. Indeed, it appears that for roughly every 2 ha. of area there was a node in which evidence for these two activities is concentrated. If this pattern continues over the rest of the site, it would suggest that manufacturing was carried out in small workshops imbedded in the urban fabric. So far no real evidence for a centralized manufacturing area has been encountered, although immediately to the north and east of the cemetery the remains of several substantial kilns were found, together with some kiln wasters and cuprous slag' (Stone 1990: 149). It is unfortunate that no comparable studies have yet been done for such methodically laid out Old Babylonian towns as Tell Harmal (Baqir 1959) and Tell ed-Diniyah (Kepinski and Lecomte 1985: 616). Clinker from pottery production, slag from metalworking, and stones or shell from the production of personal ornaments and tools are the most common waste products on Mesopotamian urban sites (cf. Postgate 1992: 79; cf. Uruk surface surveys: Finkbeiner 1991).

(ii) INVESTIGATING THE MATERIAL RECORD FOR CRAFT AND INDUSTRY

Three new approaches are now commonly used in investigations of the craft procedures of antiquity based primarily upon the surviving material evidence in addition to the traditional ones. They involve:

(i) *Scientific techniques* for establishing the identity of raw materials, natural and artificial, and the processes to which they have been subject in manufacture and use; for the scientific fingerprinting of materials and of artefacts to trace the source of ores and stones, or places of manufacture (cf. Tite 1991).

(ii) *Ethnographic analogies* (cf. Watson 1979; Kramer, C. 1982) have not been so neglected in studies of the history of technology in antiquity as they have

been in general archaeology until recently, though much invoked in the nineteenth century. The soundest frame of reference is that provided by studies of the ethnography of the Near East, not of distant and often very different ecological and cultural contexts. Two works are particularly relevant and valuable in this respect: Dalman's monumental *Arbeit und Sitte in Palästina* (1928–42) and Wulff's *The Traditional Crafts of Persia* (1966).

(iii) *Experimental archaeology*: the reconstruction of devices and processes with the greatest possible degree of conformity to the known conditions of antiquity in any particular context. Microwear analysis of stone tools depends ultimately on this approach (cf. Semenov 1964).

Each of these approaches has its virtues and its drawbacks. The problems presented by enquiry through the natural sciences are particularly relevant to many of the following chapters. At first archaeologists tended to expect miracles from natural scientists, with consequent frustration and irritation when expectations were rarely, if ever, satisfied. Once the first phase of establishing simple, uncomplicated basic data is passed, the real complexity of the processes of procurement of raw materials, manufacture, and distribution are inevitably apparent. In studying ancient production processes, much of what is said here, as in all modern textbooks, is framed with the benefit of scientific hindsight. The words of an English craftsman of this century, who worked within an age-old craft tradition, are of particular significance for academic students of 'primitive' technologies:

There was nothing for it but practice and experience of every difficulty. Reasoned science for us did not exist . . . What we had to do was to live up to the local wisdom of our kind; to follow the customs, and work to the measurements, which had been tested and corrected long before our time . . . So the work was more of an art—a very fascinating art—than a science; and in this art, as I say, the brain had its share . . . But there was no science in it; no reasoning. Every detail stood by itself, and had to be learnt either by trial and error or by tradition.

(Sturt 1923: 19–20)

As this passage so well confirms, the knowledge acquired by craftsmen is empirical, with endless possibilities for variation not only in the composition of fired objects but also in the manipulation of materials: there was not, to take a single well-known example, a single 'lost' art of granulation. Ancient or 'primitive' technology is not necessarily either as simple or predictable as has too often been supposed. Modern sculptors working with metal might consider the casting of large-scale statuary in almost pure copper a crazy enterprise. It does not mean their ancient counterparts were unable to master its hazards with notable skill. Successful sol-

utions to chemical and physical problems were eventually arrived at by trial and error over long periods of time, by careful selection from amongst the raw materials available in one time or place, and by the native ingenuity of generations of craftsmen passed on from master to apprentice. Nor should individual initiative be overlooked, even if it is invisible to the eye of the archaeologist. This is a highly controversial topic upon which Near Eastern texts throw some ambiguous, yet interesting, light.

Claims to special interest in technology in the inscriptions of kings or governors in Mesopotamia have always been read as little more than conventional formulas, like so many others bombastically asserting authority or indulging in vainglorious boasting. Yet there are isolated instances in which something more personal comes through. Gudea (PLATE IA), ruler of the city-state of Lagash early in the Ur III period, c.2100 BC, in a varied range of personal sculpture without close parallel in Mesopotamia, chose in one case to have himself portrayed as an architect, seated with a building plan and measure on his lap (Statue B: 'L'Architecte au plan': Amiet 1977: pl. 380; Lambert and Tournay 1951). The accompanying text, describing the building of the temple for the city god Ningirsu, offers details about the procurement of raw materials, and the fittings manufactured with them, virtually without parallel before the records of the Assyrian kings of the late second and first millennium BC. In the inscription of his Cylinder A Gudea is more explicit about his own involvement:

the ruler
sat with the silversmiths
building *Erinnu* with precious stones,
he sat with the jewelers
building with copper and tin,
Ninturkalamma (goddess) directed before him
the craftsmen and metal casters.

(Jacobsen 1987: 408)

In the often stereotyped inscriptions of the Neo-Assyrian kings over a millennium later there are instances when something more than tradition seems to have inspired the royal choice of topic and phraseology. Sargon II took a personal interest in the processing of metals at certain places in Syria, to the extent of watching the work in progress and then having his scribes report the fact (cf. Dalley 1988: 100–2). But of all the Neo-Assyrian rulers it is Sennacherib whose inscriptions leave the strongest impression of a particular interest in technology. Here again it is metalworking that attracts royal concern. In one case he claims innovation in casting colossal metal statues (cf. Dalley 1988: 103–5); in another it is in the alloy used for casting ornamental metal friezes for gates (cf. Walker 1988: 116).

However, it required an unusually bold and independently minded administrator for a non-royal inscription to escape from the traditional themes and turns of phrase. In the region of Mari and Suhu a governor active in the second quarter of the eighth century BC, named Shamash-resu-usur, inscribed a stela with a highly idiosyncratic and unconventional account of his enterprise in bringing new life to an agriculturally depressed area on the middle Euphrates. He improved irrigation systems, planted palm and willow trees, built new settlements, and 'bees that collect honey, which none of my ancestors had ever seen or brought into the land of Suhu, I brought down from the mountain of the men of Habla, and made them settle in the orchards of the town "Gabbari-built-it". They collect honey and wax, and I know how to melt the honey and wax—and the gardeners know too' (Dalley 1984: 203).

Current evaluation of ancient craft practices is as much at the mercy of prevailing research fashions and academic preoccupations as it is of the nature of the

surviving material evidence. Not only increases in the information available modify ideas about ancient craft practices, since the spotlight of scientific research passes to and fro, often erratically. Long-standing interests in composition may suddenly give way to an exclusive concern for aspects of production, so that much more may become known of the one than of the other in a particular case. This variation has been especially evident in studies of faience. Consequently, there is no standard form within the following chapters, though it is hoped that there is a general consistency. They tend to vary as the available information, or the nature of the material, dictates. Questions appropriate to gold may not be relevant to iron, or those relevant to clay not applicable to bitumen, and vice versa. It may be possible, for instance, to say much more of glazed quartz bodies (faience) than of glazed baked clay, not for any academic preference but simply because one is generally better known and more widely recognized than the other.

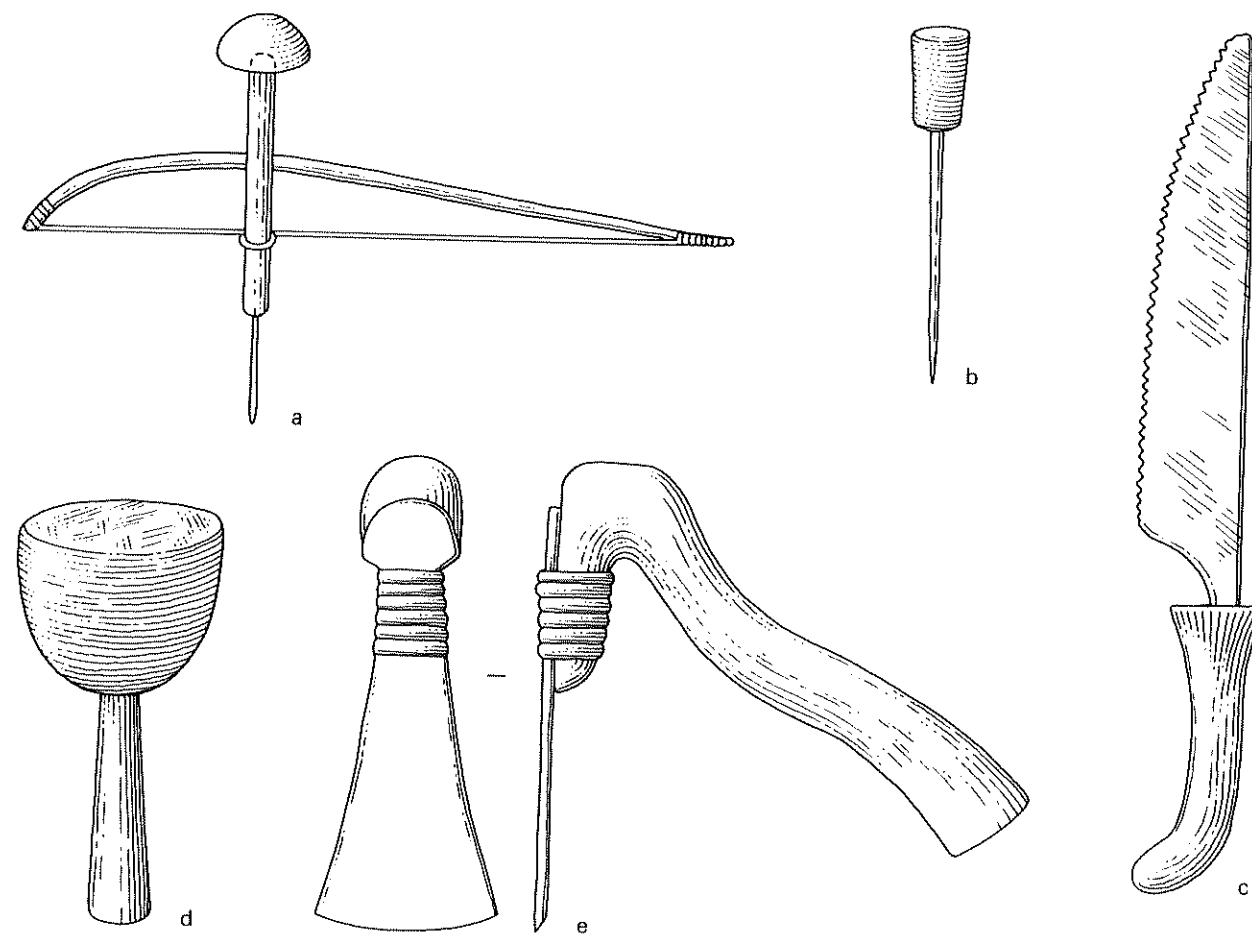


Fig. 3. The basic tools of the Mesopotamian craftsman, variously equipped with stone or metal cutting edges: (a) drill; (b) awl or chisel; (c) saw or knife; (d) hammer; (e) adze (or axe).

I

THE STONEWORKING CRAFTS: ✂ THE COMMON STONES

IN THE GEOLOGICAL HISTORY OF THE NEAR EAST one or two features may be singled out as significant for any study of the common stones exploited in Mesopotamia from the time of the earliest settlements there. Only in Sinai and western Arabia and occasionally in Iran and Turkey are igneous rocks with their valuable mineral deposits easily accessible; otherwise most of the surface rocks are more recent sedimentary deposits, either originally formed under the sea like limestone or redeposited eroded rocks like sandstone. Complex geological interactions created structural weaknesses where earthquakes and volcanoes are common, so that in certain areas, as in Syria and Turkey respectively, extensive deposits of basalt and obsidian exist. Continuing geological processes account for the recurrent sand dunes or the river valleys filled with alluvial silt carried down by rivers from eroded highland zones. The alluvial plain of southern Mesopotamia was created after the sea had reached its modern level, from about 4000 BC, so that evidence for the earliest occupation there is buried below deep sediments.

(1) Introduction

Although northern Mesopotamia had supplies of common stone, the south was largely, but not wholly, devoid of them. In the south gypsum, limestone, and sandstone were available on the Euphrates west of Uruk, at Samawwa and el Khidr, and into the desert at Umayyad and elsewhere (Boehmer 1984; Williams 1981: 311), and further south at Eridu (Wright, H. E. 1981: 300). Granite was available in the Arabian Desert (Rawlinson, G. 1875: ii. 158). A much wider variety of stones were eroded from their banks by the Euphrates and the Tigris and carried south in the annual flooding, when boulders of breccia and bituminous stone, calcite, limestone, and sandstone, to name but a few, may have been available among the debris for use virtually unworked as door-sockets and with minimal working as boundary stones (*kudurrus*). South Mesopotamian statuary sometimes shows clear signs of manufacture from eroded boulders rather than from quarried blocks. The import of dark and decorative stones to Sumer is

evident in the material record and is documented in texts, but whence they came is often obscure and the quantities in which they arrived is wholly unknown (see below).

Geological indicators suggest only the broad range of potential sources, since within the great curving arc of the Amanus-Taurus-Zagros mountains many common stones were widely available (cf. Schüller 1963). Most accessible to the east were limestone, calcite, and gypsum, as well as such sedimentary rocks as sandstone and shale (Williams 1981; Harrison 1968: 166 ff.). Deeper into the Zagros were more limestones, but also such harder and often darker metamorphic and igneous rocks as granite, marble, quartz, schist, and serpentine (Morgan 1900: 135; Harrison 1968: 159–63). Further into highland Iran steatite/chlorite is widely available (Kohl 1975: 30). Within a volcanic belt extending from Azarbaijan south-eastwards to Baluchistan may be found such stones as basalt, diorite, dolerite, gabbros, and granites (Harrison 1968: 156; Schüller 1963). Away to the south, Arabia offered steatite (Zarins 1978: 67); Oman and southern Iran could provide steatite/chlorite, diorite, and olivine-gabbros (Hauptmann 1985: 17, 22 ff.; Vallat 1985).

As many of these stones were also available to the north and north-west, extreme caution is needed in identifying sources on the evidence of inference alone. It may only be said that significant quantities of stone are unlikely to have moved except where transport by water was readily available. For instance, both Xenophon (*Anabasis* i. v. 5) and the Mari texts of the earlier second millennium BC (cf. Dalley 1984: 170) record the supply of millstones to Babylonia, from a region of the Middle Euphrates where they were locally available, by river transport.

In Assyria, stones of good quality such as limestone, sandstone, and conglomerate were readily available. Mosul Marble ('alabaster') 'abounds in the country, and being very soft is easily quarried and sculptured . . . When first taken from the quarry, this alabaster is of a greyish white; but on exposure it soon changes, growing darker, and ultimately becomes a deep grey' (Layard 1849: ii. 313–14). As Layard also noted, black basalt was readily used when more durable stone was

required: 'it abounds in the Kurdish hills . . . and in that part of the Taurus through which the Tigris, and Euphrates, find a narrow and sudden outlet into the plains of Assyria' (Layard 1849: ii. 316).

Scientific fingerprinting of the common stones used in Mesopotamia has barely begun, and is a formidable task to judge by the evidence of such research on steatite/chlorite (Kohl *et al.* 1979). This line of investigation tends to highlight the range of geologically disparate sources used, whilst yielding instructive but largely negative results about the raw material's actual source. Three factors in particular are important to stone and other characterization studies. First, the degree to which sources may be uniquely characterized; second, the number of sources in a given region and the area over which practical identification of material with sources is to be attempted; and third, the extent to which material may have come from sources other than the nearest. It has to be remembered that factors other than simple linear distance have from earliest times affected the use of sources of raw material. Aesthetic considerations, natural and political barriers, and problems of transport, as well as adherence to established patterns of exchange, are among the variables that have to be assessed in the final analysis.

Little or no systematic work has been done on the proper mineralogical description of the objects made from common stones regularly found in excavations. Semi-precious stones have been little better served. It is the small number of potential sources and their ready recognition by eye, supplemented by a degree of scientific analysis, that have made possible significant advances in sourcing lapis lazuli and obsidian. When, as for stones like cornelian and haematite, potential sources are geologically evident in Turkey or in Greater Iran, then other factors, archaeological and textual, have played a critical part in present attempts to locate the source areas being exploited at any particular time. At present, only collections of cylinder seals are regularly studied by mineralogical experts. It is also likely that many stone objects were recycled for their raw material, at times confusing patterns of source distribution.

The Mesopotamian stoneworker or lapidary employed a range of skills developed early in human history and then little changed. Loding (1981) has reviewed the Sumerian terminology for stoneworkers and the light it throws on their procedures. A calcite bowl from Telloh is inscribed 'Lú-utu the *zadim* made [this] fine bowl' (Genouillac 1936: pl. 85/2; Loding 1981: 7, fig. 3). The cuneiform sign read *zadim* may occur as early as the Uruk IV–III periods (Green and Nissen 1987: 310, no. 614) and has been interpreted as a bow-drill or bow-driven lathe of the type Nissen (1977) argued was used by that time in seal-cutting. The same craftsman is the dedicator of a gypsum plaster offering-

stand for Gudea (Foster and Foster 1978: 63), whilst this ruler relates how he sat with the craftsmen working with precious stones in his temple for the god Ningirsu (Cylinder A: Jacobsen 1987: 408). Loding (1981: 8) cites a passage from the cultic text *Ershemma* in which a distinction is made between two types of craftsmen in stone: '[my house whose] stonecutter (*bur-gul*) used to carve bowls, my [house whose] lapidary (*za-gin-dim-e*) [literally 'maker of lapis lazuli'] used to make jewelry'. *Bur-gul* is a term emerging in the early second millennium BC at a time when the cuneiform sign *zadim* is first used to denote 'bowmaker' (*sasinnu*) rather than 'lapidary' as before; perhaps significant indication of the bow-drill's role in the life of a Sumerian lapidary of the third millennium and earlier. *Bur-gul* is a craft which embraced seal-cutting as well as vessel manufacture (*bur* is a vessel), as *zadim* had probably done in earlier times. Salonen (E. 1970: 231–43) has analysed the Akkadian terminology for craftsmen working with stone, but it does not add to understanding of their tools and procedures.

In the present state of the subject any general study of the stoneworker's craft has to use a simple, crude classification for the common stones to accommodate as far as possible the very uneven value of published identifications and the dearth of systematic mineralogical surveys. Four broad categories are used here (for Woolley's system see p. 43).

1. *The calcium-based sedimentary rocks* (limestones and marbles) and secondary mineral formations (calcites and gypsums, including travertine calcite taken from stalagmites and stalactites). It is here that the term 'alabaster' is regularly encountered, variously describing calcite and gypsum. In modern geological usage 'alabaster' refers to fine-grained massive gypsum, whilst in the archaeological literature it is as often as not used to describe types of calcite.

2. *The other sedimentary rocks and metamorphic derivatives* like conglomerate, dolomite, sandstone, schist, shale, and slate. This category embraces some of the soft dark stones (3, below).

3. *The grey-green secondary minerals occurring in metamorphic rocks*, like chlorite, serpentine, and steatite: the soft dark (greasy) stones.

4. *The opaque grey-green or black igneous and altered igneous rocks*, such as basalt, diorite, dolerite, and granite: the hard dark stones.

This survey of stoneworking in ancient Mesopotamia is divided into two main sections covering first the 'common' stones, second the 'semi-precious' stones. Overlap is inevitable, but broadly speaking three main areas of handiwork are embraced by the first category: sculpture, stone-vessel manufacture, and tool/weapon production; two by the second: seal-cutting and personal ornament manufacture. Any separation will be

arbitrary; but for purposes of study at this stage this one allows for minimal repetition, whilst dealing with the major surviving groups of material evidence as coherently as possible. As there is no existing survey of this kind, the emphasis throughout has been on attempting to pinpoint and to integrate the most significant evidence in a vast and heterogeneous body of information. Stone, as the most durable of the natural materials employed by man, may be recurrently available to archaeologists, but it is not therefore necessarily the best understood.

The first systematic geological identification of stones recovered in an urban surface survey has been undertaken for Uruk (Rau, in Finkbeiner 1991: 68–72). Since these samples are undated, they simply confirm that the range of stones reconstructed in the following pages from the evidence of surviving artefacts offers a reliable cross-section of what was available at one time or another at a major urban centre in the south, either as raw material imported for manufacture or as water-borne debris. The common stones include: breccia, calcite, chalk, conglomerate, dolomite, gypsum, limestone, and sandstone; basalt, diorite, gabbro, granite, rhyolite, and trachyte; marble, quartzite, and serpentine. The ornamental stones listed are: agate, amethyst, augite, rock crystal, chrysoprase, haematite, cornelian, lapis lazuli, pyrites, quartz in various colours, talc, turquoise, and sphalerite.

2. Sculpture and Sculptors

In historic times in Mesopotamia, human sculpture in stone, whether in the round or in relief, was produced for the service of the gods: 'all Mesopotamian statuary was intended for temples; the human form was translated into stone for the express purpose of confronting the god' (Frankfort 1970: 45). Consequently, what has survived is almost exclusively from temples, where it was originally deposited as votives. No special privilege was extended to such statuary once it was obsolete. It was cleared out of shrines and buried beneath floors as build-up or placed in specially dug pits. When temples were sacked, statuary appears often to have been systematically shattered so that excavators find only scattered fragments incorporated in the foundation levels of the reconstructed shrines. Very few statues of deities have survived. They were commonly plundered for the precious materials of which they were made or carried into exile by conquerors as visible tokens of submission, as was other monumental stonework stored in temples. This is evident from the sculpture of the Akkadian period originally set up in Akkad and Sippar, but recovered in modern times from Susa (Amiet 1976). Animal statuary for the most part also adorned temples or

shrines in palaces; only animal amulets had a wider social distribution.

Although in the later prehistoric period, as at Uruk, sculptures are already found primarily in temple deposits, there are earlier instances such as the human figures from Tell es-Sawwan, when they are recovered from private graves. However, even in this context, it is important to appreciate that stone sculptures, of whatever size, were to a degree luxuries. Terracotta, even more subject to the depredations of time than stone, was the common medium for statuary and figurines from earliest times through into the first millennium BC. Even the stones most readily available in Mesopotamia, like gypsum and limestone, were overwhelmingly employed for statuary within the orbit of the great organizations of court and temple; this was not a popular art.

The distribution of surviving examples through time and space is also a significant variable. Only in the Early Dynastic period, c.2750–2350 BC in the south and the Neo-Assyrian period, c.883–612 BC in the north, is there a substantial body of evidence for three-dimensional and relief sculpture. In Babylonia evidence for the later third and earlier second millennium BC is adequate only as a broad indication of trends; thereafter the boundary stones (*kudurrus*) alone sustain a survey of sculpture. Remarkably few sculptures are known from Assyria before the first millennium BC and what there are, if not imported from the south, were probably created under strong southern influence.

Consequently, the extent of the use of stone for sculpture is extremely difficult to estimate for Babylonia after the third millennium and for Assyria before the first millennium. Stone was not used for substantial programmes of relief sculpture before the Neo-Assyrian period and, so far as the evidence allows, only relatively rarely for statues of life-size or larger. Texts rather than archaeology suggest that the most valued and most expensive images of the gods were composite; kings alone may more regularly have appeared in three-dimensional statuary entirely of stone on a grand scale. As in building so in sculpture, it was only the kings who had at their disposal the means to procure, either on their own behalf or for the service of the gods, substantial quantities of any stone or usable quantities of rarer, dark-coloured, hard stones that had to be transported from distant sources. Even here it is evident that this was rarely if ever done, even by kings, unless transportation by water was possible for the greater part of the journey.

Sculpture has been more intensively studied than any other aspects of the use of stone in Mesopotamia, though very rarely from the point of view of materials and manufacture. All the standard histories of Mesopotamian art contain a selection of illustrations, whilst monographs are increasingly available on the more

important categories of sculpture. Fundamental art-historical guides to the whole range have been provided by Spycket (1981) and Börker-Klähn (1982), whilst Braun-Holzinger (1991) has listed inscribed statuary up to the Kassite period.

(i) HISTORICAL SURVEY OF STONES USED FOR SCULPTURE

Until the Akkadian period in the third quarter of the third millennium BC, the vast majority of surviving pieces of sculpture are in the softer, light-coloured sedimentary and metamorphic rocks which were most readily accessible either in the outcrops of the desert periphery to the west of Mesopotamia or along the banks of the Euphrates upstream from the region of modern Baghdad. The only detailed geological research so far undertaken, by Meyer (1981) on statuary from Nippur and sites in the Diyala valley, confirms this.

A continuous sequence of evidence for stone sculpture does not begin until the middle of the fourth millennium BC (Uruk IV); but already in the ninth millennium and thereafter at sites like Nemrik in the north there are isolated signs of much older traditions yet to be fully revealed. At Nemrik local river pebbles, pecked and then polished, with detail worked with flint tools, were transformed into the bodies or just the heads of lions and snakes, bustard or vulture heads, or human figures. They include a woman and a phallus-shaped male head with tattooed cheeks. All may represent domestic deities (Kozłowski and Kempisty 1990; Watkins 1990). By the early sixth millennium BC, craftsmen producing a varied repertory of stone vessels at Tell es-Sawwan used the same source of calcite to create a remarkable series of statuettes that remain for the moment even more isolated in the material record than the vessels do (cf. Amiet 1977: pls. 164–74; Amiet *et al.* 1980: nos. 2–17, fig. 5 (colour)). They are female and are thought to represent human beings rather than divinities. Elsewhere in prehistory, as well may often have been the case later, painted terracotta was the preferred medium for small statuary. Even at Tell es-Sawwan it was used for part of the repertory of small human sculpture (cf. Oates, J. 1966).

Although the Uruk IV period saw an unprecedented variety of stones entering the river valley for the service of the temples at Uruk itself, small human statuary like sculptured vases was predominantly of the light-coloured calcium-based stones reasonably accessible within the immediate orbit of Mesopotamia (cf. Heinrich 1936: pl. 7a; Orthmann *et al.* 1975: pl. 1 (colour); Amiet 1977: pls. 28–30 (colour), 226, 248–50). A significant phenomenon at Uruk, not again paralleled until the first millennium BC, and then in the north, was the use of basalt for relief sculpture. This rock was employed for the famous lion-hunt stela (Nöl-

deke 1934: 11–12, pls. 12–13; Börker-Klähn 1982: nos. 1–3) and for a relative of the same date reported by Loftus in the last century, but only known from drawings (Curtis 1986). Although Early Dynastic in date, the stela from Ras el-Tell (Djebel el-Beida) in the Syrian Jezirah is also cut in basalt and is likely to indicate the general region whence came the stone used at Uruk in the previous millennium (Moortgat-Correns 1972; Börker-Klähn 1982: no. 13). Syria was the source of the basalt used by the Neo-Assyrian kings for sculpture. This stone may well have reached prehistoric Uruk by water from 'colonies' established on the middle Euphrates, perhaps to facilitate the procurement of raw materials (cf. Lebeau 1990: 250–2).

A greater variety of stones is evident in small animal sculpture, some so tiny as to be better described as amulets (Behm-Blancke 1979; Spycket 1981: 39 ff.), and inlays (Dolce 1978: 12 ff.). In this case both the variously coloured limestones and calcites, as well as sandstone and the darker soft stones like steatite, serpentine, and chlorite, were exploited. An attractive translucent green gypsum was used for amulets (Weiss *et al.* 1985: no. 28) and pictographic tablets (André-Leichnam 1982: 53, no. 8). It appears later in the Early Dynastic period for seals (cf. Buchanan 1966: no. 233) and notably in a headless female statuette from the Inanna Temple at Nippur (cf. Orthmann *et al.* 1975: pl. II (colour)), perhaps from sources in the Zagros also accessible to artisans working at Susa (Morgan 1900: 48).

One of the more unusual uses of stones recurrent in southern Mesopotamia is to record land transactions (*kudurrus*). They first appear in the fourth millennium, with the earliest writing, on the enigmatic 'Blau Monuments' made of phyllite or slaty schist. The shape of these two small objects may imitate respectively the stylus for writing pictographs and the semi-circular tool used to shape and smooth tablets (cf. Postgate 1992: 67, fig. 3:14) (PLATE VIA). Bituminous limestone, popular in Susiana, was much more rarely used at this time in Sumer, where finds seem to be confined largely to Uruk, where it was used for small sculptures (Lenzen 1961: 25). Exceptionally, gypsum plaster was modelled to make monumental statuary at Uruk in the late prehistoric period, though the published pieces are largely incoherent fragments (Strommenger 1973).

The lighter stones were persistently popular through the Early Dynastic period for the production of royal as well as private human statuary. In historic sequence the carved macehead of Mesilim (Amiet 1977: pl. 302), the wall-plaques of Ur-Nanshe (Amiet 1977: pls. 324, 326; Boese 1971: T5–7), the 'Vulture Stela' and macehead of Eannatum I (Amiet 1977: pls. 328–30, 333), all illustrate the royal use of such stones for relief carvings. Elsewhere they served as the primary medium for stelae (Börker-Klähn 1982: nos. 4–14, 16–17), for wall-

plaques (Boese 1971: *passim*), and for decorated votive maceheads (Frankfort 1935). It may be assumed that all such sculpture was intended to be kept within temple buildings and not exposed to the weather. A striking exception to this pattern is a stela (0.25 m. high; 0.25 m. wide), found at Ur, inscribed on the reverse for Ur-Nanshe of Lagash: 'it is of mottled red, black and white granite, and the material was evidently too hard for the sculptor to cope with by ordinary means, instead of being cut, the relief is made entirely by rubbing-down the stone' (Woolley 1956: 46, pl. 39U.17829; Börker-Klähn 1982: no. 15). It is possible that such a stone was brought down by river action and not specially procured. What may be a comparable stone was used in the Kassite period for a macehead inscribed for Kadashman-Enlil (I or II) found at Nineveh (Campbell Thompson and Hamilton 1932: 107, pl. LXXXIII; Brinkman 1976: 134).

A greater variety of stones is evident amongst the surviving private human statuary, but here again the light-coloured soft stones were overwhelmingly popular, notably gypsum, calcite, and limestone. In Braun-Holzinger's (1977) catalogue of the common worshipper statues slightly less than 5 per cent were made of other stones. On the rare occasions when foundation figurines are in stone rather than in metal, it is also calcite or limestone (Ellis 1968: 48 ff. (Uruk), 52 (?Telloh)). In foundation deposits with copper figurines, the inscribed stone tablets laid over them are most often described as alabaster (calcite/gypsum); occasionally they are of steatite, schist, or even lapis lazuli (Ellis 1968: *passim*). As so often, it is at Mari, with access by river to the varied stones of the north, that unusual minerals are exploited, such as pink breccia for statuary (Parrot 1967: nos. 33, 35, 65, 73–4, 105).

A small programme of analyses of statuary and vessels of the Early Dynastic Period recently conducted at the British Museum indicated an enduring preference for gypsum rather than calcite (travertine) for small statuary, probably because the former was locally available (J. E. Curtis: personal communication). The most important exceptions in Braun-Holzinger's (1977) catalogue are the Early Dynastic III male statues in the darker, harder stones which anticipate the marked preference for these stones in royal workshops from the Akkadian Period for major pieces of three-dimensional sculpture. All the inscribed examples, dating to Early Dynastic IIB, appear to be in the range of stones broadly categorized as 'olivine-gabbro/diorite' though none of these statues has yet been mineralogically analysed. If subsequent developments are a reliable guide, this would be the earliest use of a category of stone brought by sea from regions on the shores of the lower Gulf. These are all statues of kings or very high-ranking male officials dedicated as votives in temples: Entemena of Lagash found at Ur (Woolley 1956: pl. 40;

Spycket 1981: 84, pl. 54); Dada-ilum from Ur (Woolley 1956: pl. 41c; Spycket 1981: 106); Lupad of Umma from Telloh (Spycket 1981: 105 ff., pl. 67); Dudu of Lagash (Spycket 1981: 105); and a fragment from a statue of Enannatum I of Lagash (Braun-Holzinger 1977: 83).

A significant exception is provided by the statue of E(kur) from Tell al-Ubaid (Hall and Woolley 1927: pl. IX). It is made of a distinctive hard grey-green stone identified by the excavators as 'trachyte'. This is a member of the lavas category that was standard in the repertory of stones used for vessels from Uruk III to Early Dynastic II in graves at Ur and elsewhere, but very rare thereafter. Spycket (1981: 106) has argued that this statue should be dated stylistically to Early Dynastic II, the peak period of the stone-vessel industry at Ur, when use of such stone for statuary, if unusual, would not be entirely unexpected. On this view it was usurped and inscribed in Early Dynastic III. This statue may not, however, be an isolated case. It is possible that the 'green stone' of male heads excavated at Khafajah (Temple Oval), at Larsa, and at Uruk is also representative of the lavas more familiar as a raw material for vessels (Frankfort 1939: nos. 42, 49, pl. 56a–c, 59; Lenzen 1961: 25, pl. 15a–d; Margueron 1971: 280, pl. XVII. 3–4).

Among the uninscribed diorite or gabbro male statues, the most significant is that from the Sin Temple at Khafajah. It was described as follows by Frankfort 1939: 26, pl. 30:17: 'probably represents a ruler, since the figure wears a plait wound round the head similar to that worn by Eannatum on the "Stela of the Vultures", by Lamgimari of Mari and by Meskalamdug as indicated by his golden helmet—a fashion not observed among commoners, as far as we know. Moreover, the costly stone from which it is hewn is quite exceptional among our finds.' At least two other statues belong with this special category, one from Bismaya ('basalt') and one from Telloh ('diorite') (Braun-Holzinger 1977: 77, 80). There is also an isolated female torso fragment, now in the Louvre, described by Parrot (1952: 75 (AO 20 145); cf. Braun-Holzinger 1977: 85, pl. 32n) thus: 'la qualité de la pierre, une belle brèche gris-bleuté, incrustée naturellement de parcelles jaunâtres, fait de cette sculpture un excellent morceau'.

Among the repertory of animal statuary (Spycket 1981: 131 ff.) in the Early Dynastic period, particularly if large and small are taken together, the variety of stones employed within the lighter, softer range continues to be striking. Special advantage seems more often to have been taken of coloured limestones or of the patterning of especially translucent pieces of banded calcite than when carving relief or human statuary (cf. Behm-Blancke 1979; Frankfort 1939: nos. 155–8; 1943: nos. 293–304), whilst the darker stones, even the softer ones, are rarely represented.

In human sculpture chlorite/serpentine/steatite

appear as inlay fragments, for hair, skirts, etc., rather than as complete statuettes; similar inlays are reported from Ebla in Syria (Woolley 1956: pl. 44: U.18313-4, 3278, 6956; cf. Matthiae 1985: pls. 44-6). It is possible that these stones were reaching Sumer along the line of the Euphrates from sources in Syria, where steatite and its relatives had long been favoured for the manufacture of stamp seals (cf. Buchanan and Moorey 1984: *passim*).

The art of inlay and mosaic, long popular in Sumer, flourished in the woodwork of Early Dynastic III. In sculpture the combination of a dark background commonly of schist or slate with light-coloured inlays of limestone was particularly favoured. This technique was used both for self-contained square or rectangular panels, fixed to the wall with a peg passed through a central hole, exactly comparable to those carved in limestone (cf. Frankfort 1939: nos. 197-8), and for more extended friezes, presumably set along walls at or near eye-level, both in temples, as at Tell al-Ubaid (Hall and Woolley 1927: 88 ff., pls. 31-3), and in palaces, as at Kish (Mackay 1929: 120 ff., pls. 35-6). At Mari, possibly from a source readily accessible north-westwards along the Euphrates, 'schiste verte' was used for large storage jars, the outer surfaces of which were carved with cavities to take inlaid design in coloured stones, again it seems both in palace and in temple contexts (Parrot 1971: 267, fig. 11, pl. XIV. 3; cf. Parrot 1955: 210, fig. 14). Parrot (1971: 267) reported that 'nous avons en effet recueilli plusieurs dizaines de parcelles de pierres de different couleurs, qui devaient donner à cet accessoire rituel un aspect diapré d'un éclat extraordinaire' (Parrot 1971: 267). Schist or slate continued to be used for undecorated, but inscribed, plaques through into the Akkadian period (Parrot 1967: 187, fig. 232 (Mari); 1948: 134 ff., fig. 32g (Telloh)).

The use of schist/slate is likely to have been more widespread than these conspicuous survivors indicate. At Ur, loose in the soil at a depth of 4 to 5 metres in the 'Royal Cemetery' area, Woolley recovered part of a shell inlay carved as the torso of a soldier, and with it 'were found large fragments of slate from the background in which the shell had been set' (Woolley 1956: 174-5, U. 12326, pl. 38). The University Museum in Philadelphia (19918-19; 12237), moreover, has worked fragments of slate, with mouldings, from the pioneer excavations at Nippur.

Bituminous limestone remains elusive in Mesopotamia at this period, though it remained popular in Susiana where it was locally available. The inscription on the bitumen plaque of Dudu from Telloh (cf. Boese 1971: no. T12) indicates that the material came from the Elamite border town of *Urua* (Steible 1982: Ent. 76). There is little or no sign in Sumer, outside the inlaid wall-plaques described above, of the blend of

gypsum and bituminous limestone which gave the sculptural repertory of Susa a distinctive black-and-white look in the Proto-Elamite and Early Dynastic III periods. There are, moreover, only isolated traces of the softer dark stones as in the case of inlays carved as felines and snakes in chlorite from Nippur (Meyer 1981), some decorated with mother-of-pearl inlays against a red pigment background, which may be imports from Iran. In statuary of the later Early Dynastic period, as later, eye inlays of stone (shell was also used) were generally of limestone in various colours with widespread use of lapis lazuli for the eyeball.

Sufficient Akkadian royal sculpture survives to indicate definite trends in the use of stone in royal workshops (Spycket 1981: 143 ff.). Much is fragmentary and largely recovered from Susa, whither it had been carried in antiquity as booty from cities like Akkad and Sippar. For the first time a degree of standardization is evident in the regular use of dark igneous-metamorphic rocks. On the basis of the statuary recovered from Susa alone, now in the Louvre, it may be said that just over 70 per cent of the available monuments are of the dark stone commonly described as 'diorite'. All but one of those with royal inscriptions fall into this category, as do fragments of Akkadian royal sculpture from Assur (Amiet 1976; Moortgat 1969: 49 ff.). The stones of four of the sculptures in the Louvre have been geologically identified (one of Sargon, two of Manishtushu, and one of an unidentified ruler (Amiet 1976: nos. 2, 11, 14; Scheil 1902, 2, pl. 1:2)) and a fragmentary statue of Manishtushu from Sippar in the British Museum (Heimpel 1987: 69). All are carved in 'olivine-gabbros', none from precisely the same specimen but likely from the same geological intrusion, or set of intrusives' (Heimpel 1982: 65; cf. 1987: 69-70).

The inscription on one of the Manishtushu statues records how, after defeating the Elamites of Anshan (Tepe Malyan), in south-western Iran (Fars), he crossed to 'the other side of the Lower Sea (i.e. the Gulf)' and there 'quarried their dark (or black) stones, loaded them on to ships, and moored them at the quay of Akkad' (Manishtushu 1, C1; cf. Heimpel 1987: 74). No specific place-name is given, nor is there one in any of the inscriptions on the Akkadian royal statues so far analysed. The statue of Naram-Sin from Susa, now in the Louvre, inscribed with a reference to quarrying *esi*-stone in Magan, was not among these chosen for sampling by Heimpel (cf. Amiet 1976: no. 29; cf. Westenholz's translation in Potts, D. 1986: 276). However, Manishtushu's inscription associates the quarries whence came dark stone with mines for silver or 'precious' metal (accepting Pettinato 1972: 80 and Waetzoldt 1981: 367 n. 23 against Heimpel 1982: 67, who translates simply 'metal'). At present, gold and silver mines are only attested on the eastern (Iranian) side of the Gulf; they are not reported in Oman. Since

gabbros are available both in Oman and in south-western Iran, it is not certain precisely which region is involved here (cf. Heimpel 1987: 69-70; Potts, D. 1990: 143 in favour of Oman).

Whatever the case, regions adjacent to the shores of the Gulf were the primary source of the hard dark stones favoured for monumental sculpture by Sargon and his dynasty, as perhaps earlier by rulers of the late Early Dynastic period. However, this need not have been the only home of these stones, as Rimush (c.2278-2270 BC) reports diorite (*esi*-stone), or diorite objects, taken as booty from *Parahshum* (*Marhashi*), a region of uncertain location in south-central Iran (cf. Steinkeller 1982: 254 n. 62), whence river transport might have carried them to the shores of the Gulf. It may not always have been a question of 'quarrying' stone. Heuzey (1885) observed that many of the famous dark stone statues of Gudea were well smoothed even in the apparently unworked areas, suggesting to him that the raw material had been collected from rock outcrops eroding into the Gulf rather than quarried (cf. Heimpel 1987: 70). This could equally well apply to earlier procurement.

Some negative aspects of Akkadian royal stone procurement are also instructive. Although the Akkadian kings penetrated far up the Euphrates to the north-west, the listed booty from these regions consists predominantly of metals and/or timber. It is significant in this respect to observe that where monuments of local rulers have survived in Syria at this period, and later, local basalt is the hard stone they favoured (cf. Matthiae 1980: pl. 32, 45). Reported exceptions in the Akkadian period in northern Mesopotamia, as with the 'diorite' male statue from Assur (Moortgat 1969: pl. 143) or the 'diorite' stela fragment of Naram-Sin at Pir-Hussein in the Diyarbakir region (Moortgat 1969: pl. 153), may well be imports from royal workshops to the south at the heart of the Akkadian realm working in these preferred dark stones from Iran and the Gulf. Moreover, the fact that a contemporary west Iranian ruler did not use this stone may be additional proof that the Akkadian rulers drew more on Gulf than on Iranian sources. Puzur-Inshushinak, the 'last king of Awan', who is best dated in or about the time of Shalisharri of Akkad (c.2217-2193 BC) (Stolper 1984: 15), has left monuments in limestone or calcite and one in the distinctive 'aragonite verte' (Amiet 1966: pl. 164), not in hard dark stones.

Even when they used the more traditional softer, light-coloured range of stones for their monuments the Akkadian kings exhibit distinctive tastes. This is particularly evident in their monumental stelae with relief designs (Amiet 1976: no. 26; Börker-Klähn 1982: nos. 22-4). The Louvre has four small stela fragments recovered from the Acropolis at Susa made of 'albâtre vert ou aragonite, qui ont dû appartenir à une, voir à

deux stèles semblables, si l'on considère la diversité de leur couleur: vert clair et veines orangées, pour les principaux fragments; vert glauque, pour les fragments de bras et de jambe' (Amiet 1976: 27). Parts of another such stela, recovered in the earlier 1950s from clandestine excavations in the region of Nashiriyah in southern Iraq, are in a green-tinted translucent calcite (Börker-Klähn 1982: no. 22). It is conceivable that these pieces came from Eridu, where the 1918 British Expedition retrieved from the surface two chips from the face of an exactly similar stela in 'yellowish translucent alabaster, with a faint suggestion of green in some lighting conditions; one has a vein of pink in it' (Reade 1981: 10). Nor are the more conventional stones absent from the repertory of Akkadian stelae. The famous stela of Naramsin is carved in limestone (*calcaire grésaux*) (Börker-Klähn 1982: no. 26) and an earlier, fragmentary one, excavated from Telloh, has been geologically identified as 'magnesian calcite micrite limestone' (Foster 1985; Skinner 1985).

The tradition of private votive or worshipper statues in stone is much less evident after the Early Dynastic period. What little has survived of private statuary in the Akkadian period continues to be generally of the softer light-coloured stones (Spycket 1981: 159 ff.), which were also sporadically still used for major, perhaps royal, statuary. An isolated male head, now in the Fogg Museum of Fine Art at Harvard, attributed to Kish, is in a distinctive black stone not geologically identified (Spycket 1981: 159 ff., pl. 106). In the north, where little is yet known of statuary in this period, a distinctive statue of a reclining human-headed bull, made of Mosul Marble with inlaid ivory eyes, was found in buildings of the Akkadian period at Tell Brak (Oates, J. 1991).

Of the local dynasties that re-emerged in Sumer following the collapse of the Akkadian Empire, that of Lagash (cf. Steinkeller 1988) is the best known in both the surviving textual and archaeological record. Here Ur-Bau was succeeded by three sons-in-law, among them Gudea, of whom more three-dimensional monumental stone images have survived than of any other Mesopotamian ruler. These minor rulers maintained the Akkadian kings' preference for statuary in dark stones. Stone was again obtained from *Magan* for royal statuary (Lambert and Tournay 1951: 60-1; cf. 1952: 78-9). However, this may not have been procured by military means, since Gudea's inscriptions only record booty from the towns of Anshan and Elam in Iran (*ibid.*). In the case of one statue in particular he reports that 'this statue has not been made from metal nor lapis lazuli, nor from copper nor from lead, nor yet from bronze; it is in *esi*-stone' (AO 2: Statue 'B': Lambert and Tournay 1951: 62-3), emphasizing the stone's importance. The rare surviving statues of the earliest recorded member of the dynasty, Ur-Bau, are unre-

markable statues in dark stones (Spycket 1981: 188–90, pl. 123). Study of the more varied statuary of Gudea himself is now complicated by unresolved debates about the authenticity of a number of examples (cf. Johansen 1978; Møller 1980; Spycket 1981: 190 ff.). This problem is particularly relevant here, since differences of stone are involved.

The primary find of Gudea statuary was made between 1878 and 1881 (cf. Parrot 1948: 16–19) in the main courtyard of a substantial building on mound 'A' (*Le Palais*) at Telloh (Girsu), on the site of Gudea's Temple, where they may have been reassembled during the reign of a later ruler, Adad-nadin-ahḫe, in the second century BC (Parrot 1948: 16, 155, 312): 'toutes ces statues sont en pierre dure, en diorite de couleur sombre, tirant légèrement sur le vert ou sur le bleu; toutes sont malheureusement décapitées; toutes, sauf une, portent des inscriptions au nom de Goudéa. Toutes ont été trouvées au-dessus du pavage de la cour, renversées sur le sol, mais formant deux groupes distincts: d'un côté, les statues debout, et de l'autre, les statues assises, comme si déjà autrefois on avait séparé ces deux séries' (Sarzec 1884–1912: 44; cf. Parrot 1948: 60 ff., nos. 1–13, 21–2; Johansen 1978: 29). There appears to be at least one exception to the statement that all the statues first excavated were of 'diorite', as a shaven head in the Louvre is in a speckled black-and-white stone (AO 12: Johansen 1978: pls. 47–9). Numerous fragments and chips of diorite heads and torsos were also found by de Sarzec in or below the Parthian 'palace'.

In 1925 Thureau-Dangin (1924: 97) reported 'la remarquable trouvaille faite au mois d'août 1924 à Tello, dans l'ancien champ de fouilles de Sarzec et de Cros. Les Arabes du voisinage, qui, au mépris de la loi sur les antiquités, fouillant librement le tell, y ont découvert un nombre encore mal connu de statuettes groupées assure-t-on, dans une même chambre' (cf. Johansen 1978: 18–19). It is this reported find that has long been regarded with suspicion. Some of the statuary attributed to this find is inscribed (Parrot 1948: 165, nos. 14–17, 19; cf. Alster, in Johansen 1978: 49 ff.). This second 'find' yielded statuary that is generally in soft stones: 'alabaster; steatite; dolerite'. As de Sarzec had earlier excavated statuary in soft stones at Telloh, this in itself does not offer any ground for suspicion, although the Telloh finds were largely of female statuary (Sarzec 1884–1912: pl. 22 bis: 3a–b, 24 bis: 2a–d, 25:2; Møller 1980; Spycket 1981: pls. 139–40), nor have the inscriptions been proved to be modern (Alster, in Johansen 1978; cf. Spycket 1981: 190n. 29). In this group the most unusual statuette is the 'Stoclet' Gudea, now in Detroit (Hansen 1988), remarkable for its small size (41 cm. high), youthful appearance, and material, a translucent green paragonite (cf. Spycket 1981: 190). As Møller (1980) has pointed out, care is necessary in

comparing work in hard stones with that in soft, since they require different techniques and tools. Although caution will always be advisable, particularly with uninscribed examples of Gudea statuary not from excavations, it is clear that his sculptors did not exclusively work in hard dark stones and that much, if not all, of the 1924 group of statuary may well be authentic.

Proper geological identification of the stones of Gudea's statues are still rare. Statue D (AO 1: Johansen 1978: 10–11) and an uninscribed standing statue (AO 19. 155; Amiet 1987) have been identified as 'microdiorite noire'; Statue A (AO 5) as gabbrodiorite (Johansen 1978: 8–9), like the Akkadian royal statuary that has been geologically identified (Amiet 1987: 170 n. 5). An art-market head in Boston, accepted as genuine, is 'green diorite with hornblende' (Johansen 1978: 26, pls. 92–3). A battered statue of Gudea from Tell Hammam, discovered by Loftus in 1850, and now in the British Museum, is of a 'uralite-quartz-dolerite, a subvolcanic intrusive igneous rock which has been slightly metamorphosed. Such rocks are common . . . in the adjacent (to Iraq) mountainous region of Iran and its continuation to the East' (BM 92988: Sollberger 1968: 142 n. 5; Johansen 1978: pl. 52). pl. 52). An unpublished fragment in the Louvre (AO 26647) is an 'equigranular quartz diorite' (Heimpel 1982: 66). The statue of Gudea's successor, Ur Ningirsu, shared by the Louvre (AO 9504) and the Metropolitan Museum of Art in New York, is described as being made of 'albâtre gypseuse (chlorite)' (Johansen 1978: 39; Spycket 1981: pl. 131).

As has already been noted, Gudea's inscriptions attribute the *esi*-stone used for much of his statuary to *Magan* (cf. Pettinato 1972: 137 n. 818). It is hardly surprising that diorite and olivine-gabbro should have been mistaken one for the other when described by eye in antiquity, as they still are today. Diorite (and dolerite) occurs in Oman (cf. Heimpel 1982: 67 n. 23; Hauptmann 1985: 17, figs. 5, 6), part at least of ancient *Magan*. Heimpel (1982: 67; cf. 1987: 69–70; Potts, D. 1990: 143) reports a geologist as saying that the Omani blocks of diorite are too small for the Gudea statuary, suggesting instead a source for the stone on the Iranian side of the Gulf some 50 miles north-north-west of Bandar Abbas. As more than one source of diorite occurs in the geological literature of Oman, it may hardly be ruled out at this stage on such an argument. Now that it is generally accepted that parts of Iran may well have been included with Oman in ancient use of the term *Magan*, the location of the diorite source exploited there by Gudea remains open to further investigation on the ground.

It is instructive to see how the types of stone used by Gudea for his statuary to some extent correlate with their relative date. On Steible's (forthcoming) chronology the oldest (Statues M, N, O,) are relatively small,

bear dedications to the Sumerian goddess Geshtinanna, and are carved from a variety of stones. The middle group (I, P, Q) are again small-scale, but in diorite and dolerite, and are dedicated to Gudea's tutelary god Ningishzida. The most recent (A–H, K) are large, even life-size or more, are sculpted in diorite, and have dedications to Ningirsu and other leading gods of Lagash. They probably mark the most successful phase of stone procurement from *Magan*.

The hard dark igneous and metamorphic rocks remained popular in the royal workshops of the Ur III period both for male and for female statuary to judge from the statuary of Shulgi and anonymous pieces (cf. Spycket 1981: 203 ff.). A fragmentary inscribed statue of Shulgi, now in New York, has been identified as basic hornfels, a mottled black stone (Civil and Zettler 1989: 65). Calcite and limestone, as in the preceding periods, were used for the monumental basins and large commemorative stelae in temples that were a significant aspect of religious furniture at this time (Börker-Klähn 1982: nos. 35–96, 100; Moortgat 1969: pls. 186, 188). At Telloh calcite was used for a pair of recumbent goats whose function is unknown (Spycket 1981: 222–3, pl. 149), whilst limestone was used for male statuary at Uruk (Nöldeke *et al.* 1938: pl. 28; cf. Spycket 1981: 207–8).

Supply lines down the Euphrates from Syria most probably account for the use of basalt at Mari, for the statue of a local governor in the Ur III period (Parrot 1959: 1 ff., figs. 1–2), as also at Eridu. There a pair of lions sitting upright on their haunches to a height of 1 m. 65 cm., carved in basalt, may once have flanked a temple entrance (Safar *et al.* 1981: 242 ff., figs. 120–1; Spycket 1981: 222, pl. 148). At a time when steatite was used for carved stone vessels and for bison-shaped supports or stands (Amiet 1977: pls. 399 ff.), it is hardly surprising that it was also used both for complete statues and for parts of composite statuary. An unusual standing figure of a king, identified as Shulgi, from Telloh may have been designed as a statue specifically to be carried in processions (cf. Spycket 1981: 206, pl. 141). Relief sculptures from the same site were also cut in this soft stone (cf. Amiet 1977: pl. 396). A model of a female wig dedicated by an official to the goddess Lama for the life of Shulgi may be carved in steatite rather than 'diorite' as published (BM 91075; Wiseman 1960: 168, pl. XXIIb; Parrot 1948: 221, fig. 46f).

By comparison with what went before and what was to come later, the second millennium BC is a time of isolated survivors, or groups of monuments like the Kassite *kudurrus*, which offer little information on the general use of stone in sculpture. There is nothing comparable to the multiplicity of worshipper statues in Early Dynastic II–III and very little indication that stone was used for sculpture outside the workshops of major palaces and temples. Here the pattern of use in

the final quarter of the third millennium is repeated in the first half of the new millennium with diorite alternating with limestone (cf. Schlossmann 1978–9; 1981–2), whilst at sites like Mari on the Euphrates, with direct access to the rocks of Syria, the variety of stone used for sculpture appears to have been greater than it was in heartland Babylonia.

At Mari diorite and 'pierre schistouse' are used for the impressive large statues of rulers (Parrot 1959: 14 ff., figs. 10–12); on a smaller scale steatite was employed (ibid.: 16 ff., figs. 13 ff., pls. IX–XI). A rare surviving statue of a goddess from the palace at Mari is carved in a fine white limestone, as are some other sculptures (ibid.: 5 ff., pls. IV–VI); small heads, male and female, are in calcite (ibid.: 11 ff., pls. VII–XIII), whilst gypsum (sometimes the coloured variants) was in use for stelae or statuary (ibid.: 23 ff.). As earlier at Mari, basalt, very rarely encountered in Babylonia, was used for statuary (ibid.: 25–6). A stela, perhaps of Shamshi-Adad I, from Mardin, now in the Louvre, is also of basalt (Börker-Klähn 1982: no. 111), clearly the preferred hard dark stone in royal workshops in Syria, where it was readily available.

At Eshnunna east of Babylon, diorite and limestone appear for major statuary (Spycket 1981: pls. 161–3, 165); an isolated 'royal' statue from Larsa is in limestone (Spycket 1981: pl. 164), whilst a Babylonian king's head found at Susa is in diorite (ibid.: pl. 168). The renowned stela of Hammurabi inscribed with his law code is on a piece of diorite 2 m. 25 cm. high; two less impressive stelae also recovered from Susa, and in part recut by Elamite masons, are again of diorite (or possibly of basalt) (Börker-Klähn 1982: nos. 113–15). A fragmentary stela of the time of Hammurabi, inscribed by a minor ruler, is in limestone (Börker-Klähn 1982: no. 112), whilst Samsuiluna records setting up a stela in calcite (*gishnugallu*) weighing 84 talents (*CAD* 'G': 105). A very rare survivor is the lower part of a tiny statuette of a seated man carved in agate and inscribed with the name of Amar-Sin of Isin (2 cm. high) (Weidner 1927).

In so far as it is possible to judge from fragmentary statues of Kurigalzu I or II, the Kassite kings also alternated in their use of hard dark stone, perhaps diorite from the Gulf, and limestone (Brinkman 1976: Q:2:2:209–10; Q:2:3:210; Q:2:4:210–11; Spycket 1981: 294–5). A complementary pair of temple relief stelae, each showing a single minor goddess, from Uruk are carved in limestone (Börker-Klähn 1982: nos. 118–9), the stone most recurrent there. But the most distinctive aspect of the Kassite repertory in stone is the occurrence of numerous *kudurrus*, generally boulders, recording land grants. They were designed to be placed in temples as perpetual records of such grants under protection of the gods. This large-scale use of stone for such a purpose is unprecedented in Babylonia and was

not to be sustained, though there is a much more restricted series of post-Kassite monuments of this type. The standard of execution of these monuments varies greatly. Unfortunately, all the published identifications of stone are by eye. In her catalogue of 110 relief *kudurrus* Seidl (1968) listed 88 as limestone, 4 as diorite, and 1 as pink granite, with 17 undocumented in this respect. When recorded the limestone is either light-coloured (24 examples) or dark (48 examples). This is an unprecedented use of dark limestone in the Mesopotamian plain outside Susiana, where it had always been a popular contrast with light-coloured stones. It would appear that it was procured from a source in the Zagros for this specific purpose (Seidl 1968: 68–9; Schüller 1963: 18; Morgan 1900: 46 ff.). A scarp of black limestone is reported in the Zagros foothills to the north-east of Halabja, close to the upper reaches of the Diyala river (Williams 1981: 313). Its use in Kassite times for boundary stones may be an aspect of their political penetration to the headwaters of the Diyala and into other parts of the central Zagros region.

As some diorite was still being employed for fine royal statuary, its occasional use for the more expertly carved *kudurrus* is hardly surprising. Granite is so rarely recorded in Mesopotamia that any appearance is notable, as in the case of a *kudurru* from Nippur (Hilprecht 1893: 54, pl. XII. 32–3). At Ur 'granite' was recorded for an Ur-Nanshe stela (Early Dynastic III), a macehead and beads that may be Kassite, and a cup inscribed both for Naram-Sin and Shulgi (Woolley 1956: 46, pl. 39 U.17829, 1965: 105; pl. 37 U.7516, 107 U.17898; 1976: 223, U.6355). If the identifications are correct, and none is geologically secure, a source in the Zagros would again be most plausible (as Seidl 1968: 69), perhaps at the head of one of the rivers flowing into the plain.

Carter (1970; cf. Spycket 1981: 301 ff.) has assembled a group of very crude statues, both of men and of women, represented by finds from sites as far apart as Tell Billah in Assyria and Megiddo in Palestine, in the Late Bronze Age. In the manufacture of these statuettes, perhaps ancestor stelae rather than deities, basalt and dark volcanic stones were preferred in those regions, primarily in modern Syria, where they were easily accessible for primitive sculptures of this type. At Tells Rimah and Billah calcite, limestone, and sandstone were used, presumably since the darker stones were not so readily available there. At Tell Rimah two such statuettes, one male, one female, were excavated from the temple complex of the fourteenth to thirteenth centuries BC (Carter, T. H. 1965: 66–7; Oates, D. 1965: 74, 77, pl. XXa) and there is no reason to doubt that the Billah examples were contemporary. Hardly less crude in conception and execution are a limestone seated figure and part of a basalt head from the area of the 'Mitannian Palace' at Brak, probably to be dated

to the fourteenth or thirteenth century BC (Oates, D. 1987: pls. XLlc, XLIII).

As the use of stone for sculpture in Assyria is so intimately linked in the surviving material record with building—indeed it has been referred to as 'architectural sculpture' (Moortgat 1969: 130–1)—the range of stones employed is discussed here in the building section (p. 341 ff.). The techniques of Neo-Assyrian sculptors are, however, treated in the appropriate part of this chapter.

Virtually nothing is known of stone sculpture at Babylon and other southern cities after the Kassite period, save for a few *kudurrus* which continue the previous tradition of light and dark limestone. It is likely that much sculptural work of this period, long since perished, was in painted terracotta or glazed moulded bricks. The most famous sculpture from Babylon is the colossal lion still to be seen there. This monumental basalt statue of a lion trampling a man (c. 1.95 m. high, 2.6 m. long) was uncovered by the Fresnel Expedition in 1852. It is generally considered to have been imported ready-made from a workshop in Syria, where this stone and the motif (in carved ivory) indicate a probable date of manufacture in the ninth to eighth centuries BC (Spycket 1981: 431–3, pl. 282). It has recently been suggested that this sculpture is a product of the Kushite period (Dynasty XXV) in Egypt (751–656 BC), taken to Nineveh by Esarhaddon about 671 BC and thence to Babylon by Nebuchadnezzar II (Moser 1984). The argument is not compelling and production somewhere in Syria still seems more probable (Tomandl 1986). As seen today the sculpture appears unfinished, but it is possible that it was designed to have either a plastered surface, upon which details would have been painted, or possibly metal overlays.

Koldewey (1931–2: 21 ff., pl. 18) found many fragments of bulls and lions carved in basalt during his excavations at Babylon, but whether they were of Neo-Babylonian or Achaemenid date, of local or foreign manufacture, remains debatable. In this case, unlike that of the monumental lion, art-historical criteria may more convincingly be used to argue for import of basalt to Babylon down the Euphrates from Syria for production in local workshops. That basalt and dolerite were carved at Babylon in the Achaemenid period is evident from the fragmentary reliefs and inscriptions, which Seidl has sought to reconstruct as part of a copy of the rock relief carved to the order of Darius I at Behistun (Seidl 1976; Roaf 1983: 131 n. 114 is sceptical; for Achaemenid animal sculpture see Kawami 1986).

(ii) SCULPTORS AT WORK

Stoneworking has been studied in detail in ancient Egypt (Clarke and Engelbach 1930; Harris 1961: 48–79; Arnold 1991) and in the Greek world (Adam 1966

with bibliography); but there is hardly any literature at all on the subject in the Near East before the Achaemenid period, for which there are major studies relating to Pasargadae and Persepolis (Tilia 1968; Nylander 1970, 1990; Roaf 1983). Although studies of the subject-matter and composition of Neo-Assyrian reliefs proliferate, techniques of production have been largely ignored save in very general surveys (cf. Reade 1979). Neglect of the subject of stoneworking is to be explained in part by the general absence of fine stoneworking on Mesopotamian sites until an advanced date in the Neo-Assyrian period and by an almost total absence of direct evidence for stone workshops and stoneworking tools in all periods. The methods of sculptors have consequently to be deduced, where possible, from the study of finished monuments and those isolated unfinished pieces so far found outside workshops. Consequently, the following concise review may do little more than indicate where and how the most pertinent questions might be pursued in future (cf., in general, Waelkens (ed.) 1990).

(a) Workplaces and quarries

The specialist tools of sculptors, in stone, copper alloys, and iron, have not yet been identified in this region before Achaemenid times; in some cases appropriate tools exist, but they may not be directly associated with the craft since they were not recovered from sculptors' workshops. In the preliminary report of the 1932–3 excavations at Khafajah, Frankfort (*et al.* 1934: 73) described as a sculptor's workshop what was later recognized to be part of the so-called 'Nintu Temple' (Q.45:4) (Delougaz 1942: 94 ff.). The objects found there illustrate the value of sculpture, whether complete, broken, or unfinished, in Early Dynastic Mesopotamia. Indeed, this is one of the largest hoards of sculpture yet found in a temple, including various unfinished parts, evidently intended to be dovetailed on to a broken original in order to replace a damaged face or beard or hand. As a hoard these unfinished sculptures have to be assessed, inevitably inadequately, away from the original workshop (Frankfort 1939: 39). Another context at Khafajah is also sufficiently anomalous for it to have been identified as either 'a priest's or temple stonemason's house on the basis of its large size, regular plan, location and the presence of stoneworking tools, maceheads, and other religious items' (Henrickson, E. F. 1981: 70; 1982: 18). Although still not published in detail, the copper alloy tools found there are listed as a needle, two pins, and a spearhead, so there is nothing to support the idea that there was a sculptor's workshop in the area.

It is not until the Neo-Assyrian period that it is possible to establish what, if anything, was done in the quarry before the stone was transported to the place where it was to be finished. When almost all the earlier

evidence is from southern Mesopotamia this is not surprising, as quarries were so far away from the palaces and temples where the sculpture was to be installed. Indeed, it is likely that stone procurement for sculpture from quarries was such a restricted activity even for kings, until the first millennium BC, that it merited special mention in building inscriptions or the naming of royal years after such an enterprise: 'The year Sam-suiluna the king (had them quarry a stone) from the great mountain of Amurru, 1½ rods, 4 cubits, 10 (inches) on a side' (Greengus 1979: 35). To a degree that is hard to establish, Sumerian sculptors were recurrently restricted not only by the quality of the stone regularly available to them but also by the size of the stones. A significant proportion of what they had was probably provided by boulders. As Heuzey (1885: 123) long ago pointed out, in relation to the hard dark stones specially obtained from afar, the use of eroded boulders is especially apparent for inscribed door-sockets and may often be observed on Gudea's statuary:

En effet, si le poli des statues est dû au travail humain, celui des *pierres de seuil*, qui ont conservé leur forme primitive, et qui étaient destinées à être enfouies sous le sol, est évidemment naturel; il montre bien que la roche n'a pas été exploitée avec le pic dans la carrière. Du reste, les statues, dans la partie non travaillée de leur base, qui accuse encore la forme du bloc roulé, ont aussi le même poli naturel.

At Telloh in Early Dynastic III small, perhaps river-worn, boulders were used for royal inscriptions to commemorate canal digging (Cooper 1986: La 3.5–6) and building activity (Cooper 1986: La 3.7, 4.10, 5.27). Some are certainly from foundation deposits, some may be votive grinding stones.

Stone of any kind was clearly scarce and generally available only in relatively small blocks. 'The rarity of stone in Mesopotamia made it imperative for the Mesopotamian sculptors to resort to patchwork when they had bungled, while a similar misfortune would have caused their Nilotic colleagues to abandon the piece and start anew; for stone patchwork is well-nigh unknown in Egypt' (Frankfort 1939: 39). The statue of one of the highest ranking priests from the Inanna Temple at Nippur is composed of the fragments of another statue (Hansen and Dales 1962: 80).

Even before the Neo-Assyrian period it is likely that quarried stone was more often used in the north, where it was available close to waterways for transport; but it is only with the appearance of large programmes of relief sculpture in the first millennium BC that the sculptures themselves indicate something of production methods. Even then, although it is clear that colossal three-dimensional sculptures were roughed out in the quarry, it is likely that little if any relief sculpture was worked there. Sennacherib recorded that he had 'mountaineers wield iron axes and pickaxes (and they

rough-hewed *aladlammû* figures for the gates of my palace' (CAD 'Q': 299). Esarhaddon ordered the transport, for his palace at Nineveh, 'from their quarries (literally "place of creation") in the mountains statues of protective deities' (Oppenheim 1969: 291). Although no quarry has yet been located that still contains incomplete Neo-Assyrian colossi, unfinished survivors are known from quarries exploited in the first half of the first millennium BC by local rulers in the south-east of Anatolia at Yesemek (Alkim 1960) and Sikizlar (Mazzoni 1986-7; cf. Waelkens 1990).

A series of sculptures in Court VI (slabs 66-8: east wall) of Sennacherib's Palace at Nineveh show the quarrying of Mosul Marble and the transport both of slabs and of roughed-out sculptures by land from the quarries at Balatai (Eski Mosul) (cf. Reade 1990; Russell 1985: 126-39). The quarry scene illustrates the extraction of a block of stone, to be carved into a colossus, with iron pickaxes of two types (Layard 1853^a: pl. 14; Strommenger 1964^a: pl. 233; Reade 1983: fig. 4). A group of men among those who accompany the roughcut human-headed bull colossus as it is transported overland by sledge carry saw-blades, shovels, and pickaxes, presumably the tools used in the quarry (Layard 1853^a: pl. 12) (PLATE IIIB). Specialist pickaxes may not be specifically identified among surviving iron tools, but stonemasons' iron saws may since the teeth are not set as they would be for cutting wood. Examples are known from Nimrud (Layard 1853^a: 195; Oates, D. 1962: 17).

The king himself is shown supervising the removal of the colossus, laid on its side, on a sledge pulled from the front up a slope. Behind the sledge, another group of men insert a large lever under the curved end of the sledge, then secure the lever with a wedge. It appears as if the sledge was moved forward in a series of jerks. The exact relation of this activity to the watercourse with shadoofs shown on the lower edge is unknown (cf. Reade 1978: 57-8), though it seems to be generally accepted that it has something to do with moving the colossus and is not simply a background irrigation scene. At the end of this sequence (Layard 1853^a: pl. 16) a colossus is shown upright on a sledge, supported and balanced with slabs of stone(?), drawn again by rows of men in front and levered from behind. Logs act as bearings for the sledge to move over. In the same scene plain slabs are moved packed on to wagons supported, or cushioned, by coils of rope. It is likely that they were unsculptured, since such stacking would have damaged reliefs. Alongside this land transport of the colossus the reliefs show coracles carrying objects, perhaps of stone, and rafts of timber on a river assumed to be the Tigris. Transport of such huge sculptures on rafts by water was hazardous and may only have been possible at the time of the spring floods when there was sufficient water in the Tigris.

On a relief from Court XLIX of Sennacherib's Palace, distinct from the previous series, a large object with ropes passed through its top is shown being moved on a raft; it is not clear whether it is an object of stone or wood (Layard 1853^a: pls. 10-11; cf. Reade 1978: 60), though the former seems more likely. Texts record that the fossiliferous limestone (*pindû*-stone) sphinxes, at the entrance to Room XXXIII of Sennacherib's Palace, were floated down the Tigris on rafts from the Judi Dagh (Luckenbill 1924: 127); but there are no published illustrations of this on the reliefs.

In studying Sennacherib's canal and related waterworks at Jerwan, Jacobsen and Lloyd (1935: 13) proposed that 'there occurred to the canal-builders the simple expedient of transporting their materials, particularly stone for aqueducts and other structures (from the quarry at Bavian), over the level bed of the part of the canal which was already completed. If the blocks of stone were moved on wooden rollers or trucks, a fairly even surface would have been necessary, which is precisely what we find in the pavement of the aqueduct.' On the pavement of Court XXVII at Khorsabad several blocks of stone were found 'lying in the courtyard awaiting their final places in the pavement of interior rooms. Remains of timber, the lengths laid upon the pavement parallel to one another (fig. 114) where a large number of blocks were found, suggests skids upon which they were moved' (Loud 1936: 108).

A limestone winged bull found at Nineveh (Nebi Yunus) in 1986 appears to have been brought from Khorsabad, where it had never been finished, by Sennacherib for his new buildings in Nineveh. Uniquely it is made of limestone blocks of varying size, mostly cubes about 0.5 m. long, rather than being cut from a single block. Although roughly shaped winged bulls were transported from quarries as monoliths, it appears that finished or more nearly finished examples were moved from one palace to another at a distance after being cut up into more manageable pieces (cf. Scott and Mac Ginnis 1990: 71).

Masons' debris round the base of the colossi in Sargon's Palace at Khorsabad shows that the carving was finished once they had been set in position. In the same palace removal of carved orthostats from their setting for transport to Baghdad and Chicago by the American excavators proved instructive: 'the slabs were backed and supported by a rough stone filling, indicating that they had been set in position before the surrounding walls were erected. This would seem offhand to be a reverse procedure, but when one considers the size and weight of these slabs it becomes evident that it would be a simpler task to build brick walls around standing slabs than to move without damage several tons of finely sculptured stone into place inside a comparatively small room. The stone slabs were thus probably first set

up and then carved on front and back. In this instance a long inscription covered the back of the slabs' (Loud 1936: 79). The bases of the slabs rested on a bitumen surface that allowed them to be adjusted. When in place they were fastened together, and perhaps sometimes to the wall behind, with metal (lead) clamps.

(b) The sculptors' methods

Unfinished Early Dynastic statues (cf. Frankfort 1939: pl. 93) appear first to have been crudely outlined on the outside of a roughly rectangular block of stone before the sculptor began working round the edges of the stone, cutting out spaces like that between skirt and base, or removing superfluous stone round the head. There is no sign of cutting into a block from four sides, each gridded, as in the ancient Egyptian manner. Even facial features appear to have been very crudely roughed out from simple guide lines and then dressed down (cf. Frankfort 1939: pl. 94F, 1). Eyes were either cut as cavities for inlay in other materials, carved, or rough-cut for details to be painted in (Frankfort 1939: pl. 87E, F). It is likely

that the fine polished surface of statues in calcite was not painted, but it is an open question how far the surfaces of statues in inferior stones were plastered and painted or just painted or overlaid.

Breakages in manufacture were not uncommon and repairs are often evident. They were sometimes carried out in the crudest fashion, as if the magic significance of the complete statue was of more importance than any aesthetic effect. The technique of cutting arms and legs free greatly increased the potential for breakage, especially in the soft and often faulty stone most regularly employed in Early Dynastic times. A great many of these statues broke off at the ankles. However, the presence of dowel and drill holes does not necessarily imply secondary or repair work, since they were, at times, evidently part of the original construction of the sculpture. This may be seen most clearly when the top of the head has been cut about or drilled to fit a head-dress or wig.

No unfinished statues have been published for the long period from c.2350 BC to 700 BC. In this period the

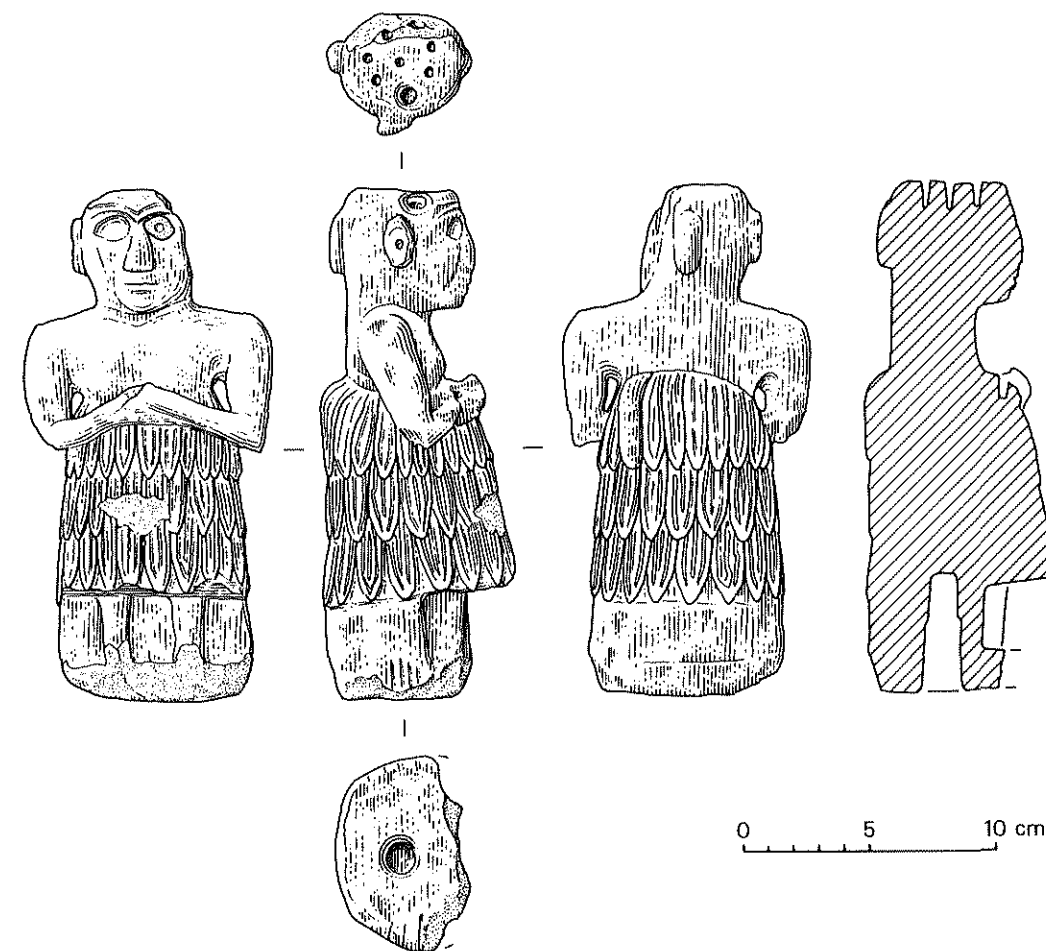


Fig. 4. Limestone statuette of a man, c.2500 BC, with holes in the head to fit a headdress or wig (20 cm. high; from Istabalat near Samarra).

regular use of the hard dark stones prized for the lustrous effect possible through polishing them with abrasives has meant that possible traces of working practices on the surface have been largely eliminated. Nor have any of these statues been subjected to the minute examination now regularly applied to establishing the working practices and tools of seal-cutters (see Chapter 2 here).

The only accessible unfinished sculpture of the Neo-Assyrian period, other than reliefs, is something of an enigma. At Khorsabad among the packing behind the sculptured relief slabs in Room 7 of Sargon's Palace was a three-fourths life-size head of a man in relief roughly cut in limestone. 'The sculptor could never have intended its completion, for the stone is not large enough to accommodate the other side of the face. But the freedom and spontaneity found in the modeling and carving of this small head are indeed rare in the official sculpture of the period . . .' (Loud 1936: 79, fig. 90; Strommenger 1970: 24; Spycket 1981: 368, pl. 238). A rather battered royal statue in basalt from Assur, of the ninth or eighth century BC, may also be unfinished (cf. Strommenger 1970: AX2, 26, pl. 15c-d; cf. in finished form *ibid.*: pl. 6a), unless it was designed to be plated with gold, as Neo-Assyrian texts indicate was sometimes the case (cf. Dalley and Postgate 1984: no. 95).

The small, often crude reliefs of Early Dynastic times established a pattern of workmanship that changed little thereafter: 'relief in the ancient Near East is simply glorified drawing, made more clear and permanent by being set in stone. The figures are to all intents and purposes flat, and their contour is formed by a vertical edge. Thus the figures are left standing as essentially flat designs with background cut away' (Frankfort 1939: 43; Boese 1971). Direct evidence for the procedures used in carving reliefs at any time, including the Neo-Assyrian period (see below), is virtually non-existent. Modern reconstructions are consequently deduced from the existing, usually finished, reliefs. At all periods stock motifs were constantly repeated as if they were copied from each other or from some kind of pattern-book, though no tablets convincingly identified as such have yet been published.

It has been suggested by Madhloom (1970: 122) that scenes on Assyrian reliefs showing two men, one with a tablet, one with a scroll, recording an incident apparently from dictation (cf. Reade 1983: pl. 45), do not depict two scribes, the one writing Akkadian, the other Aramaic, as is commonly said. The scroll, Madhloom argued, is being used by a draughtsman ('war artist') to record the scene for later use in designing reliefs. The suggestion is attractive; but remains wholly conjectural in the absence of supporting evidence. The only representations of Assyrian sculptors at work are those on the bronze covering of the great wooden doors com-

missioned by Shalmaneser III at Balawat. They show the carving on a rock face of a commemorative inscription and a stela marking this ruler's visit to the sources of the Tigris (Reade 1979: pl. 1a) (PLATE IIIA). Three men are involved in the scene where the inscription is cut: a supervisor in court dress; another man in court dress with stylus and tablet, who has clearly composed the inscription; a third man, the mason in a kilt, who actually cuts the cuneiform on the rock face with hammer and chisel. In a lower scene a mason, again taking instruction from a courtier, is shown cutting the stela portraying the King.

A letter sent to Ashurbanipal (c.668-626 BC) indicates that designs for reliefs were first drawn up in outline and then inspected and approved by the king before final carving (Paley 1976: 8; cf. Waterman 1930: ii, no. 991 + 1051, pp. 187 and 233). There is remarkably little surviving evidence for preliminary sketches. A letter of the late eighth century BC addressed to the Assyrian king has been read to show that scribes 'designed' images of the king; but it will not bear this interpretation (K.652: Harper's translation in Waterman 1930: i. 102-3, letter 151; S. Dalley: personal communication).

Although a number of Neo-Assyrian clay and stone objects have been described as sculptors' models, this identification is not self-evident. The best-known clay objects, three reliefs on a small scale closely matching the major palace sculptures in stone, are finished to a remarkably high degree of precision in their surface detail for trial-pieces or models (Moortgat 1969: pls. 226-8; Hall 1928a, pl. LVII) (PLATE IVB). Two are from Assur, one from Nineveh, but nothing is known of their precise context to assess whether it is likely to have been a sculptor's workplace. Two small-scale limestone column-bases set on the backs of sphinxes, despite their size, may have been objects in their own right rather than models from which monumental versions were made (Hall 1928a, pl. LVIII, lower, from Nimrud and Nineveh). Nor is it clear that unbaked or unpainted terracottas were in some cases models, since some at least of the clay figurines placed in votive deposits were traditionally unbaked and paint was so fugitive as to make its presence or absence a hazardous criterion. Indeed, the distinction between sun-dried or unbaked and kiln-fired clay may only be properly made on the basis of laboratory tests.

How the teams of sculptors worked is not known. No mason's marks have been identified on Assyrian palace reliefs that might allow for the kind of analysis permitted by their occurrence at Persepolis (cf. Roaf 1983). The quality of work even on the same slab may vary and mistakes sometimes remain very evident (cf. Reade 1979: pl. 1b; 1983: 16). It is still difficult to proceed further than Layard did in his succinct comment on the use of teams of masons: 'the work of

different artists may be plainly traced in the Assyrian edifices. Frequently where the outline is spirited and correct, and the ornaments designed with considerable taste, the execution is defective or coarse; evidently showing, that whilst the subject was drawn by a master, the carving of the stone had been intrusted to an inferior workman. In many sculptures some parts are more highly finished than others, as if they had been retouched by an experienced sculptor . . . It is rare to find an entire bas-relief equally well executed in all its parts' (Layard 1849: ii. 78). In one case where two versions of the same scene exist—the death of Ituni in Ashurbanipal's Elamite campaign—the later sculptor used the same central motif, but revised the landscape setting, possibly indicating a degree of individual freedom at that level (Reade 1978: 25, pl. 2a,b).

As these reliefs are two-dimensional drawings rendered in relief which is generally very low and often flat, without rendition of spatial depth, it is likely that their execution was influenced from the outset by the techniques of wall-painting already well developed before such friezes first appeared in the second quarter of the ninth century BC (Moortgat 1969: 130-1). The design would be sketched in, in ink, then the background cut away; surface detail would then be incised and cut shallow. It is on the colossi that some of the most sensitive engraved detail is to be found (Frankfort 1970: 154). It is hard to sustain Canby's (1971) hypothesis that the unusually elaborate rendering of embroidered designs on garments, in incised line, in the reign of Assurnasirpal II was the work of foreign craftsmen, supervised by Assyrian sculptors. They may more appropriately be related to the techniques of drawing in wall-painting and glazed mural friezes in the preceding reign of Tukulti-Ninurta II (cf. Reade 1983: pls. 18, 41) or to contemporary incised designs on Neo-Assyrian ivories (Mallowan and Davies 1970). There is evidence in Sennacherib's Palace at Nineveh that a late ruler sometimes had his predecessor's orthostats modified and recut, often with sharp juxtapositions of scene (cf. Reade 1983: 41, fig. 58).

The close relationship of painter and sculptor is emphasized by the use of applied colour on the reliefs. This is readily evident in scattered instances, and was first recorded by Layard (1849: ii. 306); but it is not clear whether paint was only used selectively for special effect or whether it was more extensively used than the present state of surviving reliefs indicates (for the same problem at Persepolis, cf. Tilia 1978: 31-69; Roaf 1983: 8). There is no evidence for coloured inlays save in the rare case of inlaid eyes (now lost) in colossi at Assur (Andrae and Preusser 1955: 27, pl. 23).

Inscriptions which in any way reveal contemporary assessments of the artistic quality of sculpture are so rare that the closing phrases of an inscription of Shalmaneser III on a statue of himself intended for

Kurba'il, but found awaiting repair at Nimrud, are particularly striking: 'So that my lord Adad may be pleased whenever he is moved to look at it, I have made this statue of polished, shining, precious alabaster (*gishnugallu*), whose artistic features are most beautiful to see' (Kinner Wilson 1962: lines 36-7). The stone has not been identified by a specialist and is variously described as calcite or limestone. Black paint was only visible on the hair, beard, and necklace, suggesting, as the inscription implies, that only parts were painted and much of the original stone surface was visible. Beauty was generally identified by the Assyrians with the opulence of the materials used (Garelli 1990).

No fragment of sculpture in the round nor any partially finished relief or wall-painting has yet been found marked up with grid-lines which might indicate how figures were laid out and whether a standard system of proportion was in use. It is, however, widely assumed that artisans were trained to depict the human body according to certain proportions. The Babylonian tradition has been sought through investigation of the statuary of Gudea. Azarpay (1990) has used his late life-size statuary in diorite as a test case. On the basis of a cubit of 24 fingers shown on the tablet held by Gudea 'as architect' on seated statues B and F, she argues that 'measured against Gudea's cubit of 24 fingers, a composite of the three standing statues of Gudea (Louvre A and E; BM 122910) shows that the overall height of the figure may be expressed in six multiples of the length of the forearm' (Azarpay 1990: 663, fig. 1). In this system the image appears to have been conceived as tiers of six superimposed blocks or units with 1:6 ratio of head to total height. However, this is modified in Gudea's smaller statuary (1:5 and 1:4), possibly to avoid reducing the integrity of valuable imported blocks of stone. As there is no surviving monumental relief sculpture from Babylonia in stone suitable for comparable examination, the general validity of these conclusions may not be tested there.

Such evidence is, however, available in Neo-Assyrian palaces. Robins (1990), an expert on Egyptian systems of proportion, has analysed some standing figures in the North-West Palace of Assurnasirpal II at Nimrud on hypothetical grids. In contrast to the Egyptian practice, in which figures were lined up so that the key points of each were on the same level, the Neo-Assyrian sculptors placed their figures so that they reached the top of the orthostat irrespective of whether they were wearing a headdress or not. In a row of figures the heights will be different and eye-levels will not line up. 'The fact that in my 15-square analysis the modes so often fall on grid lines suggests that in the model governing bodily proportions that I have postulated, the Assyrians themselves may have employed units relating to fifteenths of the eye-height, in conformity perhaps with a sexagesimal counting system'

(Robins 1990: 116). Robins (1987–8) has pointed out that Azarpay's (*et al.* 1987) interpretation of the proportions of the archers depicted in glazed brick at Susa in the Achaemenid period and those of the statue of Darius I, also found there but made in Egypt according to the inscription, cannot be sustained as a correct assessment, leaving the question of the canon of proportion used by the Achaemenids still open (cf. Roaf 1983: 97 ff.).

The end of this consideration of the technology of stone sculpture is the best point at which to call attention to a ubiquitous aspect of Mesopotamian crafts easily overlooked as it survives only in the textual evidence and then usually only in respect of divine and royal statuary. Mesopotamian craft activity was almost certainly permeated by rituals; success in manufacture—often described in terms of gestation and birth—was a gift of the gods whose favour was invoked in the appropriate manner. Although it is only the more elaborate rites for animating and installing statuary that have generally survived in texts (cf. Winter 1992), the pattern of ethnographic comparisons indicates that craftsmen in all levels of society would have practised the rites thought to ensure success in their work, often under the aegis of a deity peculiar to their craft and by no means only for artefacts created for the service of the gods.

3. Stone Vessel Manufacture

As there has not yet been a systematic study of any aspect of the stone vessel industry in Mesopotamia, this section treats the evidence in sequence from earliest times, with a separate section on manufacture. The archaeological evidence reveals distinct patterns in the use of stone for vessels. The prehistoric tradition, evident in the earliest settled communities before the use of pottery, exploited predominantly local stone resources within a restricted range of shapes, but was capable of remarkable productivity and skill, as at Bouqras and Tell es-Sawwan, where suitable soft stones were readily available. Evidence for stone bowls in heartland Sumer is rare until their appearance in the temple complexes at Uruk from the middle of the fourth millennium BC. This is, however, clearly a special case, with conspicuous consumption reflected in the range of stones employed (some very unusual), in the variety of decorative techniques, and in occasional vessels of exceptional size. This is the first clear indication of a luxury industry servicing the gods, whereas earlier stone vessels had been, to a greater or lesser degree, standard items of domestic equipment. Never again, it appears, were stone vessels to be quite so varied and, at times, so spectacular as in the final centuries of the fourth millennium BC.

In the third millennium BC the industry is represented, at least until the Akkadian period, wherever graves have been excavated, outstandingly at Ur in a sequence which spans virtually the whole millennium. The evidence from temples is at times equally rich; but not from private houses, where more basic stone containers, pestles and mortars, querns and sherds of vessels, predominate. In the past scant attention has been paid to undecorated and uninscribed stone sherds in excavation reports; but wherever funerary evidence is available for the Early Dynastic period stone vessels were regularly placed in graves with high concentrations, particularly when combined with fine quality of manufacture, indicating wealth and status. The peak of their popularity appears at present to fall in the second quarter of the third millennium BC.

By the end of Early Dynastic III it is clear that domestic use of stone vessels, if that is what their presence in graves may be taken to indicate, was in gradual eclipse. By the Akkadian period their disappearance had accelerated. Thereafter, in homes and graves, there are few stone vessels and what there are seem either to have been cosmetic containers or vessels for grinding and pulverizing. The dedication of inscribed vessels in temples is first evident in Early Dynastic II and endured, if intermittently, through to the Achaemenid period. It is likely that a far higher proportion of these vessels, by definition the finer examples of the genre, were booty or tribute from foreign sources. As Potts (T. F. 1989: 143) has argued, 'stone vessels were not imported into Mesopotamia to fill a gap in local production; both plain and decorated forms were made in Sumer throughout the third millennium exploiting the local supplies of calcium-based stones. The attraction of foreign vessels depended rather on the aesthetic appeal of their harder, darker stones and especially on what might be called generally their exoticism.' As these vessels are largely known only from fragments, their proper study is difficult. The difficulty is compounded by the fact that they are usually published simply for their inscription or decoration with little or no attention to their form or material. After the third millennium BC, when distinctive types of stone vessels do appear in Mesopotamia, they are usually closed shapes designed as containers for precious liquids or pastes, normally made in a restricted range of stones. The Neo-Assyrian court may have had table services in stone as varied and colourful as those evident at Persepolis in the time of the Achaemenid kings; but only isolated clues can be traced in the existing archaeological reports.

(i) CONCISE NOTES ON THE STONES USED FOR VESSELS

As no systematic work has been done on sourcing the stones used in vessel manufacture, only the most elementary guide may be offered to the repertory of materials; the numbers in parentheses are the measure of hardness on the Mohs scale:

Agate (7): a form of chalcedony distinguished by its colourful banding; probably from Iran. Used for small dishes in the Neo-Assyrian and Achaemenid periods (cf. Woolley 1962: 106, pl. 34: U.310; *Iraq*, 51 (1989), 259). See also the entry under 'Ornamental Stones' in Chapter 2.

'*Alabaster*': variously used to describe both *calcite* and *gypsum*, even sometimes *limestone* and *marble* in the archaeological literature.

Aragonite: see under *Calcite*; for scientific distinctions see Casanova 1992: 11–17.

Basalt (5.5–6): a dark (black/brown), fine-grained compact igneous rock, composed mainly of dark feldspar, often showing tiny glittering particles. (The coarser variety of the rock is *dolerite*.) Tobler (1950: 176) refers to sources near Tepe Gawra; but it is common in Syria (cf. 'Lavas' below); primarily used for grinding equipment and large vessels in western Mesopotamia.

Calcite (2.5–3): a compact crystalline form of calcium carbonate, commonly white or yellowish white in colour, but may be green, grey, or brown. It may have secondary veins or streaks. The banded variants are known commercially as 'onyx marble' (or 'cave-onyx' or 'Mexican onyx'), sometimes erroneously termed *aragonite* which, though of the same composition, has different crystalline form and specific gravity. *Aragonite* is a form of calcium carbonate commonly laid down in shells and has been used in some seal catalogues to describe 'shell seals' cut from the columella of Meso- or Neogastropods (Collon 1982a: 13; 1986: 7). *Calcite* is very widely distributed; it is a major component of limestones and marbles and frequently occurs in cavities in other rocks. Although not good for utilitarian purposes, since it fractures easily at an obtuse angle, its variety of colours, attractive banding and translucence, combined with its relative softness, makes it very attractive for ornamental objects. It was a stone much favoured for vessels in third-millennium Iran and this is the most likely source of much of the calcite used for vessels in southern Mesopotamia in the fourth to early second millennia BC, particularly the most attractive banded and coloured varieties. However, as prehistoric exploitation of local sources clearly shows, varieties of this stone were available in northern Mesopotamia.

Chlorite (2–2.5): (commonly known as 'steatite'; 'soap-

stone'; 'serpentine'). As the various members of the chlorite schist family are hopelessly confused in the literature, since they may not be easily distinguished by eye, this term is loosely used in reference to 'chlorite' and 'steatite (talc)'. Chlorite varies in colour from soft green to black with a vitreous lustre to pale speckled grey. It is a widespread component of metamorphic rocks. It was particularly attractive to carvers in antiquity as it is soft and takes a high polish. The stones of this family reaching central and southern Mesopotamia were from Iran or the west side of the Gulf, notably Oman. 'Glazed steatite' may have been a specifically Egyptian phenomenon (see p. 169 here).

Diorite (and *gabbro*) (about 6): crystalline, granular rocks with an attractive black (or dark green) and white speckled appearance, either fine-grained or coarse-grained; hard enough for construction work and for pounding stones, appearing more rarely for ordinary vessels. This stone, available on both sides of the Gulf, may also have been obtained on occasion from Syria.

Dolerite: see under *Basalt*.

Dolomite: see under *Limestone*.

Gabbro: see under *Diorite*.

Gypsum (2): a very soft, whitish stone, sometimes slightly translucent, that often appears in archaeological contexts cracked and badly eroded; sometimes with coloured bands. It was the most readily available of all the stones used for vessels in Mesopotamia, as gypsum beds 'are widely exposed in the bluffs of the Tigris and Euphrates rivers, over the Jezireh, and in the foothills' (Wright, H. E. 1955: 85). In modern times it has been worked mainly at Falluja, Kifri, and Mosul (Mason 1944: 475).

Lapis lazuli (5–5.5): the ultimate luxury stone for vessels (cf. Woolley 1934: pl. 174); from sources in Afghanistan. See also the entry under 'Ornamental Stones' in Chapter 2.

Lavas: this term has been used here as shorthand for the opaque black-brown or grey-green igneous and altered igneous rocks employed for vessels, particularly in the first half of the third millennium BC which may not be separated by eye. Their source is still unclear, since they might have come from Syria, the Gulf, or Iran.

Limestone (about 3): a very common sedimentary rock usually white or light grey in colour, but also appearing in reddish-pink and black (including a variety with white calcite veins). It is usually fine-grained and may on occasion be slightly translucent. It is sometimes hard to distinguish from *marble* into which it is metamorphosed under high temperature and pressure. It was almost as readily available to vessel-makers in Mesopotamia as was gypsum, since it is abundant in the hills

and cliffs of the river valley. *Dolomite* (3.5-4): limestone in which some of the calcium has been replaced by magnesium (usually flesh-pink in colour) is reported within Iraq (Mason 1944: 475). A brownish stone bowl fragment, now in the Semitic Museum, Harvard, bears an inscription of Nabonidus for the cult of the moon-god at Harran that refers to the material as *alallu* (*elallu*)-stone. Analysis showed that the stone was about 65 per cent dolomite and 30 per cent calcite, confirming that this word denoted a brownish limestone (CAD 'E': 75; AHw 34; Campbell Thompson 1936: 159 ff.; Dole and Moran 1991).

Marble (3): see under *Limestone*; sometimes black as well as light-coloured, when it probably comes from sources in the Zagros.

Obsidian (about 6): used sporadically and rarely for luxury vessels from prehistoric through to Neo-Assyrian times; sources in Turkey.

Rock crystal (7): used for luxury vessels in the Neo-Assyrian period, perhaps under Egypto-Phoenician influence. It is reported within Iraq, but has not been extensively exploited in modern times. It is also available in Turkey and Iran (see entry in Chapter 2).

Sandstone (variable; soft): contains many impurities and varies in colour. As it is too porous for vessels that have to hold liquids for any length of time, it does not appear to have been used much, though easy to work and geologically abundant. It is reported within Iraq (Mason 1944: 475).

Schist (about 3): 'With this may be grouped other allied rocks, namely tuff (volcanic ash), mudstone and slate, since they are frequently so much alike that they cannot be distinguished except by a microscopical examination of thin sections, and they all occur in the same locality' (Lucas 1962: 419). This stone and its relatives are characterized by their lamination. None of them, from the Zagros Mountains in the east or the Anti-Lebanon mountains in the west, are particularly well suited for the manufacture of vessels and do not commonly appear in this role.

Serpentine (2-5): strictly describes a specific soft white-to-green stone, of greasy appearance, sometimes mottled. The term is so loosely used in the literature that much reported as *serpentine* is something quite different. The term embraces any green or greenish coloured rock from greenstone (diabase) to chlorite or steatite (talc). It was long exploited for stamp seals in Syro-Anatolia, whence supplies would have reached Mesopotamia.

Steatite (talc): see under *Chlorite*.

(ii) HISTORICAL SURVEY OF STONES USED FOR VESSELS

It is possible to detect the slow emergence of stone vessel manufacture in Anatolia and Syro-Palestine from at least the eighth millennium BC employing skills already well developed for the production of polished stone tools (Roodenberg 1986: 145). On the northern fringes of Mesopotamia, where the raw materials were readily available, the inhabitants of Çayönü in eastern Anatolia by the later eighth millennium had achieved considerable skill in the manufacture of polished stone artefacts including vessels in soft dark stones, some with surface decoration (Çambel and Braidwood 1980: 48, pl. 46). In northern Mesopotamia the repertory of vessels may first be studied at Nemrik (Kozłowski and Kempisty 1990: 351) and at Tell Magzaliya, where 'numerous fragments of stoneware have been found such as large flat-bottomed vessels, basins, bowls, and pieces of stone mortars' (Bader *et al.* 1981: 62, pl. XXXI). Then for half a millennium published information is sparse; but, where it is found, there is evidence for finer craftsmanship, more elaborate forms, and the first appearance of the miniature vessels popular later, as at Tell Aswad on the Balikh (cf. Cauvin, J. 1972: 87, figs. 4, 9, 11: 'albâtre ou marbre'). A single large stone dish at Abdul Hosein is among the earliest recorded from a grave, in this case intramural (Pullar 1979: 155).

About 6000 BC the well-documented stone vessel industries of Tell Bouqras on the Euphrates (Roodenberg 1986) and of Jarmo in the Zagros Mountains (Adams 1983: 209 ff.) open up the subject in a way not possible yet with the published material from earlier sites. On both these sites, stone vessels were found in domestic debris not in graves. In neither place was there direct workshop evidence of manufacture on site; but local, if not on-site, production was assumed from the presence of partly finished vessels, of appropriate tools, and use of local stones.

At Jarmo the vessels were generally open bowls, with straight or carved (sometimes carinated) sides; 'the regularity of form, the high polish, and the extreme thinness that were frequently achieved reflect a high degree of craftsmanship' (Adams 1983: 209). Some sherds were pierced for repairs; on others bitumen had been used to seal a repair. During the later periods a new range of small and relatively shallow bowls and saucers came into use; there was also a trend towards the more rounded and vertically sided vessels easier to hold in the hand. The stones were probably boulders gathered from the wadi below the site or at the foot of a ridge some kilometres away to the east. 'Materials used include limestone, marble, and to a lesser degree, sandstone. At all times the artisan seems to have been concerned with selecting materials that would make the

finished product pleasing to the eye (fig. 110: 2-3). Colorful red and orange mottled limestone or marble was frequently used in the lower levels, and in the upper levels a variety of white marble, parts of which are translucent, became quite common. Also in the upper levels, a banded effect was often achieved through the use of a light-colored marble with parallel streaks of a darker red or gray impurity' (Adams 1983: 210).

The steady appearance of pottery from about 7000 BC saw a growing specialization of function rather than parallel repertories of shapes (Adams 1983: 221). Although the two materials were used for comparable shapes in many cases, there was a marked tendency for stone to be manufactured into small bowls, plates, and cups, whilst baked clay was used for larger pots and bowls.

Vessels from Bouqras on the Middle Euphrates in the first half of the sixth millennium BC illustrate very much the same repertory of shapes as Jarmo, with the addition of a distinctive four-footed type of vessel (Roodenberg 1986: figs. 75-6) and more closed shapes, but in a different, locally available range of stones. About 80 per cent of the analysed fragments were of soft stones, primarily limestone, exceptionally gypsum. Hard rocks (Mohs 5.5-7) included anorthosite, basalt, granite, and tonalite. Although the limestone used for celts was fluvial, that used for bowls was thought to have been quarried. This industry also produced remarkable zoomorphic vessels in calcite ('alabaster'), outstandingly one of a hare, the other of a hedgehog, also known elsewhere at this time in baked clay (Weiss (ed.) 1985: nos. 8-9, colour plate p. 9; cf. colour plate p. 10). Small stone pots with narrow mouths and relatively deep interior cavities do not appear at Bouqras until level 3, when their appearance may be correlated with the presence in the chipped stone tool-kit of 'long drills' appropriate to their particular manufacturing requirements (Roodenberg 1986: 70-2, fig. 34: 14, cf. 38-9). Such drills had earlier been used for perforating beads. Whether this innovation was an achievement of craftsmen on the Middle Euphrates or intrusive is, for the moment, best regarded as an open question.

East from Bouqras, across northern Mesopotamia, related stone vessel repertories are increasingly evident at Tell Magzaliya (Bader *et al.* 1981: 30), where 'marble, alabaster' and veined limestone were used; at Umm Dabaghiyah in 'alabaster' and pink-veined limestone (Kirkbride 1973: 4, pls. II.i-ii, VIIb, IXd), and at Tell Sotto and Kul Tepe (Merpert *et al.* 1977: 99 pl. XXXI). A successor to the Jarmo industries in the Zagros may be observed at Shemshara, where open bowls appear in 'a carefully polished pink or cream coloured marble, often with red veins' (Mortensen 1970: 47, figs. 38-40).

For the moment, only the outstanding polished stone

artefacts from graves and buildings of the second half of the sixth millennium BC at Tell es-Sawwan on the Tigris bear any close comparison with the earlier industry evident at Bouqras. Unfortunately, they remain largely unpublished. 'The most remarkable objects . . . were found in level I, mainly in graves under Building I; their material is usually a creamy alabaster' (Al-Wailly and Abu es-Souf 1965: 22, pls. XXXII, XXXIV). Published group photographs reveal an extensive repertory of bowls (very much the majority), jars, dishes, and isolated special shapes. The excavators believed them to have been made primarily for funerary use from locally available stone. As nothing comparable is yet known, any conclusion about their purpose needs to be circumspect. As repaired stone vessels are included, it seems more likely that they represent vessels in everyday use at a time when pottery vessels were still rare; unfortunately, the reports do not say whether stone vessel sherds were recovered from domestic contexts. Out of the 175 graves published in sufficient detail, 166 contained stone vessels; the majority of burials were said to be of infants. The stone vessels were distributed as follows (the number of graves precedes the number of vessels in each, given in parentheses): 71(1), 57(2), 25(3), 7(4), 3(5), 2(7), 1(8). In other words, only 7 per cent of the graves held more than three vessels; but it is not known whether there may sometimes have been multiple burials, so recurrent suggestions that they are good evidence for a ranked society may well be premature.

The marked absence of reported stone vessels in later levels at Tell es-Sawwan (where, it must be said, excavated graves are scarce) may perhaps be accounted for by an increasing use of pottery vessels. Without statistical data from other sites, where sherds are usually more common than complete vessels and the contexts are broadly domestic, the status of this quantity of material is hard to assess. It may be noted that only one 'alabaster' bowl was reported from Hassuna (Lloyd and Safar 1945: pl. XI.1:4) and in the lowest level of Yarim Tepe I, 'fragments of ten polished marble or alabaster bowls and jars, and seven palettes' (Merpert and Munchaev 1987: 15). At Choga Mami stone bowls were rare and none was comparable to those from the neighbouring early site of Tamerkan (Oates, J. 1969: 131). Unusually easy access to a particularly attractive soft stone source may have fostered the prolific stone vessel industry at Tell es-Sawwan.

Evidence for stone vessels on sites of the Halaf period, through into the fifth millennium BC, in Mesopotamia remains sparse, possibly suggesting a marked decline of production with the now almost universal use of pottery in coarse and fine painted wares. The poverty of evidence would be increased if it is accepted that the reported stone vessels at Arpachiyah may more often be of the Ubaid rather than of the Halaf period

(cf. Bielinski 1987: 263 ff.). Mallowan thought that most of the stone used at Arpachiyah could have been obtained from the local hills; though the obsidian certainly came from further afield in Anatolia. He mentions alabaster, brecciated limestone, chlorite, diorite, fine-grained micaceous calcareous sandstone, serpentine, gritty shale, steatite, and white limestone at this site, all expertly identified. The shapes of stone vessels are still in the Bouqras and Tell es-Sawwan tradition, including miniatures: 'many of them are beautifully finished, and have a high polish' (Mallowan 1935: 76). An isolated obsidian vase is of particular interest. Its outer surface is roughly 'pecked' and 'it was evidently ground out with a cylindrical drill, but as will be seen from the section, the obsidian worker feared for the fracture of the vase and was content to leave a very small aperture' (Mallowan 1935: 76, fig. 44:15, pl. Vc: 16 cm high). Mallowan noted how the craftsmen had particularly favoured fine banded limestones. Some of the craftsmen here had begun to emancipate themselves from the earlier restricted repertoire of bowls and jars, by creating bowls or dishes on pedestals in pink and white mottled limestone and Mosul Marble (Mallowan 1935: 78, fig. 44:16, pl. Vd). By association, Mallowan linked a series of carinated bowls with painter's palettes and paint to identify them as water or mixing bowls. Such palettes and what 'may be another 'water bowl' (actually decorated with red-painted semicircles) were found in the early levels at Tepe Gawra (Tobler 1950: 209, pl. CLXXX: 73). At Yarim Tepe I and III, in graves attributed to the Halaf period, there was said to be evidence for the deliberate breaking of stone vessels placed in burials (Merpert and Munchaev 1987: 25 ff.). Vessels were made of light-coloured calcium-based stones to a high degree of skill, as is also evident in the stone beads and pendants of this period.

Away to the south, the range of stone vessels on settlement sites in prehistoric Khuzistan from the later seventh millennium BC is primarily represented by finds in the area of Deh Luran (Hole *et al.* 1969: 106 ff.). Shapes are comparable to those found in pottery, manufacturing skills varied, and stones ranged in hardness from gypsum to marble, none likely to have been imported from any great distance.

Available evidence for the Ubaid period indicates that production of stone vessels continued on a relatively restricted scale. The vessels of this period are predominantly of calcium-based stones; a black stone, sometimes described as 'steatite' (cf. Bielinski 1987: 265), occasionally appears. There is a greater frequency of stone vessels in graves at Tepe Gawra in the north, where they appear in about 13 per cent of the published Ubaid period graves, whilst at Ur it is between 4 and 5 per cent (Woolley 1956: 21, 87-8), and little above 1 per cent at Eridu (Safar *et al.* 1981: 232, figs. 112-14). No stone vessels were reported from the prehistoric

cemetery at Ubaid. Such figures, however, need to be read with caution, since the Gawra graves were intramural. Even so, cemeteries at Hakalan and Dum Gar Parchinah in the Zagros foothills yielded remarkably few stone vessels (cf. Berghe 1987: 112) and the same pattern appears to be evident in the Hamrin (Bielinski 1987), where the repertoire of shapes has most in common with the traditions of northern Iraq. It is there that the industry may best be studied at this period.

A group of four vessels in a grave intrusive into level XIX at Tepe Gawra included carinated bowls continuing the later Halaf repertoire in grey, white and red 'marble' (Tobler 1950: 209, pl. CLXXX.75-8). One has a pouring lip. In level XVIII the three stone bowls were from graves and in the same 'gray marble' (Tobler 1950: pl. CLXXX.79-81); in XVII two only came from occupational debris (ibid.: pl. CLXXXI.83-4), this time in 'gray-and-white marble'; there were none in XVI, then they reappear in XV with one example, anciently repaired, cut from 'a piece of beautifully veined gray-and-brown marble'. In level XII a distinctive series of 'black steatite' kohl-pots appears with four of the seven found at Gawra coming from this level; all but one have incised decoration (ibid.: pl. CLXXX.63-6). At this time miniatures seem also to have been particularly popular, in black steatite or serpentine and in alabaster (ibid.: pl. CLXXX.67-70). With the possible exception of the steatite/serpentine, the 'marbles' used for vessels at Gawra during this period, in contrast to what followed, were easily procurable in the locality. The Gawra evidence in the Ubaid period does not suggest an extensive production compared with some earlier sites.

In the south stone vessel sherds from contemporary occupational debris at Eridu and Ubaid (Lloyd and Safar 1947: 104 ff.; cf. Hall 1924: 109), and at Ur (Woolley 1956: 8) indicate little more than the presence of stone vessels in temple and domestic contexts. Whether or not the remarkable collection of sherds, including some of obsidian (see p. 70 here), attributed to the intermediate layers between C and D of the Anu Ziggurat at Uruk, should be dated before the Uruk period is debatable (cf. Perkins 1949: 86, 134; Nöldeke 1937: pls. 58-60). By comparison with what went before, and what was to come, the Ubaid period in this, as in so many other industries, remains singularly ill-documented.

In the north, the final phases of the prehistoric period in the fourth millennium give evidence of a continuing production, but so far without the more exotic forms associated with Uruk. The settlement at Gawra in levels XI-VIII is part of a local culture with its strongest connections in the direction of the north Syro-Mesopotamian steppe and beyond to the Taurus mountains (cf. Algaze 1986). The luxury objects of silver and electrum in a few tombs and an unusual variety

of stones, including obsidian, reinforces the impression of strong cultural connections with the highlands to the north-west in the Late Uruk chronological horizon. In levels XI-VIII stone vessels are represented in six tombs by particularly fine examples; but they disappear from contemporary occupational debris in which they had appeared sporadically before and were to appear again later. What may have been a utilitarian local industry was replaced, but only for a period it seems, by more specialist luxury products in exotic stones. Now maybe ready-made vessels were being imported.

The most remarkable stone vessels from Tepe Gawra are listed below with the excavator's original attribution to levels (for a recent reappraisal see Forest 1983: 28 ff.):

LEVEL X:

Tomb 102: Two obsidian spouted bowls of remarkable technical excellence; ground and polished, one rather more than the other; one repaired with holes and thongs in antiquity. Tobler 1950: 94, pl. CIII.7-8, pl. LIIIb-c.

Tomb 109: Two bowls and one jar of oölitic limestone, marble, and black and white marble. Tobler 1950: 95, pl. CIII.9-10, pl. LIII d, f.

Tomb 110: Two stone beakers of dark green serpentine. Tobler 1950: 83, pl. CIV.13 (= LIIIe), 14.

LEVEL VIII C:

Tomb 24B: One small ointment jar of oölitic limestone. Tobler 1950: 93, pl. CIII.11.

Tomb 31: One unique double bowl of Mosul Marble ('only stone vessel found in a tomb where a common, local variety was employed in manufacture'); one small ointment jar of oölitic limestone; one small alabaster ointment jar; one exceptionally fine handled bowl of highly polished translucent dark green serpentine. Tobler 1950: 93, pl. CIV.15-17, 19 (= LIIIa).

LEVEL VIII B:

Tomb 45: (thoroughly robbed in antiquity); small alabaster pot; fragment of translucent green serpentine bowl (pl. CIV.18); two fragments of a large four-lugged jar of variegated grey-and-white marble (pl. LII.5).

In view of the extensive use of stone for decorative purposes and for amulets at Tell Brak in the later prehistoric period, and the site's links with the Sumerian south, the few stone vessels Mallowan reported from his excavations may indeed indicate that at this time local production was not extensive. A few miniature jars are variously described as made of 'steatite, white alabaster and white limestone' (Mallowan 1947: 210, pl. LII). The same picture is given by the stray stone bowls excavated from levels 4 and 5 in the deep sounding at Nineveh (Campbell Thompson and Mallowan 1933: 148, pls. LI.10, LXX.15).

Before considering the stone vessel production associated with Uruk IV-III from the mid- to later fourth millennium BC, a glance at the evidence from the site of Jamdat Nasr, in central Iraq, in Uruk III, gives a sense of perspective to the account, since the Uruk evidence is still exceptional. In the building complex uncovered at Jamdat Nasr few stone vessels were found. In describing them, Mackay made a point that remains true of much stone vase production in Mesopotamia through the next millennium and contrasts with the remarkable level of excellence maintained by stone vessel production in contemporary Egypt: 'a striking feature of these vessels is their extraordinary thickness, which was unnecessary and must have added greatly to their weight. It is particularly noticeable in the deeper jars and suggests that great difficulty was experienced in drilling out their interiors. In Fig. 35 the grinder has left a great deal of horizontal grooving, which no attempt was made to remove' (Mackay 1931: 279). Light soft (limestone; calcite) and hard dark ('gray granite, porphyry') stones are represented. One vessel (GN 3410: Mackay 1931: 279 = Ashmolean 1926.43) may be made of some kind of gypsum plaster, but so far specialist tests have been inconclusive.

At Uruk, where no graves or domestic occupation levels of the mid- to later fourth millennium BC have yet been reported in detail, published stone vessels come almost exclusively from the elaborate shrines of this period and their ancillary buildings. Preliminary reports indicate, as might be expected in such a context, an unusual prevalence of exotic features. In general the shapes are not outside the established tradition of bowls and jars, save in a tendency to imitate more elaborate contemporary ceramic shapes; but materials and means of decoration are not conventional. Although there was evidence for local manufacture, as indeed the more exotic shapes might suggest, the stone sherds found in workshop areas have not yet been published in sufficient detail for close study (Warke 1979).

Many fragments of vessels, in a range of stones, were reported from the intermediate layers between levels C and D of the Anu Ziggurat (Nöldeke 1937: 52, pls. 58-60). The dating of these levels is problematic (cf. Margueron 1986). Among the small finds is an unusual cylinder seal best paralleled at Susa in levels Ca-Cb (cf. Amiet 1980: 31; Nöldeke 1937: pl. 49a). It is likely that Anu levels B, C and intermediate C to D belong in the horizon Eanna V-IVa (cf. Dunham 1980: 143) with the probability that level IVa provides the *terminus ante quem* for these stone bowl sherds (cf. Vértessalji 1988: fig. 7). Many, if not all, of the sherds are as early as the Late Ubaid period (cf. Perkins 1949: 86; Henrion *et al.* 1990: 73). Some of the shapes, notably nipple—or button-based beakers, are remarkable enough, the more so when obsidian appears as a medium among the more familiar calcium-based

stones, many of them red or black in colour. Obsidian vessel fragments are also reported from Eridu (Safar *et al.* 1981: 232) and Ur (Woolley 1956: 71) in Late Ubaid contexts. Earlier Hall had noted 'fragments of obsidian and smoky quartz vases beautifully ground' at both Eridu and Tell al-Ubaid (Hall 1924: 109; for sources of obsidian see pp. 64 ff. here).

Three main forms of decoration are evident in the Uruk IV–III horizon and they particularly distinguish the stone vessel production of the time in the published record, though this may well be biased against routine types not thought worth mentioning in preliminary reports. Examples of the main decorative groups will be cited in turn: those carved with low relief friezes; those with high relief, almost free-standing sculpture; and those with polychrome inlays.

The very large calcite vessel with hollow splayed foot (1.05 m. high), known as the 'Uruk Vase', is the outstanding example of a vessel decorated with encircling friezes in low relief (cf. Heinrich 1936: pls. 2–3; Amiet *et al.* 1980: pl. 27 (colour)). But there was a more regular production, usually in limestone, of open bowls with animal friezes carved on the exterior. Their style and iconography indicate manufacture in Sumer (cf. Basmachi 1950; Möller 1984; Woolley 1956: pls. 31: U.18524, 19378, 2000; pl. 35: BM128438; Amiet 1977: pls. 225, 231, 236). Such relief decoration was found on vessels in the Diyala, made of limestone and of green 'lavas' (Perkins 1949: 138; cf. Frankfort *et al.* 1936: fig. 54). A green stone is also used for a bowl, said to be from Uruk, decorated with animals and men in a boat (Hall 1928*: pl. VI). Dark stones are more rarely encountered in this relief series; but there is a fine example, in 'dark steatite', decorated with a frieze of bulls, found in a house of the Achaemenid period at Ur (Woolley 1956: 32, 52, pl. 35: U.18118; cf. also Buren 1939: fig. 71, fragment in New York).

In many ways more remarkable are the vessels cut from blocks of softish light-coloured limestone with elaborately carved supporting groups of heroes, animals, or birds in such high relief as to be almost in the round. A spouted vessel so decorated was associated with the 'Uruk Vase' (Heinrich 1936: pls. 22–23a; Amiet 1977: pl. 224), as was a fragment of another (Heinrich 1936: pl. 23b, c). That such vessels were more widely produced for the service of the gods is indicated by their appearance at Ur (Woolley 1956: 173–4, pl. 42: U. 7560) and in the Diyala Valley (cf. Frankfort 1970: figs. 17–19). Variants like a crude bird-shaped vessel and a cosmetic jar set on the back of an animal (Behm-Blancke 1979: no. 86, pl. 27: 149) from sites in this region indicate a fusion of stone vessel production and sculpture not evident thereafter in Mesopotamia. Here again both style and motifs indicate production in Mesopotamia.

In the Archaic Ishtar Temple at Assur the German

excavators found a battered fragment of an elaborate vessel support, carved in relief with figures of heroes and animals, in steatite or soapstone (*Speckstein*) (Andrae 1922: 81, fig. 60, pl. 50a–e). Moortgat (1939) associated with it two unprovenanced vessel-stands of comparable type and material in the Berlin Museum and dated the group to the later prehistoric period. The same type of stone, in this case identified as ophiolite-clinoclomite, was used for an unprovenanced cup, now in Glasgow, carved with an elaborate animal support in high relief (Peltenburg 1991: no. 16).

The special character of the repertory of stone vessels at Uruk is particularly evident in those where colour contrasts and inlaid polychrome designs accentuate the impression of ingenuity and display for their own sakes. Some of these vessels are composite with body, neck, and spout made separately, sometimes in stones of contrasting colours and textures. In the *Sammelfund* at Uruk dark stone vessel bodies (?bituminous limestone) were combined with necks and spouts of lighter colour in limestone, gypsum, or calcite (cf. Heinrich 1936: fig. 4). Various coloured limestones and lapis lazuli were combined in the inlays. These were set into cavities, secured with bitumen either as horizontal or vertical bands, or as rosettes or geometrical shapes (cf. Nöldeke 1936: pl. 24g; Heinrich 1936: pl. 25). Unusual stones, the grey-green lavas (Orthman *et al.* 1975: pl. X) or the dark-coloured 'slates', were used for open bowls cut on the exterior with recesses for the reception of coloured inlays. Similar decorative techniques were used in the manufacture of animal statuettes at this time (cf. Behm-Blancke 1979: no. 5: colour plate). Here again local production from imported stones seems most likely in view of forms and designs.

The deep penetration of Uruk 'colonies' along the line of the Euphrates into Syria and eastern Turkey may indicate a possible source for some of the exotic stones used in Uruk IV–III, but hard evidence is still absent. At Tell Qannas the East Temple yielded fragments of stone vessels in 'alabaster', conspicuous among them close replicas of contemporary ceramic shapes (Finet 1977: 78 ff., especially 93, fig. 23; Weiss (ed.) 1985: nos. 30–1). At Habuba Kabira a miniature jar in an unusual blue-green stone imitates the lugged jar of the potter's repertory (Weiss (ed.) 1985: no. 29, colour on p. 11); but for the moment published evidence does not match the exotica of Uruk. Only the use of shale or schist at Tell Brak, in the decorated altar, recalls Uruk (Mallowan 1947: 93–4, pl. III). If correctly identified, the prominent use of bituminous limestone at Uruk in the late prehistoric period contrasts with its subsequent rarity in Sumer. It enjoyed considerable popularity, however, in Susiana, and this trait might indicate that Susiana was Uruk's point of access to supplies of unusual stones from the Zagros and beyond in Uruk IV (cf., in general, Amiet 1986;

Carter, E. 1990). There is no firm evidence for the use of stones from the Gulf area at this stage.

Chronological debates no less than selective publication obscure the history of stone vessel production at the end of the fourth millennium BC (Uruk III/Jamdat Nasr period). Vértessalji (1988: 23 n. 108) identified a revival of the mass-production of stone vessels in the early Jamdat Nasr period and attributed it to Egyptian contacts at the time; but even if the first proposition is accepted, and that is debatable, the second is far from clear, since contacts with Egypt were always remote and probably earlier (cf. Moorey 1987). It is unfortunate that it is difficult to date the levels excavated by Genouillac at Telloh in which he noted a particular wealth of stone vessels in calcium-based stones, with dark stones and 'rocks of porphyritic type' (Genouillac 1934: 50, pl. 5:2a). In so far as the published evidence goes, there is a marked contrast with Uruk IV and Telloh, where the evidence may be later, since there is a difference of shapes and of the stones used. At Telloh obsidian, for instance, is not reported and the footed vessels and narrow beaker-like shapes of Uruk also appear to be missing.

Ur alone provides a sequence of graves through the Early Dynastic into the Akkadian period offering the only available guide to the distribution of materials for stone vessels through the third millennium. At every step problems of stone identification (always that given by eye), of chronology, and of typology complicate the picture. Woolley's (1934; 1956) descriptive categories for the stones used for vessels may be summarized:

1. *Calcium-based (altered) sedimentary rocks*: Woolley generally specifies limestone; but his use of 'alabaster' (usually for gypsum) may confuse the picture for gypsum and calcite.
2. *Steatite/Chlorite*: There are cases when Woolley's term 'diorite' is used for vessels in this category.
3. *'Diorite/basic Diorite'*: This is Woolley's terminology for the igneous and altered igneous rocks used for stone bowls, predominantly greenish-grey in colour, primarily in his 'Jamdat Nasr Cemetery' ('lavas').

From Woolley's lists the following *gross* trends emerge. In the late prehistoric period about 60 per cent are category 1, 40 per cent category 3. In the earlier part of Early Dynastic I some 65 per cent are category 1, 35 per cent category 3; in the later part of Early Dynastic I some 55 per cent are category 1 as calcite begins to supersede gypsum markedly, whilst some 45 per cent are category 3. In Early Dynastic II some 65 per cent are category 1, 35 per cent category 3 with calcite continuing to outpace gypsum. It is possible that the first sign of steatite/chlorite appears at this stage. In Early Dynastic III some 85 per cent are category 1, about 2 per cent category 3, and some 10 per cent category 2. In this period the royal tombs introduce a

miscellaneous element with one vessel of lapis, one of obsidian, three of green calcite, and one of grey-and-white speckled marble in RT 800, which has the greatest variety of stones represented among the vessels. RT 1618 stands out here on account of about 15 per cent of category 3, which might indicate an early date. Stones of categories 2 and 3 were certainly intrusive, so either the raw material or the finished vessel arrived in Sumer from elsewhere. Category 1 is more complex in this respect, embracing gypsum, calcites, and limestones that are almost certainly native to the river valley and its immediate periphery, as well as distinctive types of calcite from Iran (see below). The precise source of none of these stones is known; but, as will be explored below in the course of the survey, certain gross deductions may be made on the basis of patterns of use.

The chronology of the so-called 'Jamdat Nasr Cemetery' at Ur has attracted considerable analytical attention in recent years. A number of detailed chronological studies now exist (Forest 1983; Gockel 1982; Kolbus 1982; 1983; Korbel and Youzan 1979; Korbel 1984). They are all agreed that the graves extend well beyond the conventionally defined Jamdat Nasr period in the late fourth through into the early centuries of the third millennium BC. Vértessalji and Kolbus (1985: 66) have pointed out that there are such serious objections to Korbel's seriation analysis, which was not checked directly against the archaeological data, that it is best forgotten for chronological purposes. In his analysis Forest (1983: 117 ff.) established a fourfold division of the graves in Pit X, dating the sequence from Uruk III to Early Dynastic I, whilst graves in Pit W were mainly dated to Early Dynastic II. In Pit X he attributed graves between 4 and 5 metres to Early Dynastic I, from between 5 to 6 metres to Early Dynastic II. Gockel (1982: table B.4.V. for stone vessels) dates the bulk of the cemetery to the middle of Early Dynastic I. In the following analysis of the stone vessels the chronology of Vértessalji and Kolbus is followed, since it presents a convincing case for a spread of graves from the late fourth to the mid-third millennium BC, when the Royal Cemetery sequence opens. For the sequence of graves from Early Dynastic III to the Ur III period (commonly known collectively as the 'Royal Cemetery') I have used the work of Karstens (1987), Nissen (1966), and Pollock (1985) for chronological purposes; their differences do not significantly affect this concise survey of stone vessels.

As was his general custom, Woolley created a typological series for stone vessels from the 'Jamdat Nasr Graves' and another for those from the 'Royal Cemetery' to which his catalogued finds are all cross-referenced, not always accurately even in its own terms. More significantly, these highly simplified 'ideal' shapes give a misleading impression of symmetry and refinement of forms that relatively few vessels actually have,

and these generally from the richest graves. Many others are misshapen to a greater or lesser extent, crudely made, and heavier than they need be; the finer examples tend immediately to stand out in any group. Woolley's type-series should be taken for no more than it is: a means for classifying a great many stone vessels as expeditiously as possible in the field during the course of excavation.

In his own analysis of the 'Jamdat Nasr Cemetery' Woolley (1956: 26) argued that 'stone vessels were most numerous in the middle graves, rather less so in the upper graves and much rarer in those of the lowest stratum.' As has already been suggested, the finest carved stone vessels belong to the final phase of the prehistoric period. Vértessalji and Kolbus (1985: 89) have noted that in the first part of the Early Dynastic period, and perhaps longer, certain pottery types (JN 16, 31, 33, 34, 35, and 36) imitate stone vessel shapes. They interpret this as indicative of scarcity of raw materials at this time: 'it may be considered as a general characteristic of Ur and its South Babylonian region at the beginning of the Early Dynastic'. These cheaper imitations of stone vessels become rarer in the second part of the period, while stone again becomes abundant in the graves. This increase persists into Early Dynastic II at Ur. Nearly half the stone vessels (about 48 per cent) excavated in the Diyala region that were dated between Protoliterate c and Early Dynastic IIIA fall in Early Dynastic II contexts (Vértessalji and Kolbus 1985: 89 n. 124). This pattern is broadly borne out by Zettler's analysis of the stone vessels from the Inanna Temple at Nippur: 'Fifteen per cent of the total number of stone vessels were recovered from the earliest levels . . . the levels of the Uruk and Jamdat Nasr periods and the first phase of the Early Dynastic period. An overwhelming seventy-two per cent of the total number were found in levels VIII–VII (Early Dynastic II/III) . . . The remaining thirteen per cent were found in later levels, and more than half of those in level IV, which dates to the time of the Third Dynasty of Ur . . .' (Zettler 1985: 48).

The majority of graves in the 'Jamdat Nasr Cemetery' contain one or more stone vessels. A greater concentration, rising from between one and three to twelve or more in some graves, broadly corresponds to an increase in the richness of other grave furnishings. On Woolley's identifications limestones and lavas predominate. With a steady emergence of calcite from the later Early Dynastic I–II horizon, both lavas and limestones at first decline, but then the lavas are wholly eclipsed by the time of the earlier graves in the 'Royal Cemetery', about the middle of the third millennium. Alabaster (or gypsum), a minor constituent of the repertory of stones used for vessels, appears to increase in use as Early Dynastic I–II proceeds, but is not recorded in Early Dynastic III, though its total absence then seems unlikely.

The accuracy of Woolley's identification of stones becomes critical with *steatite* (and its relatives) in graves attributed to the 'Jamdat Nasr Cemetery' in its latest phase (Early Dynastic II). His identifications of it are rare, but some at least seem likely to be correct, thus anticipating its more regular appearances in Early Dynastic III. Many of Woolley's JN stone shapes (Woolley 1956: 157) reported in 'steatite' have relatively close parallels among the vessels reported from Tarut by Zarins (1978: pls. 64–5, 75–6), but one or two (JN 60–1 only in *steatite*) do not. The possible sources of these vessels are considered on p. 48.

Allowing for all the hazards—and there are many—it is the eclipse of the lavas that is most striking, since they were certainly imported, whereas the calcium-based stones might often be local. Whence the lavas came is presently unknown, though the tendency has been to attribute them to inner Iran (Schüller 1963). As such stones are not conspicuous amongst those used for stone vessels nor for sculpture at this (or any other) time in Susa, caution is in order. Sources within the Arabian peninsula or up the line of the Euphrates or in the Gulf cannot yet be ruled out. It may be significant that the statue of a squatting man from Tell al-Ubaid (Hall and Woolley 1927: 27, 125, pl. VIII: 4, 5) was reported to be of 'greenish-grey trachyte'. This stone is rare in the repertory of published Early Dynastic statuary (see p. 25) and closely resembles the lavas used for stone bowls until late Early Dynastic II.

The ill-recorded graves from the deep sounding Y on Tell Ingharra at Kish have been dated most recently towards the end of Early Dynastic I (Algaze 1983–4: 148). For stone vessels the pattern of deposit and the range of shapes and materials is broadly comparable to that from Ur, though *steatite* is not recorded. Evidence from other sites for Early Dynastic I–II remains meagre and difficult to use.

At Ur, and elsewhere, in the earlier third millennium BC bowls are very often of limestone, rather than of calcite or gypsum, when not of lavas. Jars are regularly of calcite, sometimes using its banded structure for decorative effect; but often poorly made, heavy and ungainly. It is noticeable that the squat, heavy jars with sharply cut shoulders and flanged rims (Woolley types: JN 53–4, 56–7) are commonly of gypsum, often crushed and distorted. The interior is not drilled out, as with the more open shapes, but gouged. 'A vessel of alabaster or of soft limestone could be carved with a knife, and we possess examples on which the tool-marks are left and shew that a knife was indeed used; a *steatite* bowl might be gouged out with a chisel—we have an unfinished specimen, but for diorite the cutting-tools of the time were inadequate, and we find constantly the stone drill-points . . . whereby the more stubborn stones were hollowed into vessels' (Woolley 1956: 26) (cf. p. 58 here).

Gypsum is conspicuous amongst the stones used in Early Dynastic I–II at Ur for pouring bowls (Woolley 1956: pl. 32: U.19744, 19770: JN 6A), for 'lamps' (Woolley 1956: pl. 32: U.19745, 19885), some with zoomorphic decoration, and for cosmetic vessels (Woolley 1956: pl. 31: U.19428, 19529, 19426). The use of any kind of surface decoration at this time appears to be rare. A single tiny bowl from a grave in the 'Jamdat Nasr Cemetery', in a distinctive limestone with 'two ochrous yellow bands', has twelve sharply pointed petals in high relief on the exterior (Woolley 1956: pl. 34: U.18583, pl. 65: JN 2).

For the stone vessels in the 'Royal Cemetery', in the middle of the third millennium, Woolley's succinct summary is an admirable basis for discussion:

The materials also varied. By far the commonest is white calcite, ranging from ordinary limestone (which is so specified in the catalogue) to the finest stalagmitic calcite richly veined and beautifully coloured (e.g. U.10882, pl. 175) or to a plain translucent stone almost blue-white, as U.9363, pl. 176; in many cases the decay of the surface has robbed the vase of its original effect, but where this was preserved the polish was admirable and brought out the full quality of the stone. *Steatite*, dark or greyish-green, was fairly common, diorite or basic diorite, popular in the preceding period, was now less in use; isolated examples occurred of lapis-lazuli (U.10517, pl. 174), obsidian (U.10488, pl. 165), black and white breccia (U.10496, pl. 178), and translucent green calcite (U.10480, pl. 174). To some extent material and shape were associated. The 'spill-vase' types 1–12 were always of calcite, the very beautiful bell-shaped bowls 49–51 were always of *steatite*, the jars 35–92 always of calcite, the oval bowl 96, which is borrowed from the metal type, was only made in rare material such as obsidian or green calcite, the decorated types 10, 29, 52, 53 were of *steatite*. (Woolley 1934: 379)

Although there are exceptions to Woolley's 'always' in his own records, this diagnosis stands up to scrutiny in all the main points. Here the significant changes are the apparent eclipse of the lavas and, perhaps more surprisingly, of gypsum, and the marked increase in the use of various types of calcite. If gypsum may be regarded as a low-status stone, since it was the most readily available, its absence from high-status graves may be explained. Limestone remains a vital minor constituent of the materials repertory and *steatite* grows in importance. As might be anticipated, the rarer stones concentrate in the royal tombs of Early Dynastic IIIA, notably single vessels of lapis lazuli and obsidian; the former as a small spouted bowl (Woolley 1934: RC type 44, pl. 245), the latter as an oval-shaped, deep bowl which has Sumerian metal prototypes (Woolley 1934: RC type 96, pl. 250). In both cases the shape suggests local manufacture, which is more significant in the case of obsidian, considering how difficult it is to work. RC type 44 is once reported also in limestone, RC type 96 in limestone (once) and calcite(?) (twice), notably in its translucent green variety. The vessels in the royal

tombs in other stones are notable for the greater care and skill with which they were manufactured. As lapis lazuli (p. 85) and obsidian (p. 63) are considered in detail elsewhere, attention here will be concentrated on calcite and *steatite*/chlorite, since closer attention to them yields more information on sources and cultural interconnections. Although there has been some systematic research on the materials in the chlorite/*steatite* range (see below), this is not the case with calcite for which few analyses are available (see p. 59 here). Analyses done in the British Museum identified it as travertine in Early Dynastic III contexts at Ur.

Distinctive banded *calcite* is first used for vessels in the middle of the third millennium BC both at Ur and at Susa. It is sometimes distinguished by its colouring, shades both of red and green. This stone is distinct from a type of gypsum, also tinted red (rose) or green, which had long been used in the region and may have come from sources relatively close to Susa in the Zagros mountains (cf. Morgan 1900: 48 ff.). Careful typological study of vessels in banded calcite in Mesopotamia, Iran, and Afghanistan by a number of scholars, notably Casanova (1982), indicates that a significant number were probably made in eastern Iran or Afghanistan, where the stone is available and was indeed used for stone vessel production in workshops excavated at Shahr-i Sokhta (Ciarla 1979, 1981; cf. Amiet 1986: 126 ff.). There are close parallels between the shapes of vessels in banded calcite at Ur and at Susa in Early Dynastic III, all perhaps imported from far to the east. However, there are also shapes at Ur with their closest parallels in eastern Iran and Afghanistan that are unknown at Susa (Casanova 1982: types IVa, IVc; cf. Woolley 1934: pl. 241: types 4–7), so they may have reached Ur directly by sea up the Gulf or along some other route bypassing Susiana.

It is significant that white and yellow calcite, often banded, is the predominant material among the stone vessels bearing dedications by Rimush (c.2278–2270 BC) to Enlil 'when he had conquered Elam and Parahshum, from the booty of Elam', found at Tell Brak, Khafajah, Nippur, and Ur. Some of the few vessels bearing Naram-Sin's (c.2254–2218 BC) 'booty of Magan' inscription are also in banded calcite (cf. Potts, T. F. 1989: 126 ff., 131 ff., figs. 12, 13; Potts, D. 1990: i. 139–41). As banded calcite has not yet been associated with the non-Iranian Gulf areas either as a raw material or as manufactured goods, this reinforces the view that such vessels are products of workshops in eastern Iran or beyond.

In the pioneering days of Mesopotamian archaeology calcite vessels from Egypt were commonly cited as parallels for the Sumerian examples and cultural contacts were proposed (Petrie cited by Woolley 1934: 379). Reisner (1931) disposed of a supposed Egyptian connection; but it is intermittently revived. The Egyptian

parallels cited by Glob (1958) and Mortensen (1970^a: 396) for the tall calcite vessels excavated from the Barbar Temple on Bahrain are not close. These are, in fact, examples of a widely distributed cylindrical shape reported from Ur, Kish, and Telloh in Mesopotamia, from Shahdad in Iran, and from Afghanistan ('Bactria') (Casanova 1982: 27), whence indeed they might have come by sea. Carter (T. H. 1987: 86) reports that 'in Failaka perhaps a dozen fragments have been excavated that are similar by "eye examination" to the material of the Bahrain vases . . . All the fragments are presently being analyzed at ISMEO in Rome and it should be emphasized that the immediate reaction of the Italian team was that the fragments were of Iranian alabaster' (i.e. calcite).

Vértessalji and Kolbus (1985: 95 n. 141) have drawn typological parallels between vessels of the IIIrd Dynasty in Egypt and Early Dynastic I in Sumer. They attribute the more sophisticated techniques of manufacture they identify in Early Dynastic II to itinerant Egyptian craftsmen working in Sumer. But close scrutiny of both Egyptian and Sumerian stone vessels does not sustain their case (cf. Potts, T. F. 1989: 124 n. 8), particularly when there is no clear indication of an Egyptian connection in any other evidence and when connections in stone vase manufacture are in general with the east rather than with the west at this time. In order to correct any tendency to see the marked increase in vessels of calcite in Early Dynastic III in Iranian terms alone it must be pointed out that there are shapes at this time specific to Mesopotamia. These include necked bottles, flasks, and globular jars (cf. Woolley 1934: pls. 248-9: types 79, 85-6, 90b, 91b) found at such sites as Kish, Mari, Telloh, Susa, and Ur.

As this case indicates, in any attempt to identify the location of Sumer's stone resources in the absence of definitive geological indicators general comparisons with the use of stone at Susa are instructive. It is remarkable that here, in much closer proximity to the Zagros Mountains and the Iranian plateau (but rather less accessible for Gulf regions), in the fourth and third millennia, local stonework is predominantly in limestone and gypsum. They were available in the western foothills of the central Zagros and as boulders in rivers running southwards from the Zagros to Susiana (cf. Morgan 1900: 46, 48; Carter, E. 1984: 122). Gypsum was particularly favoured in attractive translucent tones from white through green or pink to grey (Amiet 1986: 127). This is the stone commonly chosen at Susa from Uruk IV to Early Dynastic III for stone vessels, for animal amulets, and for a series of worshipper statuettes and wall-plaques with close Sumerian parallels (Amiet 1976; Pelzel 1977). Coloured marbles were used in the later Uruk period. The light-coloured range of stones was juxtaposed in Susiana with the

locally available bitumen mastic (Marschner *et al.* 1978) and bituminous limestone (from Pusht-i Kuh: Morgan 1900: 46), which only seems to appear at Uruk in Sumer. When 'black and white' contrasts were used in Sumer, schist or shale provided the dark contrast. It may be significant that the 'lavas' used at Ur from the late prehistoric period to Early Dynastic II are not evident amongst the stones used at Susa for vessels.

In view of the disproportionate attention paid in recent years to decorated vessels in *chlorite* or *steatite* (talc), it is useful to separate the undecorated vessels in these stones from their now better-known decorated relatives. The evidence for plain *steatite* vessels in Sumer before Early Dynastic IIIA is equivocal, since it is possible that some of the shapes from contexts of Early Dynastic I-II at Ur, paralleled in *steatite*/chlorite at Tarut, were of lavas. Plain vessels dominate the third-millennium *steatite* vessel repertory of Failaka, Oman, and Tarut in the Gulf, whilst there is evidence for the manufacture of plain vessels at Tarut (Zarins 1978: pl. 75A), at Maysor-1 in Oman (Kroll, in Weisgerber 1981), and at Tepe Yahya in Iran (Kohl 1974: 3 ff.). The raw material is widespread on both sides of the Gulf (for Oman: David *et al.* 1990), as it is in the vicinity of Tepe Yahya and elsewhere in Iran (Kohl *et al.* 1979). So far, no plain vessel has been recorded with a Mesopotamian royal inscription. They are confined to decorated vessels offered as votives, probably all from consignments of booty (Potts, T. F. 1989).

As Woolley (1934: 379) recognized, there was a close correlation between shape and stone in his recovery of chlorite/steatite vessels from the Royal Cemetery at Ur, notably in the case of the 'bell-shaped' types RC 49 to 51 (Woolley 1934: pl. 245), which are virtually never in any other stone. These deep bowls have well-defined circular bases and sides that flare gently towards the rim. They appear in what has every appearance of being a carefully graduated series of standard sizes, ranging from mouth diameters of 18 cm. or less to as much as 60 cm., with a proportionate range of heights from 7 cm. to more than 25 cm. Both the British Museum and the University Museum, Philadelphia, have impressive examples of these types. Observation by eye indicates that even in this well-defined series a range of stone types in the broad *steatite*/chlorite category was being used. They correspond to the predominant undecorated shape in Tepe Yahya IVB1 and IVA (Kohl 1974: 218, pl. LXa, b). Comparable vessels may be noted at Shahdad (Hakemi 1972: pl. IXe) and Tarut (Zarins 1978: pl. 74:593). 'The different sizes could have been stacked for shipment one inside the other, and it is probable that the largest vessels, if traded in finished form, had to have been transported by sea' (Kohl 1974: 220). A plain, flat-based bowl with concave sides recorded at Ur is also matched at Yahya (Kohl 1974: pl. XIa), at

Shahdad (Hakemi 1972: pl. IXa), at Hili in Oman (Friefelt 1971: 375, fig. 3b).

Decorated vessels in chlorite/steatite have been the subject of unusually concentrated interest following excavations at Tepe Yahya in south-central Iran, between 1968 and 1973, which identified workshop debris from the manufacture of vessels of all kinds in the locally available chlorite at some time in the second half of the third millennium BC. Kohl's (1978; *et al.* 1979) subsequent analytical programme to fingerprint carved chlorite vessels and his stimulating attempts to relate his conclusions to understanding the role of long-distance trade in social development in highland Iran made a considerable initial impact. His optimism has been tempered by time to the point where Lamberg-Karlovsky, director of the excavation at Tepe Yahya, recently concluded that 'the quest for pin-pointing the origin of this class of artifact is a hopeless endeavor' (Lamberg-Karlovsky 1988: 54). It all depends, of course, upon the degree of precision which is sought. It is certainly true that the sheer complexity of the matter is now apparent to a degree the early reports never anticipated (cf. Baudot 1987: 19; Carter, T. H. 1989).

Miroschedji (1973), when publishing the *steatite* vessels in the Louvre collection, divided them into two major groups which he termed *série ancienne* (c. 2600-2200 BC) and *série récente* (c. 2300-2200 BC). A third *série tardive* (c. 2000-1700 BC) was defined later. Kohl (1974: 1) preferred to call the *série ancienne* 'vessels in the intercultural style'; but this term is not a sufficiently faithful description of the older group's peculiarly Iranian character (cf. Amiet 1986: 133), so Miroschedji's more objective terminology is preferable. These decorated vessels had an 'intercultural' appeal, but the style in which they were carved has more specific origins.

The stone employed for these vessels varies considerably in appearance and in texture, most often embracing a colour range from grey-green to almost black and surfaces from rough to greasy and highly polished. In the older literature these vessels are commonly described as either 'steatite' or 'serpentine'. Following the analytical work of Kohl (*et al.* 1979), these terms tend to be replaced by 'chlorite' as a generic term where specific identifications are not available. As the correct category may not be judged accurately by eye, whatever term is used will be no more than conventional, unless it is based on proper geological identification. At Mari, for example, the range of stones for vessels broadly of this class is very varied, to judge from what is said in published reports (Parrot 1956: 113 ff.; 1967: 179 ff.).

The elaborately carved vessels of the *série ancienne* had aroused the interest of scholars long before the discoveries at Tepe Yahya (Kohl 1974: 24 ff.). In 1932 Mackay compared a design on one such carved fragment, from the lower levels at Mohenjo-Daro in Paki-

stan, with that on one half of a conjoined chlorite vessel from Susa in Iran. As time went on more and more examples of these vessels were assembled from Mesopotamia and her neighbours to south and east. Woolley postulated non-Sumerian manufacture, probably in Iran, whilst Frankfort supported a Sumerian source (Kohl 1974: 1 ff.). The discovery of a manufacturing centre at Tepe Yahya confirmed the existence of at least one Iranian source, though unfinished pieces retrieved through clandestine excavations on Tarut Island, on the west of the Gulf (cf. Potts, D. 1990: i. 66-7), at much the same time, indicated that the network of production and exchange was complex and geographically extended (cf. Zarins 1978: 67, pls. 72b:110, 75a:505). Nothing is yet known of what was transported in these vessels. Lamberg-Karlovsky (1988: 53) noted a 'hardened grey substance' in the vessels found at Shahdad, whilst Miroschedji (1973: 33) has identified lead oxide in some of the later *steatite* vessels.

It is now apparent that this category of stone vessels is a very heterogeneous one (Baudot 1987), with no well-defined stylistic definition, grouped for purposes of study through a common class of stones (with exceptions) and a universally clear distinction from the products taken to be typical of Sumerian stone vessel workshops in the third millennium BC. Distinctions of shape do not appear to correspond with distinctions of material. The shapes best attested in Mesopotamia, cylindrical vessels and globular jars (akin to pottery forms), are rare and some are not found elsewhere. Again the bowl shapes shared in common by Oman and southern Iran (Fars (Tepe Malyan) and Kerman) are distinctive, whilst vessels divided into compartments, perhaps typical of Baluchistan and the Indus region, also appear in Oman and Kerman.

At Tepe Yahya there is evidence both for primary manufacture and for reworking of carved chlorite vessels (Lamberg-Karlovsky 1988: 52, pl. I, fig. 3c-d). 'All Intercultural Style vessels from Tepe Yahya were smoothed by hand . . . while a few examples from Sumerian sites, such as a vessel with a carved snake design from the Sin Temple at Khafajah, were turned on a lathe' (Kohl 1982: 24). The corpus of material from Tarut Island in the Gulf includes unworked lumps of chlorite and unfinished vessel fragments, among them two partially worked 'Intercultural Style' vessels decorated with combatant snakes (Zarins 1978: nos. 110, 251, pls. 72b, 75b:605). Plain vessels were lathe-turned. Excavations on the island of Failaka off Kuwait have yielded many carved bowl sherds considerably earlier than known settlement on the island, presumably assembled for recycling (cf. Carter, T.H. 1989).

In the main repertory three basic shapes have been isolated: cylindrical bowls; jars with more or less straight sides narrowing towards the top; globular storage jars (cf. Kohl 1974: 202-9; Baudot 1987: 4 ff.).

Kohl's (1974: 227 ff.) pioneer survey did not indicate that particular schemes of decoration were preferred in specific areas nor that individual sites favoured vessels with particular motifs. However, it may be cautiously stated that the 'hut' and a series of simple geometric designs were more common in Iran than in the Gulf. In Mesopotamia, notably on vessels found at Mari and sites in the Diyala Valley, the favoured patterns were those involving complex figured designs with snakes, zebus, and human-headed eagles as well as palm trees and scorpions. Some of these vessels, notably those decorated with combatant snakes, had coloured inlays of various materials set into cavities cut into the designs. Allowing for some individual exceptions, both these categories of vessel were found at Tepe Yahya. In Mesopotamia there appears to be a tendency for patterned vessels to appear in richer graves. For example, all, save one in the royal tombs at Ur and vessels in temple repositories, are of this type (Potts, T.F. 1987). Although these vessels concentrate in élite contexts in Mesopotamia (palaces; temples; rich graves) their distribution in cemeteries in the Gulf and in Iran requires caution in offering single, all-embracing socio-economic or ideological explanations for their wide currency (reviewed by Lamberg-Karlovsky 1988: 53–5).

Kohl (*et al.* 1979: 147–8; cf. 1975: 29–30) has described his analytical studies as follows:

It proved extremely difficult to obtain meaningful separation of a large fraction of this soft-stone material. A major source of our difficulty was the variety of the chlorites present in the Tepe Yahya area. As most of our source samples came from this area, their diversity seriously undercut our attempts to define a Yahya pattern or 'fingerprint' which then could be compared to analyses of artefacts from other areas. Our results allow us to reach the following conclusions:

- (1) I.S. (= intercultural style) material found at Tepe Yahya is consistent with local production; chlorite deposits with compositions similar to artefacts abound in the mountains surrounding the site. Yahya specimens are composed almost exclusively of chlorites that are remarkably free of admixture with other minerals.
- (2) Separate talc, i.e. steatite, sources appear to have been utilized to carve I.S. vessels, although the possibility exists that all of this talc may have come from a single source of great variability. Artefacts from Bismaya, Mari, Tarut, and Failaka and samples from the Arabian peninsula, however, suggest the existence of separate talc sources.
- (3) Material from the site of Bismaya (Adeb) is highly distinctive. This is true not only of the overwhelming predominance of talc examples from this site but also of the diverse and extremely atypical chlorite specimens.
- (4) Tarut and Failaka islands appear to have imported their soft stones from a variety of sources. [Tarut may have been drawing on sources 150 to 200 miles southwest of Riyadh (cf. Potts, D. 1990: i. 67).]

- (5) Chlorites from Nippur, Khafajeh, Kish, and Ur show remarkably similar composition, probably suggesting that they received their chlorites from the same still-to-be-identified source. Occasional non-chlorite specimens from these Sumerian sites indicate that they too had access to additional soft-stone sources.
- (6) Chlorite artefacts found on the Arabian peninsula fall into two highly separate groups. This evidence suggests the possibility of two chlorite sources in Eastern Arabia (see note on 4 above).
- (7) A separate talc-chlorite-dolomite source has been established for Iranian Khorasan and a chlorite-quartz deposit may exist in or near Iranian Seistan [a talc-chlorite-dolomite stone is currently used by stone bowl manufacturers in Meshed].
- (8) Less conclusively, the resemblance between chlorites from Susa and Mari, on the one hand, and these two sites and Yahya on the other, may suggest that some of the trade in I.S. vessels was conducted overland or, at least, bypassed southern Mesopotamia.

The chronological range of the *série ancienne*, in all its variety, is extended. Examples appear first in excavations in Mesopotamia in Diyala Early Dynastic II. From Adad (Bismaya) there is a sherd inscribed for King Mesilim in Early Dynastic IIIA (Delougaz 1960: pl. IXa; Cooper 1986: 19; Ki 3.3), and a vessel from Iran with a Sumerian inscription broadly dated to Early Dynastic III (Amiet 1986, fig. 73). There are stray indications that there is an even earlier tradition behind the appearance of such vessels in Mesopotamia in the second quarter of the third millennium BC. From levels at Uruk of the later fourth millennium came a fragment of 'bituminous limestone' carved with a snake very like the 'combatant snake' on the vessels of *série ancienne*; a vessel of *série ancienne* is incorrectly said to be of 'bituminous limestone' elsewhere in the Uruk reports (Lenzen 1961: 24 ff., pl. 1, c; cf. Nöldeke *et al.* 1939: 20, pl. 24). A chlorite 'handled weight' from Taylor's excavations at Ur has motifs—eye and rosette patterns—strongly reminiscent of inlays on stone vessels of Uruk IV–III (Gadd 1934: 43, pl. XII: 1; cf. Heinrich 1936: pl. 26). Such distinctive 'handled weights' are intimately associated with the *série ancienne* chlorite vessels with which they appear to be contemporary.

Vessels of the *série ancienne* occur in Mesopotamia well into the Akkadian period with half the well-stratified fragments coming from a destruction level at Mari on the Euphrates, where a *terminus ante quem* is provided by a group of metal vessels inscribed for daughters of King Naram-Sin (c. 2254–2218 BC) (Parrot 1955: 195; 1974: 90). Fragments of a *série ancienne* vessel inscribed for King Rimush (c. 2278–2270 BC) from Ur were found in the *Enunmah* in a deposit below a pavement laid down in the Kassite period (Woolley 1956: 168, pl. 36:U.231). Other isolated finds, commonly assumed to be survivors or heirlooms, might sustain the case for believing that production went on for

longer in the third millennium than is usually acknowledged. These are, particularly, a double vessel from the Inshushinak Temple at Susa (Amiet 1986: fig. 70) built by King Shulgi (c. 2094–2047 BC) (Mecquenem 1911: 67 ff.); a vessel from Nippur in a context dated to the Ur III period (Peters 1897: caption for plate opposite p. 140; cf. Kohl 1974: 151); and an example from below an Ur III structure at Uruk (Kohl 1974: 194). The chronological significance of the many sherds retrieved from the settlement at Failaka, founded in the Ur III period (Kjaerum 1980: 45), is also equivocal, since there is no evidence there for manufacture. These pieces may have been scrap assembled for use as raw material in the local production of stamp seals.

In the years since Kohl's research was first published, the date of the chlorite workshops at Tepe Yahya represented by finds in levels IVB and IVA has become controversial. Kohl gave the Yahya production a range of date within the periods Early Dynastic II–III, primarily through the contexts of *série ancienne* vessels found in Iraq. However, it may not be assumed that production at Tepe Yahya covered the entire period during which these vessels were being made in Iran. Nor can it be taken for granted, on a partially excavated site, that the workshops found were the only ones located there. Kohl's (1974: 229 ff.) argument offered no hard evidence that vessels from the excavated workshops were actually reaching Mesopotamia in Early Dynastic II–III, when *série ancienne* vessels seem to have arrived there in greatest numbers.

It is now increasingly argued, on the basis of ceramic and glyptic evidence, that level IVB at Tepe Yahya should be dated to the later third millennium BC c.2200–2000 BC, not to c.2600–2500 BC as Kohl (1979: 62) concluded (cf. Miroschedji 1973: 23–5; Carter, E. 1984: 205 ff.; Amiet 1986: 160 ff.). If the workshops at Tepe Yahya were active from the later Akkadian through the Ur III Periods, this would not be inconsistent with the pattern of occurrence in Mesopotamia, though by that time these vessels may well have been arriving in smaller numbers than before. If these vessels were primarily arriving in Mesopotamia as booty not as traded goods, they may have disappeared from the area not because production had ceased in Iran, but because Mesopotamian rulers concentrated their campaigns in other regions after the Akkadian period (Potts, T. F. 1989).

Both the emergence of the often hybrid motifs of the *série ancienne* and the mechanics of their distribution were clearly processes of considerable complexity, interrelating artistic motifs of Mesopotamian and Elamite origin, some current since the prehistoric period (cf. Amiet 1986: 137–8), with materials of diverse character and origin in workshops whose locations, save for those at Tepe Yahya, are at present unknown. Interpretations as diverse as the objects themselves do

little more for the moment than emphasize how impossible any comprehensive explanation is (contrast Amiet 1986: 137–8 with Kohl 1977: 77 ff.).

Vessels are not the only category of chlorite artefacts decorated in the same style as the *série ancienne* that have a wide distribution. 'Handled weights' were manufactured at Tepe Yahya (Kohl 1979: 71; cf. Lamberg-Karlovsky and Kohl 1971: 16). Eastwards they have been reported in Afghanistan and in Uzbekistan. In Mesopotamia a finely decorated example was found by Taylor in excavations at Ur in 1853–4: 'this stone is a kind of grey slate or schist, and is consequently very liable to flake away' (Gadd 1934: 43, pl. XII.1); another comes from the pioneer excavations at Nippur (Miroschedji 1972: 159, pl. v, fig. 7); and a third is said to have been bought at Palmyra (Godard 1938: 310, figs. 212–13). Comparable objects, in various stones, are reported from the excavations at Susa, where they are dated to the late prehistoric period (cf. Amiet 1986: 136, pls. 13–16).

At Tepe Yahya there is evidence for some overlap of the *série ancienne* and the *série récente* (Lamberg-Karlovsky 1970: fig. 21R, pl. 24E; figs. 23J, T, pls. 23E, 24A: level IVB). In fact, the two groups have little in common save the raw material and even that is, at least to the eye, distinct. It is grey rather than greenish-black in colour and is easily distinguished by eye from the earlier range when the two are set side-by-side. The new repertory of shapes is broader, including hemispherical bowls and boxes, though the most popular shape in the earlier group, the cylindrical vessel, persists. Decoration is minimal and wholly different from that found in the *série ancienne*. It consists of simple geometric designs made up of incised circles with central dots and simple linear designs. The pattern of distribution also diverges from that currently established for the *série ancienne*. It is, in short, a quite separate phenomenon.

The earliest dated vessels of the *série récente* category in Sumer are those from graves attributed to the Akkadian period at Ur (Woolley 1934: U.9020, 541, pl. 245:53 from PG 473; U.10547, 559, pl. 245:52 from PG 899). The same site yielded two fragments of a vessel bearing a damaged inscription of King Naram-Sin (c.2254–2218 BC) referring to 'booty of Magan' (Potts, T. F. 1989: 133–4, fig. 10). Other fragments bear inscriptions of the Ur III period (Miroschedji 1973: 27 ff., n. 116; Amiet 1986: fig. 88) and the series continues to appear in Mesopotamia in contexts of the early second millennium BC at Larsa, Uruk, and Ur (Huot *et al.* 1983: 209; Ratnagar 1981: 119; Woolley 1974: pl. 49:6; 1976: pl.100:1, 6). The chronological significance of an example published from the Early Dynastic cemetery at Tell al-Ubaid is uncertain (Hall and Woolley 1927: pl. LXII: type XXXV; cf. Woolley 1976: 224, pl. 100:6). If it is indeed from a grave of the

Early Dynastic III period, it would be the earliest vessel of the *série récente* recorded in Sumer; but, as this site has remains of the Ur III Period, it is best attributed to that horizon until supporting evidence for the earlier date appears elsewhere (cf. Hall and Woolley 1927: 14, 191: C.19). At present vessels of the *série récente* are less commonly reported from Mesopotamia than are those of the earlier series. They are rare in ordinary graves. They more usually appear as votives in temples, where they were dedicated by major rulers, provincial rulers, and private citizens.

Recent research in Oman (Potts, D. 1990: i. 106–10; 249–52), and continuing reports of *série récentel**série tardive* vessels from Iran through into 'Bactria', steadily allows for finer definition of the likely source of the examples reaching Mesopotamia, where they are reported from Abu Hatab, Larsa, Telloh (Girsu), Uruk, and Ur (Miroschedji 1973; Ratnagar 1981: 119; Amiet 1986: 164). They divide chronologically into two groups dated on either side of 2000 bc. The earlier group has parallels in the islands of the Gulf, in Oman, in Iran, in Baluchistan, and in Pakistan; the later in Arabia, the Gulf, Iran, and Oman, where it overwhelmingly predominates. The material is typically a light grey chlorite, widely available in Oman (Cleuziou 1981: 290; Hauptmann 1985: 15 ff.; Becker 1985). Other types have distinct distributions. One, associated particularly with Baluchistan, appears not yet to be represented in the south of the Gulf, in Sumer, or in 'Bactria', though its products penetrated eastwards to Mohenjo-daro and along a westward route from Shahdad and Yahya to Susa. A 'Bactrian' group, like other objects associated with this complex of cultures, reached as far west as Susa, but does not appear to have penetrated into Babylonia (cf. Potts, T. F. 1987).

It is likely that vessels of the *série récente*, unlike their predecessors, were traded as much for their contents as for themselves. Lead oxide is mentioned in relation to them at Shahdad (Miroschedji 1973: 33); others may have contained unguents (cf. Amiet 1986: 164). If, as seems probable, they reached Sumer for the most part as elements in the flourishing Gulf trade, their disappearance may be accounted for by the reduction and gradual cessation of direct trade with Oman early in the second millennium bc (Oppenheim 1954; Leemans 1960).

This extended treatment of 'steatite/chlorite' has carried this account forward out of step with other categories of stone vessels to which the following paragraphs return. The tradition of relief carving in soft, light-coloured stones is carried through the Early Dynastic period by a series of vessels, perhaps predominantly for cosmetics or unguents, borne on the backs of animals, primarily bulls (or cows) and calves, or carried in the hands of human figures (cf. Amiet 1977: pl. 299). As such vessels (Behm-Blancke 1979: *passim*)

have been reported both from temple and domestic contexts at sites in the Diyala Valley, at Fara, Nippur, and Ur, they do not appear to have been exclusively votive shapes, though they were clearly used in this role quite commonly.

Steinkeller (1982: 251) has suggested that the soft stone termed *marhashu* (CAD M/1: 2) used for bowl and oil containers, which takes its name from *Marah-ashi* (*Parahshum*), a region in south central Iran, may be the chlorite or steatite used for vessels in the third millennium bc. As the particular reference to 'alabastrons filled with perfumed oil' (CAD) is of Neo-Babylonian date, caution may be in order, since at this period the surviving material evidence would favour calcite (or possibly gypsum) in such a context. This stone would also be more appropriate for the stela of *marhashu*-stone attested in a text of Sharkalisharri (Frayne 1984: lines 72 ff.).

Outside Ur, even in Early Dynastic III, the relative rarity of stone vessels in private graves points to the gradual eclipse of the industry save for restricted purposes. In the graves at Tell al-Ubaid about one grave in three contained a stone vessel; at Khafajah one in six; and about one in twenty at Abu Salabikh and Kish late in the period (Martin 1982: 16 n. 19; Martin *et al.* 1985: *passim*). They generally appear in the more richly equipped graves. The rapidly declining occurrence of stone vessels in burials at Ur throughout the Akkadian period culminates in their virtual absence thereafter from graves at this site, save as cosmetic containers. Reliable published evidence from elsewhere remains scarce, but what there is does nothing to confound this general conclusion (cf. McCown 1967: 79).

The independent light thrown by inscriptions on the stone vessel industry before the Ur III period is slight; but they do include some special categories like stone mortars or exceptionally large vessels dedicated for temple use (Braun-Holzinger 1991: 115–50). In an inscription on a fragmentary calcite vessel found at Nippur, Entemena of Lagash recorded that 'he had (this) large vase brought down from the mountains for Enlil's flowing water' (Cooper 1986: 64). If read literally, this might indicate manufacture in or close to the quarry, at least for large vessels. The scale of production of stone vases until late in Early Dynastic III in royal workshops is remarkably indicated by a long inscription of Lugalzagesi of Lagash, arranged in three or four columns, carved on well over fifty calcite vessels of varying shapes and sizes. They were dedicated as containers for food offerings and libations in the temple of Enlil at Nippur (Hilprecht 1896: 51 ff., pls. XVIII–XIX; cf. Cooper 1986: 94–5). Large stone vessels, some carved with relief scenes, were also produced for temple use in the Akkadian period (cf. Layard 1853: 595, figure) and decorated stone vessels are now beginning to emerge amongst the debris from Akkadian

buildings in the north, as at Tell Brak (Oates and Oates 1989: 202–4, fig. 5; 1991, fig. 6).

One type of vessel needs special comment. Although they were predominantly made of baked clay, offering-stands of stone are recorded in the third millennium bc, notably a fine example in serpentine inscribed for Gudea's wife (Caubet 1991). As large pieces of hard stone would have been rare and valuable, soft porous chalky limestone or sandstone was also used, suggesting that such stands were for dry offerings. Caution is required, as so often, with gypsum as it may be either the natural stone cut to shape or plaster-of-Paris moulded and occasionally inscribed, as with a stand dedicated to Geshtinanna at Telloh in Gudea's time (Foster and Foster 1978). In this case the plaster may have been heated to a high temperature in order to make it harder than was usual for ordinary gypsum plaster.

At Ur in graves attributed to the earlier second millennium bc Woolley recorded stone vessels in only three out of 198; two were of steatite (one a miniature) and one of limestone (Woolley 1976: 185; graves LG 51, 113, 169). No stone vessels were reported from domestic contexts. One was found in a minor shrine, but the majority were in major shrines on the Temenos, where they appeared, often inscribed, as votives. This trend continues at Ur. There were no stone vessels in the so-called 'Kassite graves' and only one calcite vessel in 98 graves dated to the Neo-Babylonian period (Woolley 1962: 66 (U. 17183), 125). By the Persian period, to which 286 graves were attributed, two had standard alabastra (graves 104, 112), one a double-column-shaped kohl-pot of marble (grave 113), and one an unusual small limestone bowl with encircling decoration of relief petals (grave 132) (Woolley 1962: 103–4). It appears that in the course of the Akkadian period the use of stone for a wide range of vessels used in daily life, as well as in religious contexts, had given way to restricted production, or import, of high-quality vessels, predominantly recovered by excavators in the debris of shrines. These are commonly represented in the published record only by inscribed vessels or fragments of them (cf. Heinz 1989; Braun-Holzinger 1991: 92–218).

The oldest recorded royal inscription on 'alabaster' vessel fragments, is of Enmebaragesi, King of Kish, one of unknown origin and one from the Temple Oval at Khafajah (Edzard 1959; Delougaz 1940: 146, no. 2) in Early Dynastic II. They open a tradition that runs intermittently, with marked concentrations in the history of certain sites like Adab, Nippur, and Ur through to the first millennium bc. As they are commonly published, if published at all, on account of their inscriptions, they offer little evidence at present for a history of stone vessels. As so often, it is Ur that provides the best indication of the general range and condition of

such collections, which are normally fragments found in debris used in the build-up for new floors in the temple complexes where they had originally been deposited as votives. Woolley has provided a good description of such a context at Ur:

Over the whole room (Room 11 of *E-nun-mah*) was a floor level (or pavement foundation) of beaten earth 0.10–0.15m thick immediately below which, in a well-defined stratum, were very many fragments of stone vases . . . The fragments lay thickest in the middle and at the NW end of the room . . . In the SW wall stamped bricks of Kudur-Mabug(k) occurred below the earth 'floor', so that the latter, and the objects below it, should have been put there at a later date . . . Some of the stone vase fragments were decorated (e.g. U.281, 886, 996); others, *ex votis* from the temple, bore inscriptions some of which gave no names (U.266, 268, 275, 276, 277, 278, 279, 281, 283, 285, 289, 880, 881, 882, 890, 908), while others gave the names of deities, e.g. Nannar (U.288), Nin-azag-nun-na (U.287), of private individuals, a priest of Nannar (U.256, 271) or a patesi of Ud-Nin-Ki (U.274), but more gave the names of kings who range in date from the Dynasty of Agade to that of Larsa. The earliest signed piece gives the name possibly of Sargon (U.221); several that of Rimush (U.206, 231, 232, 251); of Ur-Nammu (U.208, 209, 249, 267, 270); of Dungi (Shulgi) (U.248, 280, a finely decorated and inlaid fragment U.254); of Gimil-Sin (U.247); of Ibi-Sin (U.261); of Ishme-Dagan (U.262); and of Rim-Sin (U.223) . . . (Woolley 1974: 51; for inscriptions see Gadd and Legrain 1928; Sollberger 1965)

The range of stones used for these vessels is wide, embracing the softer light-coloured stones and the harder, dark stones favoured at this time for statuary. Lapis lazuli and green banded calcite are not recorded after Early Dynastic III for vessels though obsidian is (Woolley 1976: U.6702). As both stones are rare in the repertory of seal stones at this time, this may indicate a real absence rather than just a gap in the evidence.

The tradition of relief decoration on stone vessels created in soft stones during Uruk IV, and persisting in a less dramatic way through the Early Dynastic period, is much less easy to trace thereafter through the surviving material. When it is evident, it appears more often to be in the darker, though not necessarily harder, stones favoured by contemporary sculptors. As most such vessels are evidenced only by fragments recovered from debris, their date may only be established through iconography or style which, with small pieces, may often be difficult to classify.

It is possible that in the Akkadian period the triumphal scenes evident in monumental art were also carved on stone vessels placed as votives in temples, to judge from a tiny steatite fragment found at Ur (Woolley 1956: pl. 36, U.7072) and an unprovenanced steatite fragment, of uncertain origin, in the Louvre, showing a prisoner led by a nose-ring on a vessel shape that directly copies metal forms (Amiet 1977: pl. 367). To the Ur III period at Ur belong a small limestone vessel

carved with a presentation scene and a private inscription (Woolley 1956: U.232, pl. 36) and a steatite sherd with a hero and flowing vases (Woolley 1956: U.224, pl. 35; Buren 1933: fig. 30). To the same period probably belong other limestone treatments of this latter motif (cf. Woolley 1956: U.449, pl. 36), sometimes on such a scale that 'basin' is a more appropriate term, as at Telloh (Parrot 1948: 195, fig. 42c).

The outstanding surviving stone vessel of the Ur III period is the tall 'steatite' spouted libation vessel inscribed by Gudea from Telloh (Parrot 1948: pl. XXI; Amiet 1977: pl. 65, 399). It is dedicated to Ningizzida and is decorated in relief with the snakes and the snake-dragons rampant associated with this deity, carrying standards. Their bodies are cut to take coloured inlays. Steatite and sometimes this inlay technique were used in the Ur III period for a series of androcephalous bulls *couchant* at Tello (Amiet 1977: pls. 400-1, 403), for statuary, and reliefs (Amiet 1977: pl. 53, 396). Some vessels, like the stone, may have been acquired from Iran since such designs and inlay shapes were more at home there; notably the intertwined snakes on a steatite 'lid' from Telloh (*Girsu*) (Amiet 1977: pl. 402; cf. Piperno and Salvatori 1983: 183 ff., table 1) and a distinctive type of inlay shape, based on squares, used in a steatite vessel fragment with *couchant* bulls in relief from Ur with traces of an inscription on the base, perhaps of Shulgi (c. 2094-2047 BC) (Woolley 1956: 32, 52, pl. 35; U.239; cf. Piperno and Salvatori 1983: fig. 12). Another inlaid steatite vessel fragment from Ur, only published by Woolley in an over-elaborate reconstruction, retains a single light blue inlay that may be turquoise (Woolley 1956: pl. 36, left: no Ur number; University Museum, Philadelphia). The Louvre has a fragmentary steatite vessel of the Ur III period decorated with a scene of drummers paralleled on Ur-Nammu's famous stela (Moortgat 1969: pl. 200). A bowl of 'pierre métamorphique grise' from Larsa of the early second millennium BC is carved on the outside with recumbent lions flanking lion-maces and women with flowing vases (Huot 1989; cf. Gastel *et al.* 1988).

With the advent of the second millennium in Mesopotamia, decorated stone vessels are very rare in the published evidence (cf. Woolley 1976: 185) and plain vessels are so rare outside accumulations of votives in temple deposits that local manufacture for any general use appears also to have been in eclipse. Of special interest is one of the rare cases of a vessel inscription, for Rim-Sin in the eighteenth century BC, referring to the basalt of which it is made, inlaid with gold and silver (Halla 1963: 141 n. 91). This apparent decline in production may be contrasted with a flourishing stone vessel industry in the court workshops of Syria and Anatolia (cf. Ötzen 1988).

Only one distinctive group of stone vessels of any

size has so far been documented on Mesopotamian sites in the second half of the second millennium BC. These are single- or double-handled jars or amphorae, set on high, hollow feet shaped like potstands, commonly made in a stone described as alabaster (calcite). They are best represented in the richly furnished Middle Assyrian grave 45 at Assur (Haller 1954: 139-40, pls. 31-2), though also appearing elsewhere on the site. The examples in grave 45 are predominantly plain; but one squat version, without handles, is patterned with vertical grooves, and two have figured designs, generally classified by art historians as 'Middle Assyrian' (Moortgat 1969: 113). Similar plain vessels are reported from Brak (Oates, D. 1987: pl. XL1b), Nineveh (Campbell-Thompson and Hutchinson 1930: pl. XXI. 2-4; Campbell-Thompson and Mallowan 1933: pl. LXX. 1-6), and possibly from the pioneer excavations at Nippur (University Museum, Philadelphia: 9207; L.29.220). Adjacent to 'Palais III' at Tchoga Zambil in Khuzistan, Ghirshman found a small cache of comparable handled vessels (Ghirshman 1968: 83-4, pls. LI-LIII, XCIII-XCIV), which he believed were derivative from contemporary metal shapes. Assur grave 45 is now usually dated to the thirteenth century BC (cf. Maxwell-Hyslop 1971: 169), though Moortgat (1969: 113) preferred a date in the fourteenth century BC. A later fourteenth- or thirteenth-century BC date suits the context at Tchoga Zambil.

It is generally agreed that neither the forms nor the stones used for these vessels are Egyptian (Bissing 1940), though such vessels might well have been manufactured under the influence of Egyptian prototypes in Syria, where the shape, with two handles, is represented at Ras Shamra in the fourteenth century BC or later (cf. Caubet 1991: 211-12; 'amphores'). These vessels are commonly made in three separate sections: foot, body, and neck. Bissing (1940), whose knowledge of Egyptian stone vessels was extensive and first hand, identified the Assur examples as products of a local workshop working in a locally available 'alabaster'. Art-historical analysis of the decorated examples tends to endorse this hypothesis (Moortgat 1969: 113). The Tchoga Zambil examples might well also derive from a northern source, traded as much for their unusual shapes as for whatever they contained, most probably an oil or unguent. An unprovenanced vessel of this shape (without the foot), now in the Yale Babylonian Collection, bears a secondary inscription of the Akkadian period referring to 'booty of *Magan*' which was added to it in modern times (Potts, D. 1986: 280-2). This vessel and its inscription consequently have no bearing upon the possible location of ancient *Magan* in Egypt. Egyptian alabaster vessels were reaching Assur in the Middle Assyrian period, but their materials and inscriptions, as well as their shapes, are distinctively Egyptian (Bissing 1940: nos. 1-5; Moran 1987: 99-

100). More enigmatic in their general implications for the history of stone vase production are various Middle Assyrian examples carved in low relief. A marble pyxis lid, of the thirteenth century BC, is carved with a battle scene (Orthmann *et al.* 1975: 331, pl. 255^a). Fragments of a cult stand in schist or shale are decorated with friezes comparable to scenes on seals (cf. Klengel-Brandt 1980).

There is very sporadic evidence for stone vessels on sites in Kassite Babylonia, usually published by virtue of their votive inscriptions (cf. Brinkman 1976: 110, 134). A small jar from Nippur in green calcite with yellow veining, very reminiscent of the stone used in the middle of the third millennium BC, perhaps from sources in the Zagros Mountains, has been attributed to the Kassite period (Quarantelli (ed.) 1985: no. 152 (with plate)). An isolated alabaster vessel, with inscription, is noted in the Aqar Quf (Dur Kurigalzu) excavation report (Baqir 1946: 90). A limestone vessel fragment, with cavities to take an inlaid design of goats and trees, inscribed for Kadashman-Enlil I or II of Babylon, was found in Hasanlu IV in Iran (Brinkman 1976: J.2.9 = Pigott 1989, fig. 16). This distinctive technique of decoration was also used in Kassite glass.

As the Neo-Assyrian state emerges, scattered evidence once again provides indications of local production of stone vessels, at least in court workshops. It is only through vessels with datable inscriptions that a crude sequence may be established, as good archaeological contexts, even when properly recorded, concentrate in the last century of the Neo-Assyrian empire. A rim fragment in a soft black stone from Rawlinson's excavations in 1852 at Sharif Khan (ancient *Tarbišu*), 5 km. north-west of Nineveh, is decorated with encircling horizontal friezes in low relief in typical ninth-century style. It bears a dedication to Nergal of *Tarbišu*, probably from the reign of Shalmaneser III (c.858-824 BC) (Curtis and Grayson 1982: 91, pl. IIIC: BM 90960). A base fragment from a comparable cup-like vessel was found at Nineveh (BM 98860: Curtis and Grayson 1982: 91 n. 42). Such vessels seem also to have been carved in light stones, limestone and marble, at the same period to judge by a ninth-century (?Assurnasirpal II) fragment dedicated to Ninurta from the Temple of Ishtar at Nimrud (BM 91582: Hall 1928a: 51, pl. LX; Grayson 1976: 197) and another (uninscribed) with a scene portraying captives, from the North-West Palace at Nimrud (Mallowan 1966: 183, pl. 119 ND 5335). An enigmatic fragment of a soft dark stone vessel has part of an ostrich hunt in the surviving frieze; such scenes were also depicted on glazed pottery (Hall 1928a: 51, pl. LX: BM 91897; cf. Mallowan 1966: fig. 61). Incised decoration was also used, as for the figure of a priest on the rim fragment of a 'grey stone' bowl dedicated by the chief *kalu* priest in the Nabu Temple at Nimrud, perhaps in the eighth rather than

the ninth century BC (Mallowan 1966: 269, fig. 251).

Inscriptions rarely help with reconstructing the history of plainer vessels. Layard (1853: 197, figure) recovered a small alabastron inscribed for Sargon (721-705 BC) from the North-West Palace at Nimrud, and a squat alabastron in dolomitic limestone, from Rassam's excavations at Nineveh, is inscribed by Sennacherib (704-681 BC) for one of his sons (Walker 1980). The vessel is called a *nahbušu*, perhaps for containing oil as the same term is used in the inscription on one of the large oil-containing alabastra seized by Esarhaddon (680-669 BC) from the palace of King Abdi-milkuti of Sidon (Bissing 1940: 159).

The large Egyptian and Phoenician storage jars of calcite ('alabaster') found in seventh-century contexts in Assyrian palaces form a special aspect of the use of stone vessels and illustrate their enduring role in royal booty and tribute. Examples were recovered from the ruins of the palace of Assurnasirpal II at Assur (Preusser 1955: 21 ff., fig. 3, pls. 103-4). An unintelligible Egyptian hieroglyphic inscription on one example, of a spectacular veined black, white, and yellow calcite, may indicate Phoenician manufacture (Mallowan 1966: 170), but there are no grounds for Mallowan's description of another as 'alabaster of a Persian variety'. It is exactly matched at Assur by an Egyptian vessel (Mallowan 1966: 170, pl. 104; cf. Bissing 1940: no. 8). All these vessels have been associated with Assyrian royal campaigns to the west in the first quarter of the seventh century BC, and a granite vase fragment inscribed for Pharaoh Taharqa from an Assyrian site (though now in Istanbul) has been linked to them (cf. Culican 1970: 31).

The most spectacular of inscribed Assyrian stone vessels well illustrates by its source, the 'Treasury' at Persepolis, how such booty was an enduringly valued commodity. This granite or meta-gabbro chalice inscribed 'Palace of Ashurbanipal . . .' was carefully described by its excavator thus: 'The four equidistant handles are fashioned in the shape of lions, which appear to cling—nostrils flush with the rim—to the shoulder of the vessel. Strips of precious metal may have been applied to narrow bands extending between the lions and terminating in pairs of holes at the sides of each animal. The lions themselves were probably covered in the same fashion, as suggested by depressions at both sides of their chests . . . Two small holes in the forehead of each lion and the hollow eyes had undoubtedly been inlaid, perhaps with semi-precious stones such as turquoise or cornelian' (Schmidt, E. F. 1957: 83-4, pl. 49:1). Comparable use of lions as handles is illustrated by a rock crystal lion's head from Rassam's 1881-2 excavations at Sippar (Walker and Collon 1980: no. 37, pl. 27) and a fragment found by Layard (1853: 597, figure) at Nineveh. Bird-heads were similarly employed on stone vessels

(cf. Assur: Haller 1954: 173, pl. 41). Iraqi excavations at Nineveh (Nebi Yunus) in 1954 (cf. Scott and MacGinnis 1990) revealed a number of dark stone oval and round dishes with bird and animal handles.

It is virtually impossible to establish through material evidence available at present the extent to which there was a regular production of stone tableware for the Assyrian royal court parallel to that evident for the later Achaemenid Persian court through finds at Persepolis and elsewhere (Schmidt 1957: 1; Cahill 1985: 382–3; Amiet 1990). Persistent inadequacy of publication cripples any attempt to offer a coherent account of the uninscribed stone vessels, complete and fragmentary, recovered from excavations at Assur, Khorsabad, Nimrud, and Nineveh, to name but the most prominent sites. Sufficient is, however, scattered through the literature to suggest that the vitality of stone vessel production for palaces and temples is easily underestimated. It also appears that this élite industry was once again using a greater variety of stones, exploiting colour and hardness. A few indicators are all that can be cited here. Part of a rectangular dish, of unknown origin, in a conglomerate stone, is decorated on the reverse with lions rampant on either side of a now headless male figure (Moorey 1984: pl. 81); a similarly shaped dish from Sherif Khan has a handle carved with a horned head like objects in other materials (Moorey 1984: pl. 82; cf. Mallowan 1966: fig. 76 in ivory). A small box-like vessel of chalcedony was recovered from the Temple of Ninurta at Nimrud by Layard (1853: 358, figure). A fragment of a rectangular agate vessel with a six-line Assyrian inscription, perhaps of the ninth century BC, was found in Rassam's 1881–2 excavations at Sippar (Walker and Collon 1980: 99, no. 36); part of an agate tripod bowl is reported from Nineveh (Iraq, 51 (1989), 259). Onyx was used for a dish from Nineveh, engraved round the rim with the name and titles of Esarhaddon (British Museum 118766). Obsidian is still also occasionally evident among stone vessels (Khorsabad: Loud and Altman 1938: pl. 64: 254). The use of rock crystal for vessels may be an innovation of the eighth century BC, perhaps under Egypto-Phoenician influence. It is directly evident at Nimrud in rare fragments with cut decoration (Mallowan 1966: fig. 143) and in the recently discovered royal tombs (see p. 222 here); and indirectly through close imitations in glass (see p. 199 here) (PLATE VA). Unfortunately, it is not possible to date closely an 'alabaster' vessel in the shape of a tube flanked by rampant lions found at Nineveh in the area of the Temple of Ishtar with other 'pieces of alabaster vases'; but it is likely to be Neo-Assyrian (Campbell-Thompson and Hamilton 1932: 68–9, pl. LI:4).

There are cases, as with a 'grey-stone' (?steatite) lion-bowl and a basalt mortar, decorated with a bull's head, from Khorsabad (Loud and Altman 1938: pl. 64:

257, 262) when distinctive types of vessel in specific stones may be identified as imports from regions exploiting their local stone resources, in this case in Syria (cf. lion-bowls, Muscarella 1974; basalt, Hrouda 1962: 66 ff., pls. 51–4). For the most part neither shapes nor stones may be attributed with any confidence to individual regions, particularly when royal campaigns into the highland zone would have brought distant raw materials to Assyrian court workshops and large-scale deportations of people regularly brought foreign craftsmen into Mesopotamia by the late seventh century BC. Stone does not appear to have been much used for vessels in Assyria outside palaces and temples, save for cosmetic palettes (cf. Nimrud: Layard 1853: 358, figure; Campbell-Thompson and Hutchinson 1930: pl. XXII:4).

Evidence from the south is, if anything, even more meagre and scattered. Of Ur Woolley (1962: 103) commented:

it is perhaps worthwhile noting the extreme rarity of stone vases in the later periods; since our evidence does not by any means suggest that the city was then greatly impoverished it would seem that as a general rule metal vessels and glazed pottery had taken the place of stone. In all the ruins and graves of the Neo-Babylonian and Persian times not more than ten stone vases were found.

On the level of the Persian pavement in Room 19 of the *Enunmah* Woolley found a small agate bowl, 'lathe-turned, the central turning-hole filled up with a stone peg' (Woolley 1962: 104, 106: U. 310, pl. 34). The shape is closely matched by a small pink marble bowl from Rassam's 1881–2 excavations at Sippar inscribed 'Property of Marduk' (Walker and Collon 1980: 99, pl. 27:30); both are most likely to date to the sixth century BC. Equally small-scale, and of similar shape, is a limestone bowl from Ur, from a grave attributed to the Persian period, that has 'a petal design in relief on the outside, and a knob handle (broken) and on the inside a rosette' (Woolley 1962: 104, 119: U. 16214, pl. 34). Such isolated finds endorse the general view that where stone, other than calcite or gypsum, was used it was for small cosmetic dishes. The most recurrent shapes through and after the sixth century BC are baggy jars or alabastra of more or less conventional shape in 'alabaster'. But even their distribution may have been that of luxury vessels before the Hellenistic period, since there are only two in the graves of the earlier Achaemenid period at Kish (Moorey 1978: 52), exactly the same number as the glass vessels in this cemetery (cf. McCown 1967: 79: Nippur).

The history and origin in particular cases of the alabastra is difficult to establish. Bissing's (1940; 1942) papers on the examples from Assur and Babylon (cf. Reuther 1926: 28–9, fig. 31) have not been superseded. Indeed, his selection of examples from each of these sites remains all that is readily available for study.

The evidence from Assur, dating before the end of the seventh century, does not include examples of the small alabastra (Bissing 1940). At Babylon Bissing (1942: no. 1) lists a single alabastron, with an inscription of Nebuchadnezzar II. A few were attributed to the Persian period (nos. 33, 2, 4, 17–18, 24–5), many, if not all of which, he judged to be Egyptian imports. The majority belong to the Hellenistic period. As Koldewey only illustrated a single vessel in his account of the workshop for the manufacture of alabastra in the southern citadel, this is equally difficult to date (Koldewey 1914: 72; cf. 1931–2: 65). In Bissing's (1942: 41) view the vessel belonged more probably to the Persian than to the Neo-Babylonian period; but an even later date is not ruled out. As Koldewey (1914: 72) records it, 'a royal manufacture of flasks was established here [in rooms 10–12 of the eastern part of the southern citadel]. A very large number of those graceful vases, which in Greek are called alabastra (fig. 47), were found here, especially waste products of the manufacture.' Alabastra of a small range of recurrent shapes are so widely distributed in the Mediterranean world and the Near East that they have been generally thought to be the product of a few specialist workshops traded for the special oils and unguents they contained (cf. Bissing 1939).

Koldewey's general account of stone vessels from the later levels at Babylon is without chronological indicators:

Storage jars of limestone were of huge dimensions. Bowls, plates and similar forms of slate, serpentine, and finely-veined marble with delicate and graceful outlines were very numerous. Several vases in schist (fig. 178) with a flattened base belong to a very ancient period, possibly prehistoric; they are decorated on the outside with incised lines in imitation of mat-work. There are numerous bowls for rubbing made of basalt, with three short feet (fig. 179), and strong limestone mortars roughly hewn on the outside, but completely smoothed on the inside by use.

(Koldewey 1914: 259)

No reason is given for what may well be a gratuitous attribution of the schist vessels to the prehistoric period. The apparent contrast with Ur might be explained either by the fact that these objects post-date the latest levels uncovered by Woolley at Ur or that more stone was shipped down the Euphrates at this time into Babylon than to Ur, as indeed seems to be suggested by the contemporary use of stone for building.

A pedestal vessel from Babylon, in 'granite', akin to those found in the Treasury at Persepolis, is one of the very rare vessels so far reported from Iraq that might belong to the repertory of luxury stone vessels produced in the Achaemenid period for court use (Amiet *et al.* 1980: no. 154, plate = IM 65629).

(iii) MANUFACTURE

(a) *Methods of study*

In the absence of any comprehensive publication of a stone vessel maker's workshop or systematic publication of relevant wasters or tools from a site in Mesopotamia, reconstructions of the processes of stone vessel manufacture will inevitably be unsatisfactory, based as they are on scattered tools and on deductions for the most part from finished vessels. It is likely that in antiquity wasters were intensively reused as raw material for the manufacture of small stone objects. It has become increasingly common for this deductive approach to be supplemented with information from studies of contemporary craft procedures in those parts of the Near East and Egypt where soft stones are still used for vessel production. This type of argument by analogy is most satisfactory when, as with evidence from excavations at Tepe Yahya and Shahr-i Sokhta in Iran, systematic recovery of ancient workshop debris may be brought forward for comparison with the modern evidence (cf. Kohl 1975; Ciarla 1979, 1981). No study of stone vessel production in modern Iraq is, however, available for direct comparison.

A special place is held by Egypt in the study of ancient stone vessel production, since there the evidence of quarrying, of tools, and of excavated workshops may be combined with explicit illustrations of craft procedures in tomb reliefs (Drenkhahn 1978: 74–8; el-Khouli 1978: ii. 789 ff.; Lucas 1962: 421 ff.). Even in Egypt, where illustrations are not available for the preliminary stages in the quarries, critical questions also remain unresolved. An instructive instance arises from Caton-Thompson's careful description of the Old Kingdom gypsum quarry and associated tools and roughed-out vessels at Umm es-Sawan above the ancient lakes in the northern Fayum Desert (Caton-Thompson and Gardner 1934: 103 ff., pls. LXVIII ff.; selectively extracted in Hester and Heizer 1981: 38–45). Very little evidence was found among the debris of anything but solid, roughed-out vessel shapes. These vessels seem to have been hollowed out and finished elsewhere, though roughed out at the quarry in a restricted series of standard shapes. Thus numerous chipped stone crescentic 'drills' or 'grinders' found at this site almost certainly need to be distinguished in function from the lenticular conical pieces of diorite, limestone, quartzite, and sandstone that served to hollow out vases both in Egypt and Mesopotamia. These chipped stone crescents were probably used in some way to grind out the rough shapes from larger blocks, not to hollow out individual vessels (cf. Hester and Heizer 1981: 14). Such crescents are not reported from Mesopotamia nor from Crete (cf. Evelyn 1980).

(b) Workshops

It is unfortunate that reported stone vessel workshops of the Late Prehistoric and Early Dynastic period at Uruk (Vétesalji, 1988: 23) and of the mid-first millennium BC at Babylon remain unpublished in detail. At Uruk Lenzen (in Nöldeke *et al.* 1939: 18, pl. 27) noted that he had found the workshop of a stone vase-maker in area Lb XII 5, where the remains of an urban quarter of the earlier third millennium BC were excavated: 'Handwerkszeug, vor allem Bohrkerne, fanden sich in allen Härten und Grössen, dazu Steingefässe und Steingefässcherben aus allen Entwicklungsstufen, vom roh behauenen Stein bis zum fertig gearbeiteten und polierten Gefäss.' Wartke (1979), in assembling a selection of the hard stone vase-borers shaped like figures-of-eight from the Uruk excavations (now in Berlin), demonstrated that they were numerous and ubiquitous at the site (cf. Eichmann 1987). He showed that their distinctive form hardly changed at all from prehistoric to Neo-Babylonian times (see below). They were clearly great survivors, often found out of context. Unless encountered in direct association with other workshop debris, they indicate little about the location or date of workshops. They were almost certainly as common on other major sites as at Uruk, but have rarely been collected or recorded by excavators (cf. Woolley 1956: pl. 13 U. 16405; Nineveh: Campbell-Thompson and Mallowan 1933: pl. LXX, 16-19).

Koldewey was as cursory as Lenzen in his description of the discovery of a workshop producing alabaster, some time between the sixth and the third centuries BC, in the region of houses 10-12 in the eastern part of the southern citadel at Babylon: 'For the purposes of hollowing them out (i.e. alabaster) a crown-bit (*Kronbohrer*) was used first of all, which cut out a cylindrical piece and afforded room for other boring instruments. Masses of these cylindrical cores were found here' (Koldewey 1914: 72; cf. 1931-2: 65).

(c) Drill-bits and drills

Even from Egypt, where organic materials so often survive, no drill of the type used to hollow out stone vessels has yet been published, though illustrations in tombs indicate their form (Drenkhahn 1978: 74-8; el-Khouli 1978: pls. 146-7). Modern reconstructions are based on the standard hieroglyph for the word 'workman' (Gardiner 1957: U. 25; el-Khouli 1978: pl. 145; Goyon 1970: fig. p. 157) and scenes in tombs. In the third millennium the Egyptian vase-maker's drill had a straight wooden shaft, with an inclined and tapered handle at the upper end; two stones, or bags of sand, were suspended on either side at the top just below the handle. In the earlier second millennium BC, drills with a single stone weight, secured to the shaft through a hole at its centre, appear side-by-side with double pen-

dant weights. In the later second millennium BC, the single weight appears to be predominant. The wooden shaft is shown in the hieroglyph, with a forked base and a line (or pin) across it. This tool appears to have been used to drive both tubular copper bits, which Goyon (1970: figs. 14-15) ingeniously argues were secured by the transverse pin shown in the hieroglyph, and figure-of-eight stone bits.

As comparable stone borers were standard in Mesopotamia from earliest times, it is assumed, in the absence of explicit illustrations, that they were fitted to vertical shafts like those used in Egypt. As drill-bits used with an abrasive wear away the forked wooden end, it is more efficient to have a separate piece lashed on to the lower shaft so that it can be replaced when necessary. Tubular drills of copper, examples of which are so far unrecognized on a Mesopotamian site, might also have been fitted to such drills if required in the manner argued by Goyon for Egypt. It is significant that no Egyptian representation of stone vase manufacture depicts a bow-drill in use for hollowing out vessels (but compare Crete: Evely 1980: 136). They appear only to have been used for piercing beads and drilling small holes in woodwork (Drenkhahn 1976: 46 ff.). Modern experiments with a bow-drill fitted with a copper tubular bit for drilling stone vessels have shown that mechanical stresses make damage to the vessel extremely likely (Stocks 1986: 15).

Modern reconstructions of stone vase manufacture as depicted on Egyptian reliefs have shown that these vertical twist/reverse twist-drills can be managed in exactly the same way as is shown, with one hand gripping the top of the shaft, the other placed just below the weight (Stocks 1986: 16; cf. Sleeswyck 1981). These experiments also demonstrated, as many Egyptologists have argued (cf. Reisner 1908: i. 105, fig. 197), that after the appearance of metal 'figure-of-eight stone borers . . . follow the use of tubular drills in stone vessel production, and are required for undercutting operations . . . In order that a symmetrical hole be produced, it was necessary to either partially rotate the vase periodically or take a new grip upon (the drill) when a full twist to the right or left had taken place. The second solution was adopted after embedding the vase in an earthen bench socket which took account of methods in use in an ancient vase grinder's workshop in Hierakonpolis' (Stocks 1986: 18; cf. Quibell and Green 1902: pl. LXVIII).

It has been suggested that men boring stone vases are shown on the late prehistoric 'Blau Monuments', whose origin is unknown (cf. Mallowan 1965: 65-6; Strommenger 1964: pl. 15; see PLATE VI A here). The accompanying pictographic texts, in so far as they may be understood, offer no independent evidence for this conjecture, since they record field sales (Edzard 1968: 171-2). Indeed, the scenes may show the pounding of

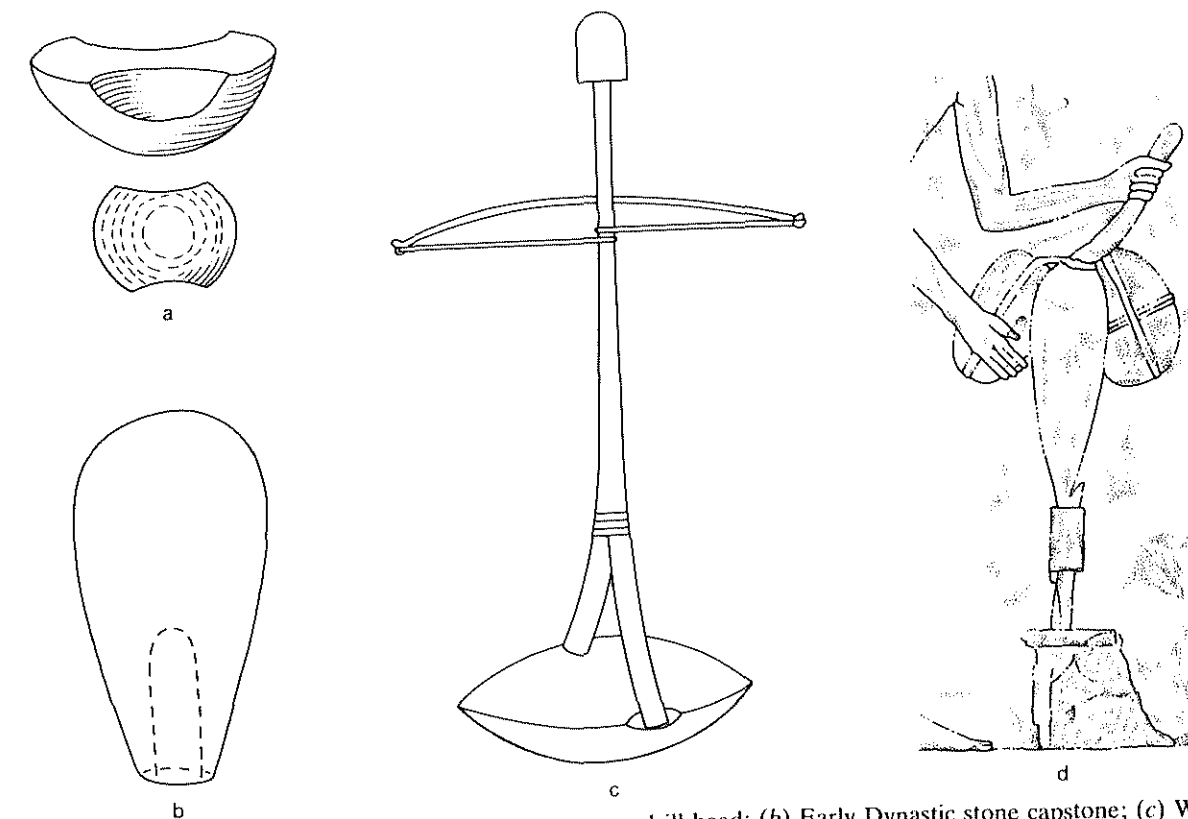


Fig. 5. Drills and drill-fittings: (a) Early Dynastic stone drill-head; (b) Early Dynastic stone capstone; (c) Woolley's reconstruction of a complete drill (all after Woolley 1956: pl. 13: U. 16405, pl. 15: U. 14925, fig. 5); (d) Egyptian representation of drilling from the tomb of Sahuré at Saqqara, c. 2450 BC.

grain with large wooden pestles, a symbolic ceremony later associated with slave sales (cf. Edzard 1970).

Distinctive figure-of-eight hard stone drill-bits appear with the earliest stone vessels in Mesopotamia and endure throughout, though rarely published. At Jarmo Moholy-Nagy (1983: 294, figs. 132:7, 140:8) reports 'large drill-bits . . . quite flattened spheroids of ground stone with waisted opposite edges' appear early in the history of stone vase manufacture. These were of hard stone, probably of indurated sandstone, shaped exactly like the vase borers familiar in Egyptian archaeology millennia later (cf. el-Khouli 1978: pl. 144: centre; Schmidt, K. 1988). It is also possible to identify the capstones for drills among the stonework found at Jarmo (cf. Braidwood, L. S., *et al.* 1983: fig. 132:3). Comparable capstones and drill-bits were recognized by Woolley in the late prehistoric levels at Ur (Woolley 1956: pl. 13: U. 1640; pl. 15: U. 14925). Woolley (1956: 14, fig. 5) reconstructed them as parts of a bow-drill: 'The stone borers for hollowing stone vases . . . are common in the Uruk and Jamdat Nasr periods; the drill-point is a circular stone flat on the top and curved underneath, and from each side a piece is cut out for attachment; the shaft of the drill would be made of two pieces of wood laid together (or one piece forked at

one end) . . . this gripped the stone drill head and was revolved by a bow, the top being held in a cupped stone handle.' It may be that, as in Egypt, these drills were operated just by hand without the use of the bow. A figure-of-eight drill-bit of uncertain date from Ur has been geologically identified as impure algal limestone (Ashmolean Museum 1935-764); examples from Uruk are of dolomite, limestone, flint, and perhaps basalt (Eichmann 1987: 110).

Although such stone drill-bits were in use well into the first millennium there is no independent evidence for the method of mounting and driving them. As most surviving vessels have polished surfaces it is difficult to reconstruct from tool-marks how they were hollowed out. Woolley (1955: 14 n. 3) described one unfinished and undated steatite vessel from Ur (U. 18754) as follows: 'The outside has been very roughly shaped. The inside has been gouged out with a chisel whose blade was 0.006 m. wide—the tool-marks are well preserved. The next stage would be to use the grinder to complete the roughly-made hollow, and the outside would be finished only when the more difficult work of the inside was safely accomplished. This is the method with soft stone such as steatite; with the harder stones there would be no chisel work and the hollow would

be produced entirely by grinding' (cf. in Crete: Evelyn 1980).

Ternbach (see Porada 1977: 12 n. 2), in examining a late prehistoric stone vase, concluded that 'there had been six drillings at almost regular intervals forming a circle about 6 cm. in diameter'. He also thought that vessels in the Early Dynastic period had been hollowed out with a tubular metal drill in the same way. The cylindrical cores produced by such activities have been reported from Egyptian sites, but seem to be largely absent from the Mesopotamian literature until Koldewey's (1914: 72) reference to them at Babylon in the first millennium BC. They do, however, turn up from time to time in museum reserve collections, and some pestles, perhaps even some of the earliest cylinder seals (cf. Porada 1977), may first have been cylindrical stone-vessel cores.

Away from a certainly identified workshop for the purpose, the tools used in the production of stone vessels, whether of stone (cf. Roodenberg 1986: 143) or metal, may not be identified. It may only be supposed that, apart from the drill-bits and capstones just described, the metal repertory progressively introduced from the late fourth millennium BC included chisels, saws, knives, and drill-bits appropriate to vessel manufacture.

(d) The pattern of production

No more than a formal description of stone vessel manufacture in Mesopotamia may be offered here in the absence of evidence from a recognized workshop. The basic techniques of production with stone tools and abrasives had been developed in the earliest settled farming communities of northern Mesopotamia. It is only with the introduction of tubular copper or copper alloy drill-bits, fed with abrasives, that significant changes emerged and may, in part at least, account for a boom in stone vessel production in the centuries on either side of 3000 BC. At all times there would have been a broad distinction between working in soft stones (Mohs 2-3), where cutting tools alone might suffice, and in hard stones, where drills and abrasives would have to be deployed. In general, and this would have been very important in Mesopotamia where good stone was valuable, wastage of material is minimized if all processes involving large-scale excision of stone and accompanying risks of damage precede decoration and surface finishing.

1. Finished vessels offer no clues to initial procedures. It is likely, on Egyptian comparisons, that vessels were either roughly outlined in silhouette close to the source of the raw material or else stone pieces of portable size were prepared for transport. Further shaping in a workshop probably preceded hollowing out.

2. The most risky point of production was the hollowing out, for on sites in Iran where unfinished vessels are reported this is the stage at which they most often seem to have broken. Without a series of unfinished vessels, any reconstruction of the procedures of hollowing out is necessarily speculative since a wide variety of methods for gouging and drilling could have been employed, both before and after the introduction of metal tools. Moreover, at this stage, there were probably sharp distinctions between methods used with the softer stones and those employed for the harder ones. In the Tepe Yahya workshop Kohl (1975: 22) believed that flint and metal tools had been used for shaping and hollowing out chlorite vessels; he did not believe any had been lathe-turned at this site. Zarins's (1978: 67, pls. 74-5) study of the scattered third-millennium steatite industries of Tarut Island, off the coast of eastern Saudi Arabia, revealed partly shaped vessels for transshipment elsewhere; vessels smoothed and finished on a lathe; vessels recut and reused locally; and vessels repaired with copper studs. Some softer stones may have been soaked in a liquid to prevent fracturing; modern Egyptian workshops use a glue like that employed by carpenters. In drilling, a central cavity would have been made before use of the distinctive figure-of-eight stone drill-bits for further hollowing out. Once tubular copper drill-bits, fed with abrasives, were introduced, this would have produced a cylindrical core. Before that the interior would have been more crudely chipped or ground out to provide a suitable cavity in which to operate a rotating drill.

3. The surfaces were polished, after the interior had been hollowed out, with hand-held stones and abrasives. At this stage any detail was worked on the outside with cutting tools of stone or metal. External decoration is generally rare on stone vessels manufactured in Mesopotamia. In the Early Dynastic period this may partially be explained by the custom of carrying them in a case of plaited straw or basketwork (cf. Woolley 1934: 381, pl. 105; U. 10556), sometimes evident in ghost impressions on the side of stone vessels or in imprints left by the bitumen in which the basket had been dipped (cf. Woolley 1934: 381, pl. 178; U. 7645). Significantly, the very rare incised patterning on limestone vessels at Ur appears to have been inspired by woven patterns (Woolley 1934: pl. 177; U. 8190, 8239). Elaborate relief decoration and other forms of ornament may have been confined at all periods when they were current in Mesopotamian workshops to vessels made for temple or funerary use, as were inscriptions.

In conclusion, Woolley's summing up retains its cogency: 'It is almost certain that the hollowing out of the vase was done when the outside had been only roughly chipped to shape and that the fine cutting of the walls from the outside was the last process of all; this would explain why in some of the finest vases an

imperfection of the stone which interferes with the regularity of the contour has been left and at best slightly "faked"; the interior having been already hollowed out the wall could not be ground further back so as to circumvent the fault as would have been done if the stone were still a solid lump' (Woolley 1934: 38).

4. *Repairs*. There is ample evidence, particularly among stone vessels from graves of the Early Dynastic period, for repairs (PLATE VB). They were usually achieved either by patching after the side or base had been inadvertently drilled through (cf. Moorey 1978: fiche 4, plate = Ashmolean Museum 1929.338 (Kish)) or more commonly by riveting breaks with lead plugs or copper wire set into specially drilled holes (cf. Moorey 1978: fiche 2: F.01 = Ashmolean Museum 1929.368 (Kish); cf. Mackay 1929: 200).

(e) Sample identifications of stones used for vessels

1. Ashmolean Museum, Oxford.

Identified in 1984 by Mr Al-Murani, Department of Earth Sciences, University of Oxford.

Kish (Oxford-Field Museum, Chicago, Expedition): Cemetery Y, Early Dynastic I:

1929.307: shallow dish of altered basaltic lava; tomb 539; Moorey 1978: fiche 2: E.14.

1929.367: straight-sided bowl of altered basic igneous rock; tomb 479; Moorey 1978: fiche 2: F.02.

1929.368: bowl in fine-grained marble, restored in antiquity; tomb 479; Moorey 1978: fiche 2: F.01.

1929.392: bowl of calcareous sandstone/impure limestone; tomb not recorded; Moorey 1978: fiche 2: D.06.

1931.409: straight-sided bowl in calcite; tomb 614; Moorey 1978: fiche 2: F.04.

1931.416: straight-sided bowl in epidotized basalt; rivet-holes for ancient repair; tomb 685; Moorey 1978: fiche 2: G.01.

Telloh (dealer's attribution): Early Dynastic III:

1921.871: cylindrical jar of calcite; repaired in antiquity; cf. Woolley 1934: pl. 241: type 4 for the shape.

Ur (British Museum-University Museum, Philadelphia, Expedition): 'Royal Cemetery'; Early Dynastic III:

1931.452 (?PG 1613): bowl of chlorite carbonate schist; cf. Woolley 1934: pl. 245: type 50.

1933.240 (no field number): bowl of chlorite; cf. Woolley 1934: pl. 245: type 51.

1935.751 (U.19805): bowl of gypsum; cf. Woolley 1934: pl. 250: type 102.

1935.752 (U.19529?): bowl of basic lava; cf. Woolley 1934: pl. 244: type 41.

1935.757 (no field number): small bowl of altered lava; cf. Woolley 1934: pl. 242: type 19.

1935.758 (U.19657): bowl of altered olivine-dolerite; cf. Woolley 1934: pl. 244: type 37.

1935.760 (U.19049): jar of calcite; cf. Woolley 1934: pl. 246: type 61.

1935.762 (no field number): bowl of gypsum; cf. Woolley 1934: pl. 250: type 96 (Variant).

1953.1331 (U.886): fragment of a gypsum bowl with relief animal decoration; cf. Woolley 1934: pl. 250: type 102.

2. British Museum

Tests made in 1990, kindly reported to me by Dr J. E. Curtis, indicated that two vessels from the 'Jamdat Nasr Cemetery' at Ur were made of gypsum (BM 123740-1) and twenty-three from the 'Royal Cemetery' at Ur were travertine (calcite) (BM 121705, 121716-17, 121723-4, 121726, 121734, 121738, 121742, 121745-6, 121853-4, 121857, 121860, 121862-3, 121865, 121868, 123715, 123717-8, 123724). The former date to Early Dynastic I, the latter to Early Dynastic III.

4. Working Stone for Tools and Weapons

(i) THE CHIPPED OR FLAKED STONE TRADITION

Nowhere is it more apparent than in the literature of the flint industries of Mesopotamia how far lithic research has slipped behind that increasingly taken for granted elsewhere, particularly in prehistory. In this respect obsidian is better served. At the most basic level of typological and contextual analysis systematic study is still impossible since 'publications have only rarely presented complete chipped stone industries, usually limiting their discussion to selected "most pretty" specimens. Such publications often overlook important informations thereby rendering all comparisons futile' (Kozłowski 1987: 282). Even where reasonably comprehensive studies of chipped stone industries from particular sites are available, as for Jarmo (in Braidwood, L. S. *et al.* 1983), Choga Mami (Mortensen 1973), Rub-eidheh (Miller 1989), and Shemshara (Mortensen 1970: 27 ff.) for example, little or no attention has yet been paid to identifying sources of raw materials, to understanding distinctive techniques or standard patterns of production, or to elucidating function through the study of microtraces of use (cf. Cauvin, M.-C. 1983); all subjects of increasing research elsewhere in the region. The primary studies of workshops tend to be relevant only to the declining use of flint for tools and weapons (cf. Miller 1985; Payne 1980).

No new technique promises more for the proper understanding of the stone tools recovered from sites in Mesopotamia than the developing research on microwear traces, for almost every stone tool is found without the hafting that might have offered some indication of its original purpose. Methods of research and interpretation in this field of study are new and often controversial, but already the results achieved for the

prehistoric stone industries on the western periphery of Mesopotamia are encouraging (cf. Cauvin, M.-C. 1983). Now that such traditional simplistic correlations as those between pioneer agriculturalists and the appearance of ground stone tools and ceramics have been discredited, the wear patterns on stone tools used in Mesopotamia from 10000 to 5000 BC have emerged as key elements in any attempt to establish precisely what, if anything, was new in the lithic technology of the earliest settled communities of the area. The basic stone implements for tending, harvesting, and preparing domesticated food species, for instance, had been known in the Palaeolithic and the Mesolithic. 'Harvesting knives' were already used in the Lower Palaeolithic; mortars and querns in the Upper Palaeolithic and Mesolithic. Stone fittings for ploughs (cf. Vértessalji 1983) and threshing sledges (cf. Adams 1975) were unprecedented, but whether or not they appeared before animal traction was available (in the later Neolithic on present evidence) remains to be resolved, since men might well have pulled them before animals did, as indeed they did intermittently after the introduction of draught animals. Economic changes are not likely to be reflected in changes of stone tool types *per se*, rather in quantitative variations or in traces of changing use in which cultural factors may be expected to have played a significant role.

(a) Flint

Flint is a very compact form of silica, dark grey or black in colour, which breaks with a conchoidal fracture providing sharp cutting edges. Chert, light grey or brown in colour, is an impure kind of flint, occurring like flint in limestone. However, although largely composed of silica, it breaks with a more-or-less flat fracture instead of the conchoidal fracture of flint and obsidian. It was sometimes used instead of flint. In the following account, as in most of the existing literature, both these varieties of chalcedonic silica are referred to as flint.

Flint was more widely available to the inhabitants of Mesopotamia than is sometimes appreciated, as Wright (H. E. 1955: 85) has pointed out: 'In the Western Desert flint fragments which have weathered out of the limestone cover the surface over large areas; in the mountain belt flint appears *in situ* in many limestone formations; in the foothills and plains leading down to the Central Lowland, flint occurs abundantly as secondarily deposited cobbles and pebbles brought by streams from the mountains.' The primary distinction to be drawn is that between the flint and silicified stone pebbles locally available in the alluvium and the best sources of these raw materials located in the eastern periphery of Mesopotamia, sometimes in areas whence bitumen would also have been coming (Miller and Miller 1984: 64).

In these circumstances it may be assumed for the present that flint, processed or semi-processed, was available for all who wished to use it. Fuller understanding of the mechanics of flint supply within Mesopotamia, particularly in the south, where it is commonly, but not necessarily correctly, assumed to have been scarce, will not be easily achieved. It is unlikely that chemical fingerprinting, successfully used with obsidian (see below), will be helpful in the separation of flint (or chert) sources, since the determinable characteristics of flint tested elsewhere are either so constant over the whole of a source region that no individual sources may be distinguished, or vary so rapidly and randomly that the density of distinguishable sources rises to as many as several per square foot.

For Mesopotamia only meticulous publication and careful observation by eye will for the moment further elucidate the possibility of short-range commerce in flint as a raw material, at least into the heart of the southern plain. A case in point might be a fine-grained honey-coloured flint constituting less than 1 per cent of the assemblage at Choga Mami in the eastern foothills, but also used 150 km. to the south-west in central Mesopotamia at Ras al-Amiya (cf. Mortensen 1973: 39), or supplies of flint shipped down the Euphrates from Syria (cf. Miller 1985; Pollock 1990: 87). In some cases where coarse flint was locally available it was used in combination with better-quality flint imported from further afield (cf. Umm Dabaghiyah, Kirkbride 1974: 89). Initial preparation of flint may often, if not invariably, have taken place at source.

Whether flint was traded simply as a raw material for customers to knap themselves is only part of the matter. There is the question of whether finished objects produced by specialist workers, either at source or at centres nearby or further afield, were widely traded. In considering the chipped stone industry of the Ubaid period at Tell es-Saadiya in the Hamrin, for example, Kozłowski (1987: 281) concluded that the 'flint blades, and possibly even finished flint implements, were mostly imports. This appears to be indicated by, for example, the almost complete absence of cores and unretouched blade blanks on the site, the absence of flint workshops, the considerable standardization of specimens . . . and, finally, by the utilized raw materials which undoubtedly originate from outside the Mesopotamian Plain. It appears that already . . . we have to allow the possibility that in Mesopotamia certain classes of flint and obsidian implements were produced by artisans and intended for trade on the vast rural market' (cf. also Quarantelli 1985: 36; Miller and Miller 1984). Here again the restricted character of the published information permits only the cautious statement that this may well have been the case through the history of the use of flint in the region. Nor, at this stage, is it any easier to assess whether specific techniques of

manufacture, such as heat treatment to improve the flaking quality of flint, are an indicator of general trends or of specific manufacturing centres (cf. Miller 1989: 80).

The historical period offers an instructive case of international exchange of specialist chipped stone implements after the probable eclipse of chipped stone industries in Babylonia. In the fourteenth century BC the Egyptian pharaoh sent the king of Babylon 117 chipped stone blades (?) for the use of barbers (CAD 'M': II. 37) at a time when it is known from the archaeological evidence that Egypt still had a varied chipped stone industry (cf. Miller 1987).

The pattern and intensity of the use of flint in Mesopotamia in historic periods remains obscure, particularly after the third millennium, since flint tools in later Bronze and Iron Age contexts tend to be dismissed as survivors (Miller and Miller 1984). It becomes increasingly clear that this was not necessarily so. It needs to be stressed that chipped stone tools have been employed to some degree in the Near East into the present. An encounter reported by Woolley (1962a: 70-1) is light-hearted, but it makes a point easily overlooked:

I saw a small boy (at Carchemish) . . . shearing a sheep . . . to my great surprise, he was using a flint knife . . . (he) picked up a couple of large flints, knocked them together and chipped out for himself in a minute a perfectly good long flint knife . . . I said to him . . . do you always use that? 'Yes', said he, 'of course we used to use iron scissors, but they are no good compared to a flint!'

There is evidence for chipped stone drill-heads and blades, for flaked stone strike-a-lights (combined with iron from at least the Parthian period: Loftus 1857: 213) and for stone-edged threshing sledges (Whallon 1978; cf. Wulff 1966: 274) into the present. Chipped stone arrowheads may have been no less enduring in specific contexts.

It is still commonly, but improperly, assumed that the increasing adoption of copper and copper alloys, from the later fourth millennium BC, marked the triumphant progress of new materials whose advantages were self-evident. But in Mesopotamia they were valuable and expensive, probably for long virtually confined to prestige and military use. For agricultural and other rural purposes, and for cutting and drilling in the ordinary household, chipped flint held its own by virtue of availability, of relative cheapness, and proven efficiency. Polished stone tools for all practical purposes seem to have been more readily eclipsed. Whereas a skilled worker produces flaked flint tools in a matter of minutes, production of ground stone tools has to be measured in hours or days. Polished stone tools, even if only the cutting edge is ground, are amongst the most time-consuming of stone tools to produce. They appear

to be much less evident in primary archaeological contexts after the prehistoric period.

By the third millennium BC, when flint knapping was still practised as required in urban and rural centres (cf. Payne 1980; Miller 1985), it seems to have been primarily confined to the production of three broad categories: microborers, as for bead production; blades, as for knife and sickle production; and arrowheads and other projectile points. There is a much more sporadic pattern of borer or scraper manufacture, with a degree of crude *ad hoc* tool production. So far as it is possible to judge at present, this pattern endured until about 2000 BC and only then, at least in towns, did metal eclipse chipped stone to a significant degree; in the countryside it may well have endured.

Since it is not yet possible to offer a coherent account of the manufacture of flint tools in Mesopotamia, the craft is best observed through some of the key groups of artefacts: arrowheads and projectile points; harvesting tools; and hoes:

(1) Arrowheads and projectile points

In the system proposed by Clark *et al.* (1974) chipped stone arrowheads may most conveniently be divided for typological purposes into two main categories:

- A. *Chisel-ended arrowheads* with a natural unretouched transverse cutting edge.
- B. *Foliate arrowheads*: pointed with either bifacial or unifacial retouch.

However, within these primary groups shapes may vary greatly from culture to culture, from archer to archer, since taste as much as function has been shown to control choice (Miller 1985: 1). The recurrent statement that the bow 'is not particularly at home in Mesopotamia' (Collon 1983: 54), largely drawn from the study of art, is increasingly hard to sustain as a valid generalization, even for the prehistoric period. It arises partly from the perishable nature of the primary evidence, partly from the difficulty of identifying unhafted chipped stone arrow-tips when they are not the conventional shape, as seems to have been the case with prehistoric ones. It is significant that all the earliest representations of arrowheads recognizable in Sumer show chisel-ended tips (cf. Korfmann 1972: pls. VII, XI).

The steadily increasing body of evidence from prehistoric sites, including the representation of an archer on a painted vessel of the Halaf period from Arpachiyah (Collon 1983: 53-6, pl. XVIII), now throws serious doubt upon Korfmann's (1972) argument that the sling was the commonly preferred long-distance weapon in Mesopotamia and Khuzistan until the Uruk period. It is increasingly likely that the bow had appeared in northern Mesopotamia and through to the Zagros soon after its earliest appearance in the Natufian Period of Syro-Palestine. Chipped stone microliths mounted as

arrowheads have been reported embedded in skeletons in the ninth millennium at Nemrik (Kozłowski and Kempisty 1990) and microliths for this purpose are also reported from sites like Maghzaliya and Yarim Tepe I (Merpert and Munchaev 1987) as well as at Jarmo (Hole in Braidwood *et al.* 1983: 258). Microwear study of lunate and triangular microliths from Abu Hureyra and Mureybet has endorsed the use of such chipped stones as arrowheads (cf. Anderson-Gerfaud in Cauvin, M.-C. 1983). Yet, still, without appropriate research, even where the chipped stone industries of prehistoric sites have been adequately published, the difficulty of determining the function of unhafted microliths should not be underestimated.

By the second half of the fourth millennium BC chisel-ended arrowheads of flint and obsidian are reported from the *Riemchengebäude* at Uruk, where they were found in two clusters associated with copper fragments which may be parts of quivers (Lenzen 1958: 33; 1959: 10, pl. 19a). One group was found with flint blades which could have been broken into segments and retouched to produce arrowheads. In the grave of Meskalamdug at Ur (PG 755), in Early Dynastic IIIA, were a 'group of chipped flint arrowheads of the triangular chisel-pointed shape . . . It is curious that nothing of the sort was found in any other grave of the cemetery, but the type is quite common in the al-'Ubaid strata' (Woolley 1934: 381; cf. 160, 553; U.10051). Here again they were clustered as if originally deposited in a quiver. Exceptionally, in an early second-millennium BC context in the defensive ditch round Tell Hadidi in Syria, a chisel-ended obsidian arrowhead was found still set into its shaft. It was mounted in gypsum plaster to cushion the stone from the force of impact (Miller 1985). It is not yet clear how far into the second millennium BC, or even later, such stone geometrics mounted as arrow-tips survived in use and production in Mesopotamia. There is evidence in northern Arabia for their use into the Iron Age (cf. Miller 1980).

Tanged triangular, ovate, and lanceolate arrowheads in flint and obsidian were in use on sites in Mesopotamia from at least the third quarter of the third millennium BC through until at least the mid-second millennium BC, often with little or no trace of metal arrowheads (cf. Mallowan 1947: 180-2, pls. XXXVII, LIII. 1-17). However, metal would have been extensively recycled, precluding any meaningful comparison. Indeed, as elsewhere in the world, even when metal had been introduced for military arrowheads, stone (or indeed bone and wood) might have endured as the preferred material for hunting-arrow tips or in communities where metal was rare and expensive.

The only special study of evidence for the manufacture of chipped stone arrowheads has been provided by Miller (1985) in publishing a knapping workshop at

Tell Hadidi in Syria, of the late third millennium BC. In this context output seems to have been confined to arrowheads, from roughing out to completion, also resharpening, so any generalizations from knapping practices here have to be used with caution. However, the survival of the distinctive 'Levallois' technique of flaking is very significant technologically:

This late survival of Levallois technique shows that skilled flintworking did not become extinct with the transition from prehistory . . . but continued as an urban craft working to the highest standards of achievement, and also raises questions about the validity of using surface scatters of flint as evidence of prehistoric dating, since it can be shown that techniques previously assigned only to the Palaeolithic or Neolithic persisted into the Bronze Age.

(Miller 1985: 6)

As the production of arrow-tips is only one part of a process, workshops like this one are most likely where bird feathers were also readily available for fletching and reeds for shafts.

(2) *Blades for hafting as 'harvesting knives' or sickles*

At a time when the proper study of prehistoric tools designed to cut cereals and grasses, wild and domesticated, as well as other vegetable matter is likely to be radically and progressively transformed by microwear studies, attention is best focused in Mesopotamia on cases where hafting has to a degree survived. In the north flint had been used for such purposes in the earliest settled communities, if not earlier (Jarmo: Hole in Braidwood, L. S. *et al.* 1983: 243-4). At a general level there is no problem. Indeed, the evidence at Hassuna was thought good enough to encourage attempts at reconstruction both of the method of attachment and of the angle of the handle (Lloyd and Safar 1945: 269, fig. 37). In the south the question is more complicated, at least during the lifetime of the so-called clay sickles, which are commonly assumed to have supplied a need for harvesting tools in a region where flint is said to have been scarce. They appear from early in the sequence of settlement in heartland Sumer to at least the end of the fourth millennium BC. It is not yet certain either that they were actually used as sickles for harvesting cereal crops, rather than as tools for cutting reeds etc. (cf. Anderson-Gerfaud 1983; see p. 165 here), or that sickles of flint were wholly absent in the south at the time of their appearance there. This seems unlikely in view of their presence on sites in the Hamrin in the Ubaid period, where they are reported to be the most common tool type (Miller and Miller 1984: 167). The 'Uruk Mound' at Abu Salabikh yielded both chipped stone sickle blades and baked clay sickles (Pollock 1990: 88).

The widespread popularity of flint sickles throughout the south from the later prehistoric period, eventually displacing baked clay sickles, has often been attributed

to the emergence for the first time of a commerce in ready-made flint blades suitable for mounting as sickles (cf. Tell Rubeidheh: Miller: 1989: 93.) This has yet to be proved. The late prehistoric 'Canaanite' flint industry, well represented in the deep sounding at Nineveh (Campbell Thompson and Mallowan 1933: 143-4, pl. LXVII) and at northern sites like Arpachiyah (Mallowan 1935: 102, fig. 52:17) and Tepe Gawra (Speiser 1935: 84-5, pls. XXXVIII-XXXIX, LXXXI), may be an instructive case of manufacture and distribution, though this industry is not yet represented in central and southern Iraq. A production centre of 'Canaanite' blades has been identified at Hassek Höyük in Turkey, a site which had contacts with Sumer reflected in the decoration of its shrines (Otte *et al.* 1990). They are made from good local flint, possibly with a special punch equipped with a copper tip. Wear traces have been taken to indicate that they were used exclusively to cut cereals, hafted in a new device which allowed the use of a single blade as a sickle. The technique of production allowed for the manufacture of regular, longer, and wider blades, which were then widely traded.

A number of sites in central and southern Iraq offer good evidence for flint sickles by the Early Dynastic period. The relatively greater proportion of sickle blades to other flint tools recovered from some, if not all, of these sites may reflect the need to conserve their bitumen hafting. Thus broken sickles were brought back into settlements so that flint and bitumen might both be recycled (Wright, H. T. 1981: 267; Miller and Miller 1984: 167). Fragments of bitumen hafting debris occurred at hearths in Habuba-Kabira-South, where the heat may have been used to soften the bitumen for re-hafting (Sürenhagen 1978: 98). Sometimes sufficient evidence has survived for restoration of hafting and shape (Khafajah: Delougaz 1940: 30-1, figs. 26-7; Nippur: McCown 1967: 156, pl. 163:13; Abu Salabikh: Payne 1980; Kish: Payne, in Moorey 1978: microfiche 2: D13-E01; Ur: Woolley 1956: pl. 13; U.14920; for technique see Miller and Miller 1984: 167). Copper sickles appear sporadically from some time in the middle of the third millennium BC (cf. Ur: Deshayes 1960: 339, no. 2736, pl. XLV:20; Woolley 1934: pl. 226: U.15189; Tell Fara: Deshayes 1960: 337-8, no. 2722; Schmidt, E. F. 1931: 211, pl. XX.2), but may well not have been common until the earlier second millennium BC (cf. Moorey 1971^a). It is not yet clear to what extent (as in Palestine) flint sickles remained in use in Mesopotamia until the appearance of cheap iron ones in the middle of the first millennium BC.

(3) *'Hoes' and 'ploughshares'*

Distinctive heavy, flaked implements of quartzite, sandstone, and limestone, less often of flint, have long been one of the most familiar stone tools on prehistoric sites in Mesopotamia and Khuzistan, commonly known as

'hoes'. Woolley (1956: 14, pl. 12c) distinguished two primary shapes: the triangular type and the spoon-shaped type: 'the triangular type is not uncommon but the spoon-shaped type is by far the most common; the broad end usually shows signs of use, so that it is clear that the long pointed end was employed for hafting and that the implements really are hoes' (cf. Cauvin, M.-C. 1979: 196).

On many sites these hoes have a heavy coating of bitumen for attachment (Lloyd and Safar 1945: 269; cf. Dollfus 1971: 64). In a detailed study of such tools from Telloh Cauvin identified them as 'hoes', but sought their origin in chipped stone tools of comparable form (adzes) for woodworking from the Natufian period on the Middle Euphrates (Mureybit; Sheikh Hassan; Cauvin, M.-C. 1979: 199, figs. 6-7). Subsequently, in the Hassuna/Samarra horizon, the situation she believed was more equivocal, with the possibility both of use as woodworking tools and/or agricultural implements; a problem only to be resolved by wear analysis. However, their presence or absence at this stage may not be taken as an indicator of the presence or absence of agriculture; thereafter the latter function is most probable. Subsequently, Vértessalji (1983) reviewed the problem in greater detail, including some microwear analysis of 'hackenblätter' from the surface at Uruk. He was sceptical about Cauvin's derivation of the type, seeing these tools as a key feature in the development of agricultural technology, of hoeing and ploughing, from an early date in Mesopotamia. At Tell el-Oueili such tools were reported as showing traces of wear related to woodworking (Tixier-Inizan cited in Huot *et al.* 1983: 74).

Miller and Miller (1984: 167) recently compared the tools of this type from Tell Madhhur in the Hamrin in the Ubaid and Early Dynastic periods: '*Hoes* were found in both periods, although the ED I examples seem to be from parallel-sided bifaces rather than the characteristic narrow-tanged broad-bladed 'Ubaid hoes found at other 'Ubaid sites . . . There was a tendency for butts to predominate in broken examples of hoes, suggesting that working edges were left in the fields when they broke while the handle and hafting were brought back to the village where the butt of the tang was removed.' It is significant that as late as 2000 BC, and maybe until very much later in the countryside, hoes, hoe-blades and ploughshares are listed among the objects made of wood in texts from Umma relating to forestry and foresters (Steinkeller 1987^a: 93).

(b) *Obsidian*

Obsidian, usually black or green in colour, is a volcanic glass that fractures conoidally like flint, making it suitable for the manufacture of tools. It registers about 6 on the Mohs hardness scale. Some varieties of chert or flint may be confused by eye with obsidian, but, apart

from physical and chemical differences, they are normally duller than obsidian, which usually has a glassy lustre. Obsidian has certain qualities that distinguish it from other chipped stones. Though more fragile, it yields a finer cutting edge; it is particularly well suited by its structure to pressure flaking (Inizan 1987).

Geologically, obsidian has been divided into three broad types recognized by their chemistry and by the petrography of the rocks associated with them in the same volcanic region: alkaline; calc-alkaline; and per-alkaline. This natural glass is formed by the cooling of lavas which have a silica content greater than 65 per cent. As several factors combine, however, to make the formation of obsidian suitable for tool-making an unusual occurrence, appropriate obsidian is only found near some geologically recent volcanoes. Obsidian was widely used in the prehistoric Near East for tools, and in historic times, when metals gradually replaced it in this role, it was used primarily for personal ornaments and luxury vessels.

In the last three decades obsidian more than any other stone used in Mesopotamia and adjacent areas has been the subject of chemical characterization or 'fingerprinting' studies. It has been claimed that 'obsidian would appear indeed to be the earliest object of trade which can be recognized and characterized with accuracy today' (Cann *et al.* 1969: 590). The purpose of these analyses, in the first instance, has been to establish chemical characteristics for each source, which will distinguish it from other sources. As obsidian artefacts from excavations can be similarly examined in the laboratory using the same criteria, the source of the raw material from which they were made may be identified. Generally speaking, there are enough sources in Western Asia to make such studies significant, but not enough, as probably would be the case with chert and flint, to make the location of sources impossible.

As with every stone considered here, the adequacy of source studies ultimately depends on the state of geological knowledge of particular areas. Fortunately, obsidian is readily recognized by eye in Near Eastern assemblages of stones and, for the greater part, those sources most likely to have supplied Mesopotamian needs are in areas reasonably well known to modern geologists. So far as is known, obsidian does not occur naturally in Egypt, but it does in Ethiopia, in the Sudan, and across the Red Sea in southern Yemen, and perhaps in other parts of south-west Arabia or on Red Sea islands (cf. Zarins 1989; Francaviglia 1990). No obsidian sources have yet been reported in Iraq, Israel, Jordan, the Lebanon, or Syria, though there are several volcanic districts within them that might eventually yield evidence of this stone. West Mediterranean sources are unlikely to be relevant to Near Eastern use at any period, but those in the eastern Mediterranean, on the three Aegean islands of Antiparos, Giali, and

Melos, have to be borne in mind (cf. Dixon 1976). Although there appears to be little or no obsidian in western Turkey, elsewhere this country contains two major obsidian sources. Each of these zones comprises a number of flows; the western one lies near the great Salt Lake in central Turkey, particularly near Acigöl and Chiftlik, and the other is to be found in the Lake Van region to the east. The latter is an extended area embracing many flows, some beyond the borders of Turkey, which are still the source of investigation and speculation (cf. Badaljan *et al.*: forthcoming).

Whether there are possible obsidian sources deeper into northern Iran than the Urmia area or to the south and east of the country that might have been exploited in antiquity has yet to be established (cf. Renfrew and Dixon 1976: 139; Blackman 1984). Local villagers have claimed that obsidian occurs in the volcanic mountain areas of Baluchistan. French archaeologists report obsidian in mountains 55 km. east of Bam in Afghanistan (Beale 1973: 136).

Far more analyses have now been carried out of obsidian from archaeological sites than from the flows themselves, and several more sources have been identified than have yet been located on the ground. Although remarkable strides have been made recently in source location, caution is required at every turn with generalizations made from the present database. It is now very apparent that patterns of exchange were more complex, with shifts in the preferred sources from one site to another through time, than was originally assumed in the pioneer studies of the 1960s and 1970s. They had a tendency to oversimplify chronological questions in their concentration on explanations for exchange processes, which were conceived as gradually evolving systems, whereas the pattern of obsidian use now becoming apparent is both irregular and unpredictable from an early date.

The chemical fingerprinting of obsidian depends on the fact that no two obsidian flows have exactly the same chemical composition and (for the Near Eastern sources so far examined) the obsidian in a given flow is taken to be homogeneous. Thus, theoretically obsidian artefacts may be related by chemical analysis not only to a source area, but to a particular flow within that area. Two practical problems at present inhibit full exploitation of this procedure: inadequate basic information on specific flows, and differing laboratory methods. There is still considerable ignorance of the chemistry of many flows, some in central Turkey, some in eastern Turkey and adjacent regions, whence came most, if not all, of the obsidian used in Western Asia in antiquity. As Blackman (1984: 28) has shown, 'the presence of multiple chemical groups from what have been taken as single source areas points up the need for extensive and careful source sampling to avoid confusion in artifact source assignment'. Moreover, the

effort already needed, after barely three decades of serious study, to reconcile and synthesize the published data is considerable. This task is made all the harder by the use of different analytical techniques of differing precision, by the choice of different element groups in statistical analysis and publication, and by the employment of varying secondary standards in quantification (cf. Blackman 1984: *passim*; Henrion *et al.* 1990).

Cann and Renfrew published the first successful application of trace-element characterization methods to Old World obsidian artefacts and sources in 1964 (see also the general introduction to Cann, Dixon, and Renfrew 1969). The obsidian sources of Europe and Western Asia were then listed, in so far as they were known, and assigned a numerical classification based on trace-element analyses by optical emission spectroscopy. These original group designations have been retained, where possible, as they have subsequently been refined by Renfrew and his colleagues (Renfrew *et al.* 1966, 1968; Dixon 1976; Renfrew and Dixon 1977) and by other scholars using different analytical techniques, notably neutron activation (Wright, G. A. 1969; Mahdavi and Bovington 1972; Blackman 1984). The value of using magnetic properties to discriminate between the obsidian sources represented by finds in Mesopotamia has been pursued by Hammo (1984) using obsidian samples from Kaleag Aga, Kish, and Shemshara. According to these procedures, Hammo attributes only the Kish piece to the Van source area, placing the others as 'Abyssinian, Arabian or another unnamed source'. Further investigation is clearly required before this method is established as decisive. It has been demonstrated that two major source zones supplied the obsidian used in Mesopotamia in antiquity, one in central Turkey ('Cappadocia') and the other in the Van region to the east ('Armenia');

A. Central Turkey (Wright, G. A. 1969: 5-9, 17-21; Dixon 1976: 300-3; Blackman 1984)

These sources are within the triangle Aksaray-Nevşehir-Niğde, south-east of the Salt Lake (Tuz Gölü) (Dixon 1976: fig. 15.9; Blackman 1984: fig. 7). Here two areas are known to have workable outcrops of obsidian: Acigöl (near Nevşehir), the original group 1e-f source (Renfrew *et al.* 1966: 30), and the area round the village of Chiftlik, the original group 2b source (*ibid.*), 50 km. south of Acigöl. There are now known to be several distinct sources in both areas whose separation remains subject to continuing investigation (as Blackman 1984). However, even with modifications, there appears to be a natural clustering of Central Turkish obsidians into two major groups (cf. Dixon 1976: 300-2). In reading the literature it is important to observe that insufficient source samples have been tested by reconcilable methods to distinguish obsidian from the Acigöl area (notionally group 1e) from com-

parable sources in the Van region (notionally group 1f). Consequently, 'group 1e-f' is currently used for obsidian from both areas (Renfrew and Dixon 1977: 145). Although obsidian from sources in Central Turkey has very occasionally been identified in lowland Mesopotamia (Renfrew *et al.* 1968: 325), there is still no evidence that it penetrated further east into the Iranian highland zone (Blackman 1984).

B. Van (VAA)-Azerbaijan (ET)-Armenian SSR (ASSR) (Wright 1969: 9-16; Dixon 1976: 303-10; Blackman 1984; Badaljan *et al.*: forthcoming).

These sources are those most relevant to study of the obsidian used in Mesopotamia, Iran, and the Gulf from earliest times. The actual sources here are geologically far less well known than those of central Turkey, since the area is far larger and uncertain political circumstances continue to inhibit research on the ground. The major exploited source flows seem to be near Lake Van, with at least one exception of a flow near Bayezid, 310 km. north-east of the Lake, and others nearer to Lake Urmia in Iran. Much fieldwork and consequent laboratory research remains to be done on the numerous subsidiary eruptive centres in this vast region before any detailed account of VAA obsidian sources may be given. For the moment a tentative scheme has been proposed in which distribution patterns play a larger part than scientific discrimination and location of specific flows in source areas. From the work of Dixon and Renfrew (especially Dixon 1976: 309; Renfrew and Dixon 1977: 145-6) the following propositions emerged:

1. In the earlier prehistoric period (c.7000-5200 BC) 1g obsidian approximates to that of 4c, which Wright (1969: 10) distinguished as from Nemrut Dağ B. The source of 4c may also not be far away from Lake Van.
2. In the later prehistoric period (c.5200-2000 BC) the distribution of group 3 obsidian as a whole follows 4c in the Zagros region, whilst 1g obsidian now shifts westwards to the Levant.
3. Distribution of 3a obsidian is centred on Lake Urmia in north-west Iran, but extends south to Khuzistan in late Ubaid times and soon thereafter eastwards into Fars at Tal-i-Bakun. In the previous Halaf period it is found at Tilki Tepe on the east side of Lake Van with 4c obsidian and southwards at Arpachiyah in Iraq; but apparently not west of Tell Halaf in Syria. The source of 3a obsidian may then be to the north or north-east of Lake Van (see below).
4. 4c obsidian is rare in the area round Lake Urmia, whereas 3b and 3c obsidian are virtually confined to it and are so far unrecognized outside Iranian Azerbaijan. The source of 3c may be in or north of the Urmia region, more accessible from Lake Urmia than from Lake Van.

Of the presently sourceless groups within the VAA

network, 3a obsidian may derive from the Zarnaki Tepe source north of Lake Van. Blackman (1984: fig. 7) has sampled natural obsidians from several localities at Nemrut Dağ on the western shore of Lake Van; from Suphan Dağ further north along the shore of the Lake; and from near Lake Sevan in Russian Armenia. The results drew very cautious conclusions from Blackman (1984: 26–8): ‘the peralkaline obsidian from Nemrut Dağ is easily distinguished from the calc-alkaline to sub-alkaline obsidians from all the other sources [in the VAA area]. Finer-scale examination of the dendrogram reveals that all of the source areas sampled can be readily distinguished from one another, although obsidian samples from some source areas are clustered into more than a single group . . . the picture that emerges from the cluster analysis and direct comparison of concentration data is complex, but promising. Although several of the source areas consist of multiple occurrences of obsidian, all the source areas sampled have readily distinguishable source-specific compositions.’

In so far as different techniques allowed, Blackman (1984: table II) correlated the evidence on geological source groups: see table below.

Blackman’s (1984) specific artefact analyses for Tepe Malyan (Anshan) in Fars and for Tepe Yahya further

east in Iran were of particular interest for the changing patterns of distribution they revealed in the early historic periods (see below).

Further work by Blackman and his colleagues (cf. Badaljan *et al.* forthcoming) has distinguished the Caucasian obsidians from known and postulated obsidian sources in north-eastern Anatolia. It appears that obsidian moved predominantly from north to south in this area. Although Transcaucasian obsidian was exchanged further to the south, the prehistoric peoples of Transcaucasia did not generally use Anatolian obsidian. The ‘3a’ group probably derives from obsidian flows from the twin peaks of Mt. Ararat, just south of the river Araxes. Group ‘1g’ does not correspond to any identified Transcaucasian source so may be located west or south-west of Nemrut Dağ as previously argued.

The pioneer studies of obsidian placed rather more emphasis on conjectural explanations of the distribution systems operative in prehistory than on the analysis of the available data. The exchange of obsidian in Near Eastern prehistory was then studied through spatial distribution patterns in the shape of a fall-off curve (cf. Renfrew *et al.* 1968; Renfrew 1977). This programme of work opened up the subject with skill and perception; but it is increasingly evident that the

primary approach was compromised by the absence or inadequacy of the requisite quantitative data from an adequate sample of archaeological sites. Although analytical techniques continue to increase the database of characterized obsidian finds from sites in Western Asia, there has been little or no significant advance for well over a decade now in elucidating the processes that created the distribution of the stone, and artefacts made from it, in prehistory.

Elsewhere, notably in America and in the Aegean, important enquiries have been pursued into the mining, manufacture, and distribution of obsidian. In particular, Torrence’s (1986) study of prehistoric obsidian exploitation and exchange in the Aegean has thrown up many challenges to received opinions, which are as relevant to Western Asia as to the Aegean, notably when she argues that: ‘each centre of obsidian consumption is likely to have utilized a combination of tactics for acquiring obsidian, involving embedded procurement and special purpose trips by various components of the society, as well as exchange. Such complexity is probably typical of many distribution systems, although it has often been overlooked by archaeologists, who mainly tend to assume that all raw material from one source was distributed in the same way wherever it was found’ (Torrence 1986: 222). This critical point should be borne in mind when reading the following attempt to provide an interim summary of what is currently said about the exchange of obsidian in the ancient Near East.

Renfrew and Dixon (1976: 147–9) postulated an exchange network in the earlier Neolithic, c.7500–5500 BC (‘the Zagros Interaction Zone’), that included Nemrut Dağ (4c) obsidian and 1g (Blackman: group D) obsidian (located west or south-west of Van), distributing the stone as far south as Khuzistan, but not on to the Iranian plateau. They noted that the proportion of obsidian within the chipped stone assemblages of sites in the region declined in a regular exponential fashion as the distance of the site from the obsidian source increased (Renfrew *et al.* 1968: fig. 2: the so-called ‘Law of Monotonic Decrement’). They also observed that when the percentage of obsidian in the chipped stone assemblage was plotted in relation to the distance from source, the resulting curve showed two zones: the *supply zone*, taken to be up to 300 km. from source, where up to 80 per cent might be obsidian; and the *contact zone* supplied by ‘down-the-line-trade’ working on a basis of reciprocity.

In the later Neolithic and Chalcolithic (c.5000–3000 BC), they argued, when quantitative data is rarely available, this model did not hold outside the supply zone for each source. The redefined interaction zone (‘the Tigris-Plateau Zone’) now embraced much of the west Iranian plateau and extended to Dhahran, near Bahrain, in eastern Arabia. The curve of quantity

against distance is no longer seen to be monotonic decreasing, but shows local maxima. Certain settlements, like Susa in Khuzistan, appear to be receiving preferential supply. This pattern was interpreted as a change from reciprocal to central-place directional exchange with, perhaps, the emergence of middlemen traders. This, Renfrew and Dixon noted, is not merely a difference in exchange mechanisms since now, for the first time, obsidian is not exclusively used for tools. Bowls, seals, and personal ornaments mark the emergence of luxury, prestige items in the fourth millennium BC.

Various criticisms of this model have been developed. Warren (1981) argued, through mathematical models, that the fall-off pattern noted by Renfrew *et al.* should be explained as a difference in mechanisms in the source, not in the supply zone, whilst Blackman (1984: 22) has suggested ‘that the luxury items and the raw material for the utilitarian items were being exchanged in terms of function rather than material type. As such, these two categories of object may have been included in different aspects of the exchange system.’

In the second phase, 3 (3a) obsidian replaced that from the 1g source. In Renfrew and Dixon’s view such obsidian penetrated the zone by way of Lake Urmia from a source north-east of Van. However, Epstein (cited by Blackman 1984: 36) has analysed obsidian from Choga Mish in Khuzistan (c.5500–4200 BC) and found that ‘1g obsidian had not been replaced by Group 3 (3a) . . . but that obsidian from these two sources co-existed with Nemrut Dağ (4c) obsidian’, which predominated. Possibly three other sources were represented in subsidiary roles. This source pattern persists to the Banesh Phase (3400–2800 BC) at Tepe Malyan (Anshan) in Fars, where Nemrut Dağ obsidian predominates with Group D(1g) and Zarnaki Tepe (3a?) obsidian present in lesser quantities. By contrast, at Tepe Yahya further east (c.3600–2600 BC) Zarnaki Tepe obsidian (3a?) is the sole source represented in good archaeological contexts. These results indicate a more complex exchange system than the Renfrew/Dixon model presupposed. Whereas Malyan might have received obsidian from Susa, it appears that Yahya was being serviced by a more direct route from north-west Iran, perhaps continuing an older reciprocal down-the-line system within Iran.

As chemical characterization has so far concentrated almost exclusively on prehistoric trade, Blackman’s (1984) work on the obsidian at Tepe Malyan (Anshan) in Fars, in the Kaferi phase (c. 2100–1800 BC), when this settlement was at the peak of its size, is of especial value. At this stage four new sources of obsidian were represented at Malyan in addition to the three known there earlier. Only one of the new sources may at present be located and that is Sevan I in Russian Armenia,

Source Groups	Hebrew Univ.	Bradford Univ.	Renfrew et al.	Location
Central Anatolian Obsidian Sources				
1. Göllü	GLD	B1	2b (ÇİFTLIK)	Göllü Dağ
2. Hotmis I	HTMS-C	B5	1e–f (ACIGOL)	Hotmis Dağ
3. Hotmis II	HTMS-A	B5	1e–f	Hotmis Dağ
4. Hotmis III	HTMS-B	B5	1e–f	Hotmis Dağ
5. Koru	KRUD	—	—	Koru Dağ
6. Hasan	—	—	1h	Hasan Dağ
7. —	NNZD	—	—	Nenezi Dağ
8. —	—	—	4f	Kulaklikepez
Eastern Turkish–Armenian SSR Obsidian Sources				
1. Nemrut I	NMRD 1	G1	4c	Nemrut Dağ
2. Nemrut II	NMRD 2 (?)	—	—	Nemrut Dağ
3. Nemrut III	—	—	—	Nemrut Dağ
4. Nemrut IV (?)	—	—	—	Nemrut Dağ
5. Suphan I	—	—	—	Suphan Dağ
6. Suphan II	—	—	—	Suphan Dağ
7. Sevan I	—	—	—	Lake Sevan
8. Sevan II	—	—	—	Lake Sevan
9. —	ZNKT	B4 (?)	3a (?)	Zarnaki Tepe
10. —	—	G2	4c	Bingöl Dağ
Sources of Unknown Provenance				
1. —	—	B2	1g	?

Source: Blackman 1984.

about 300 km. north of Lake Van. There is also a marked change in the distribution of artefacts among sources: 'The Nemrut Dağ I source contribution drops from 88 per cent in the Banesh Phase to 29 per cent in the Kaferi Phase; the contribution of the other sources rises from 12 per cent in the Banesh to 71 per cent in the Kaferi. Two of the sources introduced in the Kaferi Phase, Groups B and C, are 21 per cent and 17 per cent, respectively, of the assemblage. The distribution pattern has changed from heavy reliance on a single source in the Banesh to a more even reliance on at least three sources in the Kaferi' (Blackman 1984: 38). Luxury items also appear for the first time: bowl fragments and a bead/ring of Nemrut Dağ obsidian; a bowl of Zarnaki Tepe obsidian. In no case is there now evidence for local manufacture, as there was with earlier tools of obsidian. Thus, by the end of the third millennium (the Ur III period in Mesopotamia) certain critical trends may be noted at Tepe Malyan (Anshan): the number of obsidian sources has doubled; reliance on a single source has been replaced by a more uniform distribution; the source zone has expanded north-eastwards to embrace the Lake Sevan flows as well as those in the Van region (cf. Capannesi and Palmieri 1984).

Wright (G. A. 1969: 47–52) was the first scholar to show that minor deviations from the straight line predicted by Renfrew and his colleagues involved problems they had not sufficiently considered. Wright highlighted a number of factors: that the weight of obsidian rather than the proportion of it in lithic assemblages should have been calculated, since the means of transport, c. 7500–5500 BC, was men not pack-animals; that there were chronological variations in the amounts of obsidian reaching certain sites; that there were variations in the forms in which obsidian was transported; that only sites with the same function (all permanent settlements) should have been included in the same analysis; that the presence or absence of local flint resources may have had important effects on the use of obsidian for tools.

Subsequent work on obsidian elsewhere continues to bring other factors to the fore: the density of obsidian may indeed generally decline with distance from sources, but that fall-off is not symmetrical in all directions round sources; topographic variation is an important factor in calculating effective distance from source. Social factors, such as the function of sites studied, may affect changes from direct access to down-the-line exchange. As with so much science-based archaeological research, continuing accumulation of analytical data has demonstrated that studies of obsidian from the perspective of consumption are not as straightforward as the pioneer research in Western Asia might have seemed to indicate. Alternatives to study through variability in the consumption rate, such as raw material

supply or production, may be of critical importance, placing emphasis on those variables consequent to competition for profit rather than on quantity. Moreover, the most recent work, as at Tepe Malyan (Blackman 1984), has indicated how an undue concentration on regional exchange processes rather than on the perspectives from single sites needs to be corrected in future surveys.

In 1969 Gary A. Wright published a comprehensive study of the role of obsidian in Near Eastern trade between 7500 and 3500 BC on the basis of the chemical characterization of flows and artefacts then available from the work of Renfrew and his colleagues and a team lead by Gordus working in the University of Michigan at Ann Arbor. The following account is much indebted, for the prehistoric period, to Wright (1969) and to the analyses given in Renfrew *et al.* (1966; 1968).

As has already been noticed, chemical fingerprinting has indicated that there was a change in the sources used in Mesopotamia at a time corresponding to the Hassuna period. Previously 1g and 4c obsidian had been the two major sources drawn upon in Mesopotamia and the Zagros region, as at early settlements like Jarmo, and Tell Shemshara in the north, at Tepes Sarab and Guran in Luristan, and in the Deh Luran complex in Khuzistan away to the south. At Jarmo five samples of 1g, eight of 4c, and one unidentified were identified by Renfrew and colleagues (1966: fig. 5). In Mesopotamia 3a replaced 1g by the end of the Hassuna period; among early occurrences beyond the source zone are those at Tell es-Sawwan and Banahilk. Now 1g appears very rarely, as at Arpachiyah, where it is associated with 3a and 4. This exploitation of 3a obsidian has been linked to the earliest occupation of Tilki Tepe on the eastern shore of Lake Van. Here the excavator recovered more than twenty obsidian cores (over 25 lbs. in weight) and hundreds of blades (Pfeiffer 1940); analyses of eleven samples identified six as group 3a, three as 4c, and two as neither group nor as 1g (Renfrew *et al.* 1966). For the Ubaid period Tell eth-Thalathat offered three samples of 3a, one of 4c; Eridu four of 4c; Tell Ubaid yielded thirteen of 4c, one of 3d, and one unidentified. Throughout the later prehistoric period, 4c appears to be the most exploited Van source. The only object tested so far that may be made of obsidian from a source in Central Anatolia rather than from Van is the spouted obsidian bowl from a grave in level X at Gawra (Renfrew *et al.* 1968; Tobler 1950: pl. LIII) attributed to group 1e–f. This suggests that it was imported ready-made (see p. 41 here).

Obsidian was already exploited in eastern Turkey by the Middle Palaeolithic (Renfrew *et al.* 1966: 40, fig. 4a), but VAA obsidian is not documented in the Zagros until its appearance at Shanidar (levels C: groups 4c and 1e–f; and B) and in the Zarzi Cave (group 4c) in the Upper Palaeolithic, when it is rare. In the earlier

Neolithic period obsidian is found recurrently on sites excavated in the Zagros area (cf. Inizan 1987: 308 ff.). Two varieties were in general use (1g and 4c from VAA sources), found in varying quantities throughout the region. Tiny amounts of obsidian are reported from the earlier aceramic sites in northern Iraq (cf. Watkins and Baird 1987: 10), representing no more than 1–2 per cent of worked lithic material; but later it occasionally rises to 30 per cent as at Maghzaliya (Pre-Pottery Neolithic B) in the Sinjar Plain (Inizan 1987: 312).

At Jarmo, where at least three sources of obsidian are represented, and there is clear evidence of local working (Linda Braidwood, in Braidwood *et al.* 1983: 287, contra Wright 1969: 35), more obsidian seems to have been available in the later life of the settlement. There has been a radical revision of Renfrew's original estimate of the quantity of this stone brought into Jarmo, down from four tons to about 196 kg., which Linda Braidwood (1983: 285) accepts 'as much closer to the mark and we would not quarrel with it as a rough guess'; but she regarded the weight of obsidian used at Jarmo in any one year as likely to be 'extremely low'. These discrepancies illustrate the great caution required in both the creation and interpretation of statistical data on the basis of very restricted and haphazardly retrieved and published samples. Linda Braidwood (1983: 287) has offered further pertinent observations on Renfrew's (1977: 296) calculations by weight:

it is also evident that the early Jarmoan idiosyncratic preference for extremely small tools in obsidian continued even when more obsidian was available; there was very little change in tool size over the years. In general, in such a conservative occupation as stone knapping, it would seem most likely to us that tool size preference would be more pertinent than availability of material. In our minds this would explain the greater size of the obsidian implements not only at Chagha Sefid [i.e. far from source] and other parts of the Iranian Zagros but also at Çayönü [i.e. closer to source].

In the Deh Luran area of Khuzistan obsidian was about 1 per cent of the lithic assemblage c. 7500 BC (Bus Mordeh phase), rising to about 2.5 per cent by about 6000 BC and dropping back to 1 per cent or so by the fourth millennium BC. It is all chips and blades (Hole *et al.* 1969: 173; cf. Renfrew 1977). At Tepe Guran in central western Iran it may have been considerably more plentiful, but it is still predominantly used as blades (Mortensen *et al.* 1964).

By the Hassuna period in northern Mesopotamia obsidian was widely used for blades and borers. In Yarim Tepe I obsidian constituted 23 per cent of the stone finds, the overwhelming majority of it as finished tools (Merpert and Munchaev 1987: 14–15). It occurs as blades, both very large ones for dressing meat (established by wear traces) and, commonly, as sickle-blades

and scrapers. At Tell Shemshara, on the Little Zab in Iraqi Kurdistan, most of the material used for flaking was obsidian and less than 15 per cent was flint. This included a remarkable 'dagger-blade' (Mortensen 1970: 27, fig. 30). At Matarrah, in the lower Hassuna level, 8.7 per cent of the lithic industry was obsidian; in the upper Samarra–Hassuna level it was 23 per cent, with blades and borers, but no cores (Smith, in Braidwood, R. J. *et al.* 1952). At Tell es-Sawwan obsidian was noted throughout, though no details are available, for borers, core-scrapers, knife- and sickle-blades. At Choga Mami (Mortensen 1973: 38) on average only 2.9 per cent of the chipped stone industry was of obsidian, declining from 5.7 per cent in the earliest phase to 0.9 per cent in the 'Ubaid well'.

No statistics are yet available for the stones used on settlement sites attributed to the Halaf and Ubaid periods, but by then tools were no longer the only objects made in obsidian. Beads, pendants, and pierced plaques for bracelets or necklaces of obsidian appear for the first time in TT6 (Late Halaf) at Arpachiyah, with the occasional vessel (Mallowan 1935: pls. VIb, XI). At Arpachiyah Mallowan (1935: 102) reported recovery of thousands of flint and obsidian blades and scrapers with obsidian 'quite as common as flint', including cores. At Yarim Tepe II 'obsidian tools are three times more numerous than flint' (Merpert and Munchaev 1987: 27). At Tepe Gawra there was also an extensive use of obsidian. Tobler (1950: 201) reported that in every level, save XVI, more than 50 per cent of tools were in obsidian, whilst pendants, seals, and vessels of it are reported. That even blades of obsidian had a special value is indicated by their presence, alone among flaked stone tools, in a few richly equipped male graves (cf. Inizan 1987: 313), where they appear singly or rarely in pairs.

Away to the south deep into Sumer, through Ras al-Amiya (Stronach 1961), Oueili (Inizan 1987), Eridu, Ubaid, and Ur (Woolley 1956: 8, 14, pl. 12b) evidence of obsidian blades and chips is widespread in the later prehistoric period, though quantities and contexts in all but the most recent excavations are usually unrecorded. Woolley (1956: 13) noted the use of obsidian at Ur for personal ornaments ('ear-studs') in the Ubaid period and later.

Inizan (1987: 312 ff.) has pointed out that obsidian is nowhere characterized by blocks of raw material, even at Tell Shemshara (Mortensen 1970: 27), where obsidian represents more than 85 per cent of the lithic industry. It was reaching settlements in a partially worked form. Cores are not reported after the Hassuna period, perhaps because they were being reworked as beads. Inizan and Tixier (in Huot 1983: 165) have emphasized, on the basis of evidence from Tell el-Oueili, the use of a special technique of abrasion and polishing on obsidian cores, a time-consuming process

which facilitates the greatest economy and efficiency in producing tool-blades from a valuable imported raw material.

With the increasing use of metal for tools from the later fourth millennium BC in Mesopotamia, obsidian tools become less and less evident, though the stone continued to be imported for decorative purposes and for luxuries. Fragments of obsidian vessels (see p. 41) were found in Late Ubaid to Early Uruk contexts at Eridu, Ur, and Uruk. Obsidian was ceasing to be a minor, if desirable, element in the tool-kit but becoming a prestige commodity, particularly when worked into fine objects. Tests on the obsidian artefacts from the *Riemchengebäude* at Uruk associated the stone with groups 1g and 4c (Lake Van, etc.) (Schneider 1990: 70). The rarity of obsidian in the flaked stone industries of the Uruk period at a number of sites has provoked comment, as at Tepe Farukhabad in Khuzistan (Wright, H. T. 1981a: 275), at Rubeidheh (Miller 1989: 77), and Jebel Aruda, where an obsidian pressure-core was found (Hanbury-Tenison 1983: fig. 27).

Although only one obsidian vessel is recorded in the graves of the Royal Cemetery, and that in the exceptionally rich tomb of Queen Pu-abi (RT 800) (Woolley 1934: 558 U.10488, pl. 165) in Early Dynastic IIIA, there are intermittent references to fragments of obsidian vessels or lids in Woolley's (1956: 170 U.28070; 176 U.13716) account of excavations in third-millennium BC levels at Ur. The obsidian bowl in RT 800 is a close copy of local metal shape 7, with its distinctive double, tubular handle-fittings, so the vessel would appear to have been made in Sumer, if not actually at Ur. Obsidian was also used for small zoomorphic fittings (Woolley 1956: 185, pl. 28: U.16400), as well as for amulets and pendants (Woolley 1956: 174 U.11231; 174 U.11960). In her study of the stones used at Tell Asmar, Khafajah, and Nippur, Meyer (1981) recognized obsidian in use for tools, amulets, beads, and an isolated stamp seal. Where they have survived, eye inlays for statuary in the Early Dynastic period appear to use black limestone rather than obsidian (cf. Frankfort 1943: *passim*).

At the end of the third millennium, fragments of obsidian vessels are reported at Ur with votive royal inscriptions, as from Room 8 in the *Enunmah* (Sollberger 1965: no. 18) and Room 23 in the *Giparu* (Gadd and Legrain 1928: no. 15). This is at a time when a marked increase in the availability of obsidian from the Van region (in its widest definition) for production of luxury vessels was noted at Tepe Malyan (Anshan) in Fars. Blackman (1984: 39) has sought to explain this change: 'One must look to developments in Ur III Mesopotamia for factors that effected the observed changes in the obsidian exchange. Expansion of Ur III influence into northern Mesopotamia or strictly local developments in the source region appear to have

resulted in increased access to a larger number of obsidian sources. A tighter control over the exchange may be indicated, with the possibility of collection and transshipment locales resulting in the mixing of obsidian from different sources.'

By the Isin-Larsa period archaeological evidence for the use of obsidian in Mesopotamia becomes extremely sparse, though the textual information is sufficient at least to provide information on its continuing use for beads (*CAD*, *surru* A), where it ranks with lapis lazuli, cornelian, and calcite ('alabaster') as the preferred combinations in fine jewellery with gold. It is also clear that, like lapis lazuli, it was one of the ornamental stones consciously imitated in faience and glass, again indicating its continuing status and relative rarity. Tiglath-Pileser I (c.1114-1076 BC) recorded that he had obtained *surru*-stone (obsidian) 'from the mountains of the lands of Nairi' in the region of Lake Van (Grayson 1976: 18), revealing the continued significance of these sources for Mesopotamia.

Whether any of the fine obsidian vessels produced in central Anatolian royal workshops in the earlier second millennium reached Mesopotamia is not yet apparent. At Acemhöyük the excavators recovered vessels and vessel fragments of obsidian (Özgüç, T. 1986; Özten 1979), whilst at Kültepe (Karum Kanesh) Özgüç (T. 1983: 425; 1986: 51; cf. Renfrew *et al.* 1968: 325) reported 'in a large building on the mound, contemporary with level Ib, two tons of unworked obsidian were found stored in a special room. Both on the mound and in the Karum many fragments of obsidian and rock crystal were encountered as workshop debris or in unfinished shape.' Even more instructive was the obsidian debris found in a 'workshop' uncovered in the destruction of level VII of the palace at Tell Atchana (Alalakh) in the Amuq Plain (Woolley 1955: 109-10, 293-4). This destruction is usually dated within Middle Bronze IIB, in the later seventeenth century BC, and attributed to the army of the Hittite king, Hattusili I. This obsidian, though damaged by fire, appeared to have been imported in ready prepared, roughly smoothed blocks measuring c.0.30 × 0.20 × 0.20 m.

Whereas in the more easily worked granite the outside was shaped first, the worker in obsidian seems to have started by hollowing out the interior of his vessel. This was done by boring holes close together with a [solid not a tubular] round-headed drill 0.013 m. in diameter and then breaking away the stone between the holes... the inside has, after drilling, been ground out to its final form, but not yet polished, so that the surface is matt and opaque; the outside has been roughed out by chipping but has not yet been ground. It would seem that the main difficulty was the hollowing out, when there was a risk of the stone breaking up; when once this was successfully done the craftsman could afford to vary the order of the finishing processes.

(Woolley 1955: 293)

Material evidence for the continuing use of obsidian in the first millennium is equally meagre, allowing for little more than the general statement that it remained available for amulets and beads, some of which may have been reused antiquities. Distinctive objects like a *Lamashtu* plaque in the Metropolitan Museum, New York (1984: 348: unpublished), are exceptional survivors; but they may be associated with such records as a gift of *surru*-stone by Sargon to Marduk (*CAD* 'S': 258) to indicate obsidian's enduring role as a prestige stone, valued for its lustrous dark colour.

(c) Rock crystal

Although rock crystal is most commonly considered as an ornamental stone (next chapter), it was entirely suitable for the production of very attractive chipped stone tools: a role in which its appearances are recurrent throughout Mesopotamia, where it was available locally. Of the more significant finds, a workshop of the Ubaid period at Tell el-Oueili (Inizan and Tixier 1983) and blades from the *Riemchengebäude* at Uruk in the fourth millennium BC (Lenzen 1959: pl. 19a) particularly well illustrate its employment both for tiny tools of unknown use and for conventional blades. It was also used for arrowheads of standard form from the third millennium BC, which endure in the Near East to this day as desirable amulets.

(ii) THE GROUND OR POLISHED STONE TRADITION

Ground stone technology long pre-dates the exploitation both of wild and domestic cereals in the Near East. The technique used in the manufacture of polished hard stone tools and weapons is distinct from that used on bone or soft stones, which is principally a matter of scraping or thinning with a flint blade. True stone polishing is polishing by abrasion achieved by extended rubbing of the tool in production against an abrasive stone. This is fashioning by wear and tear, perhaps assisted by sand between tool and polishing stone. Its emergence marked an important step, since hard stones unsuitable for flaking might thus be employed for the manufacture of tools. The technique is evident in pendants at Mureybet and elsewhere, by the Natufian period in the ninth millennium BC, when it may be traced eastwards through chipped celts with polished butts and polished marble bracelets at Karim Shahir (Braidwood and Howe 1960; cf. Nemrik: Kozłowski and Kempisty 1990: 351). The technique had a long life in Mesopotamia, still being used for the production of fine maceheads, for example, well into the first millennium BC. The polished stone tools of Mesopotamia are best rapidly reviewed by category. In doing so it is important to remember that many unmodified stones were used for a variety of purposes: hammering and pounding; grinding and pressing, so that

this is only a sample of the common stone used in daily life both in northern Mesopotamia, where such stones were readily available, and in the south, where they usually arrived as river-borne debris.

(1) Axes and adzes.

See p. 73.

(2) Celts

These ground stone tools were used from at least the seventh millennium BC through until the later prehistoric period. Meyer (1981) recognized in her sample from the Diyala sites and from Nippur that there was a close correspondence between shape and specific stones, some of which are otherwise relatively rare in the contemporary repertory of stones. She isolated trapezoidal celts of basalt, triangular ones of diabase/gabbro, rectangular ones of hornblende schist, and an exceptionally large specimen made of dolomite. As she argued, this correlation would be best explained by import ready-made from those regions in the highland periphery, or adjacent to river-beds with suitable debris, into central and southern Mesopotamia. In his study of celts of the later seventh millennium BC from Tell Bouqras in Syria, Roodenberg (1983) sought to demonstrate that microwear analysis indicated at least four functional types: felling axes/adzes/wedges or chisels/paring chisels. His comments on stone sources are very relevant to occurrences elsewhere then and later:

L'outillage est fait sur galets en pierre dure, ramassés pour une part dans les terrasses de l'Euphrate à proximité de l'installation néolithique; ce sont là des galets de roche sédimentaire de provenance régionale, comme le calcaire et la dolomite, relativement peu résistants à l'application de grandes forces. Une matière première possédant une plus haute résistance, telle que les roches volcaniques et schisteuses, n'est présentée dans ces terrasses que sous forme de très petits galets. Étant donné que leurs dimensions ont été réduites au cours du long transport dans le lit du fleuve, il faut conclure que la plupart des haches au roche volcanique et schisteuse ont été fabriquées en revanche, à partir de galets ramassés plus près de leur gisement, probablement dans les terrasses de l'Euphrate et du Tigre dans le sud-est de la Turquie.

(Roodenberg 1983: 177-8)

(3) Dagger-hilts

The only stone dagger- or knife-hilts to have survived appear to be those in rich graves as at Ur (cf. Woolley 1934: 317, pl. 151, 190: U. 9361) or deposited in temples as votives, some inscribed (as Kish: Ashmolean Museum 1937.651; Sollberger 1966: 99). Ornamental stones and a wide variety of the softer light- and dark-coloured stones were used, as they were also for pommels, which are regularly confused in the literature with 'knobs' and 'maceheads'.

(4) Hammers (shaft-hole) and hammerstones

As might be expected, the stones chosen for polished

stone *hammers* were those with tough consistency like basalt, diabase, greenstone, and siliceous limestone (Meyer 1981). It is still impossible to say how late their production ran on into the historic period. In Room 10 of the *Enunmah* at Ur, in a context of the earlier second millennium BC, Woolley recovered part of a finely polished hammer in a fine-grained volcanic stone (Woolley 1974: 85; U. 196).

(5) 'Knobs'

The typology of this heterogeneous category of polished stone objects, often embracing what are better defined as 'maceheads' (see below) or 'staff-tops', remains undeveloped. Zettler (1987: 210 ff.) has gone far towards establishing the forms of the stone *door-knobs* used in standard knob-and-hook fittings within major administrative and religious centres (for the ancient terminology, cf. Leichty 1987). The softer, calcium-based stones are the primary medium and they range in date from the third (if not earlier) to the first millennium BC. James (1978), primarily using Egyptian and Palestinian examples, has sought to do the same for various *knob-like chariot fittings* in stone most familiar in Mesopotamia in the Kassite period. Many of these objects are inscribed (and not all correctly identified in the existing literature) and the stones vary from the lighter calcium-based stones to more decorative varieties.

(6) Maceheads

Stone maceheads emerged in the prehistoric period (cf. Berghe 1987: 16–20) and survived through into the first millennium BC, when some may perhaps have served as 'staff-tops' or some comparable purpose. It is one of the remarkable features of the archaeological record for Mesopotamia that stone maceheads are so rarely found in graves, at least after the prehistoric period, and constitute a negligible aspect of the surviving material record in metal. They seem predominantly to have served in historic times as votive objects (Cocquerillat 1952; Braun-Holzinger 1991: 26–82). In Meyer's (1981) study of the stones used in the Diyala sites and at Nippur, maceheads were listed from temples not from large administrative buildings ('palaces') or graves. Some of these are so lopsided, so incompletely finished, or ineptly bored, as to indicate production for votive purposes rather than for use, particularly when made, as they often are, of soft stones like poor chalk or gypsum. Maceheads, like beads, were produced in the whole range of potential natural materials from the cheapest and commonest (clay) to the most rare and valuable (lapis lazuli); and also in faience, blue frit, and glass after the middle of the second millennium BC. In the Meyer (1981) sample it was maceheads that provided the largest pieces of worked haematite (233 g.), of ilmenite (200 g.), and of

lapis lazuli (148 g.), whilst also extending in range to miniatures (35–135 g.) of cheaper stones such as calcite, gypsum, and limestone.

Among stones represented in the macehead repertory, best known from the third and earlier second millennium BC, are: basalt, calcite, chalcedony, chalk, chert, dolomite, gypsum, haematite, ilmenite, lapis lazuli, limestone (28.6 per cent in Meyer's Diyala/Nippur sample), marble (35.3 per cent in Meyer's Diyala/Nippur sample), quartz and quartzite, silica, talc, and trachyte. In the second half of the second millennium they appear on Kassite sites in chalk or limestone, some reported from the palace at Aqar Quf, including an unusual type with a low relief frieze of animals carved on it (Baqir 1945: 8, 13, pls. XXV.27, XXVI.28; 1946: 90). They also occur at Assur (Andrae 1935: 102, pl. 59C; Grayson 1987: 77.2: 210–11), Nineveh (Campbell Thompson and Mallowan 1932: 98, fig. 2) and Nuzi (Starr 1937: pl. 121 N, P, S–U, Y, Z; 1939: 468–9). Thereafter they tend only to get into the literature if inscribed as votives. In historic times fine examples in soft stones were sculptured, particularly in the Early Dynastic period (Frankfort 1935), and many bore votive inscriptions (listed by Braun-Holzinger 1991: 26–82).

(7) Mortars and pestles; millstones; querns

What might broadly be described as grinding stones play an essential role in subsistence, converting raw grain to usable food, and the best rock for their manufacture may well be relatively scarce even where stone is not uncommon. The best require a surface that should not wear smooth, but should retain a rough texture which will continue to process grain. The rotary quern was not used in Mesopotamia until the Seleucid period, but various types of grinding stones and saddle querns were ubiquitous from the earliest prehistoric settlements, if not before, and are likely to have been constantly recycled. A grinding room with querns set out on benches for individual workers was found in the early second-millennium BC palace at Ebla (cf. Postgate 1992: fig. 12:5).

This specific category of stone equipment is one of the very few to which special philological study has been devoted (Stol 1979: 83 ff.). Old Babylonian texts indicate that the lower grinding stone was sometimes made of *ušum* ('diorite') and the upper of *sūm*-stone (?sandstone); at others 'one millstone of *atbarum* ("basalt")', of good quality, together with its "rider" (Stol 1979: 83 n. 325). Various types of basalt were used and the terminology is loose, sometimes referring just to 'black' stones, as in modern Arabic usage for basalt and its relative dolerite. The lexical series *Harra*=*hubullu* and the *Lipšur* litanies identify Mt. *Saggar* as a 'mountain of millstones'; but whether this refers to basalt or to sandstone is not clear. If this is

indeed a reference to Jebel Sinjar, as Stol (1979) argued, local geology suggests that the rock in question was sandstone. Since several hundred grinding stones were recovered from a single room in the Ubaid period settlement at Yarim Tepe, this may be indicative of an early production centre in the region (Postgate 1992: 207, fig. 11.1).

Other gritty rocks were also used. Some seventy miles north of Babylon, where the Euphrates comes closest to the Tigris, Xenophon (*Anabasis*, 1. v. 5) reported that 'the inhabitants used to quarry by the river and manufacture upper millstones for grinding corn; but they took them to Babylon to sell and lived on the food they bought with the proceeds'. Some fifteen hundred years earlier, among the commodities coming down the Euphrates to Mari by boat in the eighteenth century BC, taxed as they passed a point near Terqa, were millstones (Dossin *et al.* 1964: nos. 82, 90; Dalley 1984: 170). Neither source identifies the type of stone used. Some indication is provided by the nineteenth-century traveller Ainsworth, whose survey of the Euphrates is still of great value to scholars. He describes how 'it is not till we have got south of 'Anah, and in the country neighbouring Haddisa, that we find a gritty siliceous rock alternating with ironstone, and intercalated among the marles, gypsum, and limestones of the country, capable of being used as a millstone' (Ainsworth 1844: 82). With more routine mortars and mauls, availability and cheapness were the relevant considerations governing the stones selected. These are normally dolomite, limestone, or low-grade marble.

(8) Ploughshares

No stone ploughshare has certainly been identified yet on a Mesopotamian site; but it is possible that a stone implement 'originally hafted in wood, of which traces remain', from Room 9 of the 'Shulgi Mausoleum' at Ur, is such an object rather than the 'stone pick' of Woolley's description (Woolley 1974: 14, fig. 4: U.16293; ?limestone; University Museum, Philadelphia).

(9) Stone bearings for slow potter's wheels ('tournettes')

Tournettes, with heads and sockets carefully formed in polished hard stones, probably fed with oil to allow for slow rotation, are reported from sites in Egypt and Syro-Palestine, but have been much more rarely noted in Mesopotamia (see pp. 148 ff.).

(10) Shaft-hole axe- and adze-heads

These tools and weapons emerge first in the Neolithic period (cf. Tepe Gawra: Tobler 1950: 227, pl. XCIVc; Ur: Woolley 1956: 87, fig. 24; Uruk: Lenzen 1965: 33, pl. 20) and persist to an unknown extent into the historic period, when isolated examples which closely match metal forms indicate a continuing production, if only for votive purposes comparable to that of maceheads. In Room 10 of the *Enunmah* at Ur, for instance, in a context of the earlier second millennium BC, Woolley recovered fragmentary polished stone axeheads in hard, dark volcanic stones (Woolley 1974: 85, U.194–5; University Museum, Philadelphia 14962(U?)). To the same period belongs an inscribed fragmentary stone axehead, with a lion in relief on the butt, excavated at Nippur (Gibson 1975: 38, fig. 28, 3ab). Tukulti-Ninurta I of Assyria, in the thirteenth century, recorded that he 'cleared a way through high difficult mountains with stone tools' (Grayson 1972: 119–20).

(11) Weights

The surviving weights from Mesopotamia may be broadly classified either as pebbles or finished pieces in various standard shapes, which are generally of the iron ores and date after the Akkadian period. Some stones, such as calcite, gypsum, and lapis lazuli, are conspicuous by their absence from those selected for weights; the majority are of limestone, marble, and haematite or its close relatives. There is more variety in the stones chosen for weights before about 2000 BC than thereafter. In the mid-first millennium BC a number of fine, hard jeweller's stones were selected for the duck-shaped weights, which also served as amulets and seals. As with so many functional objects in stone, votive examples were inscribed and placed in temple deposits.

THE STONEWORKING CRAFTS: ✕ ORNAMENTAL STONES

1. The Materials

(i) FOR SEALS

MANY OF THE STONES TREATED IN THIS CHAPTER are those commonly classified as 'gemstones', but there are others, and some organic materials, of less restricted use which also had a role as ornamental materials. They were used primarily in ancient Mesopotamia for beads and seals. At present, in the absence of systematic studies of beads, the varying use of these stones through time may only be traced through seals, since they (unlike beads) may be dated independent of context and an increasing number are being properly identified by mineralogists. The total is still a tiny percentage of the whole; but it is at least a start. By contrast, only the pioneer studies of beads by Horace C. Beck in the 1920s and 1930s embrace material identification, typology, and study of manufacture; but his database was exceptionally narrow and ill-dated, as well as generally being a sample, often very small, selected by excavators. Even so, Beck's pioneering studies (also those on glass and glazed stones) and his comments in reports on beads from the ancient cities of the Indus Valley, offer a valuable starting point for a survey of the stones used for beads in Mesopotamia. His results are incorporated here into the entries for particular stones.

It has long been recognized that there were significant chronological differences in the materials used for seals in Mesopotamia (Ward 1910: 5 ff.). Legrain made the point succinctly, if somewhat crudely, long ago: 'The hematite period succeeded the diorite [in fact serpentine and chlorite] period, as the diorite had replaced the shell, marble and calcite period . . . The hematite is now abandoned for more brilliant stones, the agate and the chalcedony . . . The early Assyrian—or Babylo-Assyrian—seals use the older material diorite and serpentine, but the more recent seals adopt the agate and the jasper in vogue since the Cassites' (Legrain 1925: 23, 36, 38). Recently Gorelick and Gwinnett (1979: 29; table 29) expressed the same trend in another way:

It was found that seals with Mohs hardness of 1–3 predominated from the Obeid period . . . through Ur III . . .

The stones often used were steatite, marble, limestone, alabaster. In the pre-Obeid period, there were no seals with a Mohs hardness of 4 through 7. They were found subsequently but remained a minority until the Old Babylonian and Kassite periods . . . when a Mohs hardness of 4 through 6 predominated. Stones of haematite, lapis and obsidian were used during this period. From the Middle Assyrian period . . . through the Sassanian period . . . stones with a Mohs hardness of 7 predominated. These included quartz and crypto-crystalline quartz material.

Any advance from such generalizations to fine-grained analysis of variations through time is still restricted by a general absence of reliable geological determinations. It is only in the last decade or so that experts have been called upon to provide proper identifications for seal catalogues (Collon 1982^a; 1986; Teissier 1984). The nature of these collections has meant that it is only in the minority of cases that the seals so identified came originally from controlled excavations. At present the following brief sketch is all that may be offered for the stones generally employed in the major periods. It rests almost exclusively on information provided by recent British Museum seal catalogues.

Petrological studies of prehistoric stamp seals are not yet available. From the outset, in the sixth millennium BC, seals and seal-pendants in the north and along Mesopotamia's eastern frontier within the Zagros range were generally of the softer dark stones, easily cut with flint or obsidian tools (cf. Wickede 1990). But, already, in levels of the Hassuna period at Yarim Tepe I seal-pendants with incised linear patterns are sometimes of quartzite (Merpert and Munchaev 1987: 17, pl. Vb). In Yarim Tepe II stamp seals become more numerous, as throughout the area covered by the Halaf Culture, and although, as earlier, many are of chlorite/serpentine/steatite, diorite, marble, rock crystal, and sandstone (ibid.: 29) are also reported where identifications by eye are given.

At Tepe Gawra, Tobler (1950: 176) noted an increase in recovery of seals in stratum XIII (Late Ubaid) with a peak in XII, early in the Uruk period. 'Most of the varieties of stone used in the manufacture of seals (such as steatite, serpentine, lapis lazuli, agate, cornelian, haematite, and obsidian) are not found in a native state in Mesopotamia, and must have been imported from

some distant source.' He noted that 'close to 60 per cent of the nearly 200 seals found in Strata XIII–XI were made of steatite and serpentine. On the other hand, only three of the ten seals found in Strata XIX–XV were made of these varieties of stone' (ibid.: 176 n.2). As he appreciated, more readily available stones might have been used, but, for reasons of friability or extreme hardness, they were clearly avoided.

Although isolated seal-pendants had penetrated to the south by early in the Ubaid period, prehistoric stamp seals characteristic of Uruk IV–III in the south are generally of limestone, marble, calcite, or gypsum, sometimes the coloured varieties. Shell was also used. Lapis lazuli was now the most exotic stone for seals. It was reaching Gawra by stratum XIII (see above), though the earliest stamp seal carved in it may be more recent (cf. Herrmann 1968: 29–30). This is approximately contemporary with Uruk IV in the south; when lapis was used for some of the earliest cylinders as well as for stamp seals (Herrmann 1968: 32–6).

Using energy dispersive X-ray fluorescence analysis (EDS-XFA), Asher-Greve and Stern (1983) have studied cylinder seals of the late Uruk period from Telloh, Susa, and various unknown sites. Both at Telloh and Susa calcite was the most popular stone, as also amongst the unprovenanced seals. 'Calcite' embraced seals that were 'whitish, yellowish, brown, reddish [particularly popular], grey and black in colour'. The red-coloured cylinder seals were usually of red serpentine (not of garnet or jasper). Regional differences were apparent with heulandite, used at Susa (cf. Lahanier 1976), but not in Mesopotamia. Asphalt (bitumen) and steatite were also used more often in Khuzistan than in heartland Sumer. Only rare cases of serpentine (red and greenish/black) were noted; the source of this stone may have been in Syria rather than Iran. Even at this early stage there are isolated occurrences of hard stones, for example rock crystal (Mohs 7), for seals in the more popular styles of the Uruk IV–III period (cf. Collon 1987: fig. 13). Asher-Greve and Stern noted some evidence of a correlation between material, colour, and motif possibly indicating deliberate choices.

Through the Early Dynastic period, in the first half of the third millennium BC, it is the light-coloured, softer stones that were preferred for the manufacture of cylinder seals, which had now virtually superseded stamp seals in Mesopotamia. Lapis lazuli was increasingly popular from Early Dynastic II as the most prestigious of seal stones. Marble or limestone (calcite), with gypsum, account for the majority of ordinary seals that are not of shell, which was especially popular with seal engravers at this period. Seals in the soft dark stones of the chlorite/steatite/serpentine range are relatively rare. The percentage of serpentine rises from 8 in Early Dynastic III to 46 in Akkadian times in the British Museum collection (Collon 1982a: 14, 26), from 21

(Early Dynastic) to 66 in the Marcopoli collection (Quick and Sorenson 1984).

In the Akkadian period, dark greenish-black serpentine was used for about 50 per cent of cylinder seals; greenstones (low-grade metamorphic rocks) also achieved considerable popularity for better-quality seals. Some diorite and various quartzes (green and red jaspers; rock crystal) were fairly common, with a persisting taste for shell. Surprisingly little lapis lazuli is encountered in the seal repertoire at this period compared to Early Dynastic III and that tends to be paler and more mottled varieties than had previously been selected. Unusual colour effects were also attempted. Two rock crystal seals from Ur (Collon 1982a: nos. 91, 108; cf. Collon 1987: fig. 101), one inscribed for a priest of Inanna, had their perforations painted in bands and chevrons of red and white pigment visible through the rock crystal.

In the post-Akkadian and Ur III periods at the end of the third millennium BC chlorite replaced serpentine as the primary seal stone. It rises from 1.6 per cent of the Akkadian seals in the British Museum to 44 per cent in the Post-Akkadian series, 55.5 per cent in Ur III, paralleled by an equally dramatic decline in the use of serpentine (Bimson and Sax 1982; Collon 1982^a: 110, 130). A similar pattern is evident in Meyer's (1981: table 23) sample of seals of this time from the Diyala sites and Nippur. It is possible that this changed pattern has a close connection with the appearance of the *serie récente* chlorite vessels in Sumer (see pp. 49 ff.). from sources in the Gulf, notably Oman, where chlorite occurs. This pattern is complemented by a low-level use of calcite and lapis lazuli in the post-Akkadian period. In the Ur III period calcite and greenstones supplement the predominant use of chlorite. Lapis lazuli and quartzes appear only intermittently.

The first four centuries of the second millennium BC are characterized in seal production by the overwhelming popularity of iron oxides, predominantly haematite, considerably less often goethite and magnetite (Sax 1986). Their appearance in this context is sudden, with little or no trace of them before 2000 BC. This is one of those rare cases where the general source of an ornamental stone may be identified with some degree of confidence. The iron oxides came from the volcanic regions of Anatolia accessible from the Upper Euphrates. They were also used, almost to the exclusion of other materials, in Anatolia itself and in Syria for cylinder seals at this time. Blank cylinders, of the type used for seals, cut in haematite were found during excavations at Tell Selenkahiyah, as if for shipping down the Euphrates into Babylonia (Loon 1968). At this time isolated cylinder seals were cut in obsidian, which also came from eastern or central Anatolia.

The softer stone used with haematite was predominantly black limestone (calcite). Serpentine returned to

favour for seals larger and of better quality than those in the calcium-based stones, and chlorite remained intermittently in use. The prevalence of dark stones is relieved among the finer seals by use of rock crystal and smoky crystal (chalcedony), red and white mottled jasper, and, later in the period, amethyst. As the agate and cornelian seals of this period are frequently barrel-shaped, they may originally have arrived in Babylonia as ready-made beads from the west coast of the Indian peninsula. Rare occurrences of the bright apple-green stone amazonite have been attributed to sources either in the Urals or Kashmir. If there really were no closer sources, the Indian connection evident at this time makes Kashmir more likely. Lapis lazuli was now increasingly rare among seals and often only scraps were used for inferior seals. It was clearly being recycled. Fresh supplies may have all but disappeared by the Old Babylonian period, perhaps as a direct result of the disruption of long-distance trade with the east by sea down the Gulf.

In the third quarter of the second millennium BC the growing popularity of faience and glass for seals, still cut not moulded, naturally affected the gemstones employed. For seals in 'Kassite' style haematite was rarely used. Cyprus was now the only region in the Near East where fine cylinder seals in local styles were almost exclusively cut in haematite. In Mesopotamia the harder stones were vividly coloured quartzes, notably agate, chalcedony, jaspers, and much more rarely lapis lazuli, feldspar, and obsidian. As before, poorer-quality seals were cut in limestone or calcite, serpentine, and related soft, dark stones. The contemporary 'Elaborate Mittanian' style continued the use of hard stones like haematite as well as agate, cornelian, chalcedony, chert, and jasper, with rarer use of serpentine and other soft dark stones. Although the 'Common Mittanian' style appears most often on seals of faience, examples in chert and haematite, as well as in soft dark stones, are recurrent. About 80 per cent of 'Middle Assyrian seals are made of hard stones, the highest proportion of any contemporary style, and faience was not normally used at this time in Assyria for seals' (Matthews 1988: 70).

Chalcedony predominated among materials for cylinder seals in Neo-Assyrian and Neo-Babylonian workshops. Of 204 seals in the British Museum attributed to them that were made of chalcedony, 93 are naturally coloured . . . pale shades of grey and brown; 39 are of the variety cornelian (including some large and fine examples); 25 are of chalcedony coloured in shades of blue . . . 12 are of chalcedony in shades of white; 10 are of agate and 25 are miscellaneous examples of chalcedony including brown, green, pink, violet and turquoise chalcedonies, two deliberately etched chalcedony beads and also some jasper seals. Other hard materials include two fine examples of translucent pale

green microcrystalline grossular garnet, a little macrocrystalline quartz and single examples of diorite and lapis lazuli' (Sax 1991: 106). The range of softer materials at this time includes serpentine (particularly common), various limestones, chlorite, vein calcite, and soapstone.

It appears from the British Museum sample that in Babylonia imported hard stones were used almost exclusively, whereas in Assyria they were supplemented by serpentinite and limestone, which would have been much more accessible in northern Mesopotamia. In Syria, as stamp seals also indicate, hard stones were rarer and locally available dark soft stones, including chlorite, were commonly preferred. White chalcedony, used infrequently in Mesopotamia, is a favoured hard stone in Syria and may have come from a source in the Taurus. The use of grossular garnet and brown-and-white garnet before the fifth century BC may indicate that semi-precious stones from the Indian subcontinent were again in use in Mesopotamia as they had been a millennium earlier (cf. Sax 1991: 112–13); but see p. 83 here on garnet).

Chalcedony continued to predominate among seals in the Achaemenid period. The British Museum collection includes at least two and perhaps four agate cylinder seals which have been artificially dyed. Limestone was the preferred soft stone, some of it black, perhaps imported from Fars in Iran where this stone was used for the sculptures at Persepolis. Among the artificial materials, like faience and glass, carbon coated lime-plaster appears, presumably a cheap imitation of black limestone. Not surprisingly there is a marked continuity with the materials used by Neo-Elamite seal-cutters in south-west Iran. Indeed, the brown limestones, both plain and streaked, used both by Neo-Elamite and Achaemenid seal-cutters, may have come from that area. The Achaemenids clearly liked banding in chalcedonies, particularly in shades of brown. It is possible that the bead-shaped seals in this material are reworked beads, possibly imported from the Indian subcontinent. Lapis lazuli is relatively rare.

When stamp seals began to return to popular use in Mesopotamia from the very late eighth century BC, under western influence, they were cut in a great variety of stones, including the soft dark ones popular in Syria. But by the time shapes and motifs had become rigorously standardized, as in the Neo-Babylonian period, chalcedonies of various colours were most commonly employed, with the blue tones predominant. This taste persisted into the Achaemenid period, when coloured glass became increasingly popular, particularly in Syria, usually in opaque colours reminiscent of the most favoured hard stones.

An interest in rare stones is illustrated by an unusual inscribed cylinder, with no engraved scene, made 'd'un beau calcaire éocène d'une pâte brune enrobant de très

nombreuses nummilites . . . 30.5mm de longueur' (Baer 1960). It is inscribed: 'Palace of Sennacherib, king of the land of Assur. Present which Abiba'al, king of the land of Samsimuru(na) gave to me.' This region lay somewhere in Phoenicia.

(ii) FOR BEADS, AMULETS, AND PENDANTS

Broadly speaking, the pattern of stone use established for seals applies also to beads whenever it may be checked, allowing that seals were primarily élite items and therefore highlight the use of the more valuable or fashionable stones in any period. The more ordinary stones, the calcium-based soft stones or the chlorite–steatite series, are likely always to have been the basis for the repertory of stones more commonly used for bead-making, supplemented by shell, bone, and clay, with glass and faience emerging in the second millennium BC as cheaper imitations of the more colourful opaque hard stones. Until there is much more reliable evidence period by period in historic times for the various stones used for beads, a general account may not be taken very far beyond that given for seal stones. For the present the systematic catalogue of beads found between 1912 and 1985 at Uruk (Limper 1988) is an isolated specialist study and it is restricted largely to beads of the later prehistoric period and the middle of the first millennium BC.

The discovery of zoomorphically decorated stone pestles at Nemrik in northern Mesopotamia has radically revised conceptions of the stone industries of the aceramic settlements of the region c.8000–7000 BC. Among the materials used for beads were marble and malachite, as with the now well-known pendant from the Shanidar Cave in the Zagros (Solecki 1969), and sandstone. Both the marble and the sandstone are local.

Jarmo remains one of the earliest settled communities in Iraq whose bead repertory has been carefully studied, though even here it was by eye and the identifications were offered as provisional:

most of the beads in the Chicago sample are of marble, usually opaque white, but also gray, pink, red and white, and red and cream in color. Opaque brown-and-tan beads are probably of limestone, while black ones seem to be serpentine or chlorite. Green beads (from light to dark in shade) resemble the stones used for some of the Jarmo celts that were identified as chlorite. Light aquamarine beads look very much like turquoise . . . Clear, colorless beads and fragments may be calcite, while the translucent red orange stone concentrated in J-II is probably carnelian. Much of the material, then, may be of local origin. Small pebbles of translucent, brightly colored stone may have come from the stream below Jarmo.

(Moholy-Nagy 1983: 298)

From Yarim Tepe I, of the mid-sixth millennium BC, many beads were recovered, of alabaster, azurite, chal-

cedony, cornelian, limestone, marble, rock crystal, serpentine, and turquoise (Merpert and Munchaev 1987: 15; 17): 'level 9 has yielded a necklace of 15 turquoise beads . . . level 10, a necklace of 10 disc-shaped cornelian beads; and lastly, and most interesting, from level 12, a necklace of 15 beads of different sizes, colours (grey, green, yellow, cherry, red, blue, etc.) and materials (including rock crystal, shell) found in the centre of the round ritual structure 319'.

Stone artefacts are very characteristic of the Halaf Culture, beads, pendants, and seal-amulets conspicuous amongst them. Amulets are particularly well represented at Arpachiyah where 'by far the commonest (material) is black steatite, but coloured limestones, calcite, terra-cotta, and even frit . . . are also used, and there are some examples of quartzite' (Mallowan 1935: 91, pls. VIa, VII–VIIIa, figs. 50–1). Among the beads Mallowan (ibid.: 97, pl. VIb) lists calcite, cornelian, lapis lazuli, obsidian, quartz, and serpentine. In one particularly fine necklace flattened obsidian double conoid beads alternated with cowrie shells filled with red pigment (ibid.: pl. XIa); in another case plaques of obsidian had been pierced for threading or mounting as ornaments (ibid.: pl. XIb). More restricted evidence from such sites as Tepe Gawra and Yarim Tepe II (Merpert and Munchaev 1987: 29) complement the more varied repertory of Arpachiyah.

Tobler (1950: 192) provided specific evidence on the materials used at Gawra: 'in Strata XIX through XVI the materials commonly employed in the manufacture of beads include obsidian, white paste, cornelian, limestone and marble . . . In levels succeeding XIII the most common materials were white paste, cornelian, obsidian and limestone, as in the lower strata, but in addition turquoise, amethyst, lapis lazuli, agate, quartz, jadeite, beryl, diorite, haematite, steatite, and serpentine are also found, although these varieties of stone are more exceptional.'

The evidence for ornamental stones in the south before the Uruk period, in the fourth millennium BC, remains sparse. As beads are normally recovered from graves and richly equipped graves are still rare in the southern Ubaid and pre-Ubaid sequences, it is difficult to assess whether this is indicative of truly restricted supplies. For beads and amulets, clay, bone, and shell are certainly the commonest materials in the published record, all locally accessible. Cornelian, obsidian, and some coloured, calcium-based stones occasionally appear, but it is only the enigmatic 'studs' of this period that are consistently of obsidian or quartz (cf. Huot (ed.) 1983: 134). Whether they were really nose or ear studs, or perhaps tools for applying kohl, is still debated. They might have been traded ready-made from northern centres of production (cf. Tobler 1950: pl. XCIIa: 11–12).

A chronological review of the stones used for beads

in historic times in Mesopotamia depends almost exclusively at present on the publications of excavations at Ur and Uruk, since little serious attention has been paid to them elsewhere. At Uruk in Uruk IV–III amethyst, cornelian, lapis lazuli, rock crystal, shell, frit, and faience, as well as the common stones used then for vessels and sculpture, are listed in the bead repertory (Limper 1988: 2, 97ff., pls. 1–13), establishing a basic pattern that was remarkably consistent. Of the Early Dynastic and Akkadian periods at Ur, Woolley (1934: 369) noted that in the Early Dynastic graves, 'only four materials are regularly used for beads, namely gold, silver, lapis-lazuli, and cornelian; wood occurs occasionally, glazed frit [?faience] is used . . . and there are two cases of glass paste [?frit]. Queen [Pu-abi] possessed a marvellous collection of agate beads of exquisite colour and polish . . . but in this she is exceptional, and the other graves both royal and private rang the changes on this strictly limited repertory. In the Sargonic period there is a far wider range; agate is common, sard sometimes occurs, steatite and haematite, marble, pebble, crystal occasionally, glazed frit is not infrequent, and there are two instances of glass paste; at the same time the four old materials continue to be the most fashionable of all.' Elsewhere at this time in lower-status graves clay and shell play a conspicuous part. Thereafter, apart from the increasing use of artificial materials in the second half of the second millennium BC, the stones used for beads parallel very closely those used for cylinder seals.

It is rarely possible to establish the range of ornamental stones on a site in Iran within a region that might have played a role in Mesopotamia's lines of supply. But at Tepe Malyan (Anshan) c.2500–2000 BC agate, calcite, gypsum, haematite, marble, milky quartz, opal, rock crystal, rose quartz, steatite, talc, turquoise, and zeolite are listed (cf. Sumner 1988: 318). With the possible exception of turquoise, these are, however, stones that might have reached Mesopotamia as easily from the north or north-west as from the east. Indeed, some may have been locally available in river-borne debris.

The problems of identity which bedevil any account of the stones used for building, for sculpture, and for vessels are relatively simple by comparison with those confronted by any serious investigator of the gemstones used in ancient Mesopotamia. In Meyer's (1981) study, the greatest variety of stones, 73 per cent (53 out of her 72 categories), were represented amongst beads from the Diyala sites and Nippur, with only totally unsuitable stones like vesicular basalt or conglomerate consistently missing. Cylinder seals, at 48 per cent (35 out of 72 categories), were the next most varied objects. The previous sections on beads and seals have sought to make clear the gross nature of the evidence at present available for identification. Even with such readily recognized semi-precious stones as lapis lazuli or agate,

fine-grained distinctions and reliable assessments of use through time are still impossible; questions of source and availability are often equally obscure, whilst any quantitative assessments are out of the question at this stage.

The pioneer lexicographers, notably Landsberger (1965: 295), took an optimistic view of the possibility of reaching one-to-one equivalence translations in the study of material culture, but contemporary scholars have a far more cautious, even pessimistic, approach. The following statement is representative of their attitude to the translation of the names for ornamental stones:

a non-rigorous, popular etymological method has already been at work on some of the names. Once a name has been deformed, or re-formed by popular etymology, it is no longer a suitable subject for 'scientific' etymology . . . Again, comparative etymology between related languages has little value for the precise identification of individual species or the like, since this is often exactly the feature that varies from dialect to dialect. Third, modern nomenclature of stones is sometimes based on scientific tests not available to the ancients . . . In ancient Mesopotamia many stones were named and classified from their appearance (colour, lustre, sheen) alone; and hardness could not be accurately computed. Magical, mythical and folklore associations, especially with animals; geographical origin; and use are also sources of names. Even the lexicographer's ideal, an inscribed object specifying the material of which it is made, is unlikely to yield more than partial identification here, owing to the unbridgeable disparity between the classification systems. So it seems unlikely that 'identification' in most cases can ever be more precise than 'elallu-stone', 'algameshu-stone' and the like.

(Al-Rawi and Black 1983: 138; cf. Steinkeller 1987^a: 94)

As yet there is no standard modern edition of the lists of stones (*Abnu shikinshu*: 'the stone whose appearance is . . .'; cf. Horowitz 1992).

Behrens has estimated that some eight hundred terms in the lexical lists of gems and stones remain to be identified (cited by Carter, T. H. 1986: 309). Some fifty-four minerals suitable for magical amulets are listed in a text from Assur, less than a quarter of which may be identified with any degree of confidence (Yalvaç 1965; cf. Limet 1984a). Such also is the case with the forty-nine stones listed in the Sumerian myth *Lugal*, in which Ninurta conquers the monster Asag and turns it into stone. Asag is supported by his offspring, personified stones whom he has organized against Ninurta (Dijk 1983). Some, who have fought against Ninurta, are cursed by him, whilst others who have not are blessed in a passage which has optimistically been described as 'un traité hermétique sur l'usage des pierres, sur la technique du lapicide, de l'orfèvrerie, de la statuaire, du sculpteur' (Dijk 1983: i. 43 ff.). For students of stonemaking in Sumer the text remains enigmatic, rarely open to elucidation (cf. Heimpel 1987; Heimpel *et al.* 1988: 195 ff.).

As the Assyriological literature is already full of apparently confident one-to-one translations for gemstones, it needs to be reiterated that, as with *esi*, which may have described hard dark rocks of similar appearance other than 'diorite', so may *za.gin*: 'lapis lazuli' have been used to describe a spectrum of greenish-blue decorative minerals (cf. Steinkeller 1987^a: 94–5). Thus it is that this survey, though it may offer no positive guide to the proper translation of the hundreds of terms for ornamental stones recorded in Akkadian and Sumerian, may occasionally help in a negative way by indicating that, in view of the material evidence, some options are more probable than others. When textual evidence is cited in the following section, it is made clear which Akkadian word is believed to denote the stone in question.

When texts, even where they exist, may not be drawn upon with confidence to establish the source of gemstones, and when chemical fingerprinting has not been applied, little if anything may confidently be said about the source of virtually all the stones listed here. It is, however, likely that all but a very few, notably lapis lazuli, were available within the mountain periphery to the north and east of Mesopotamia or in regions directly accessible by sea up the Gulf. Consequently, and it is a possibility often overlooked, many may have been much more readily available through debris brought down by the Tigris and Euphrates, and their tributaries, than might at first be apparent. As study of the prehistory of the area increasingly makes clear, a remarkable range of ornamental stones was already being exploited in northern Mesopotamia by at least the eighth millennium BC in the earliest village settlements.

(iii) HISTORICAL SURVEY OF THE ORNAMENTAL STONES USED IN MESOPOTAMIA LISTED ALPHABETICALLY; FOR CONVENIENCE AMBER (5) AND PEARL (53) ARE INCLUDED

1. AGATE. See Quartz.

2. ALABASTER. See Gypsum.

3. ALMANDINE. See Garnet.

4. AMAZONITE. See Feldspar.

5. AMBER AND OTHER RESINS. 'The first time I encountered decayed amber [in Sasanian or Early Islamic graves] in northern Iraq, a light brown flaking powdery substance, I was inclined to suppose that it might be glass: decayed glass of c. 1400–1200 BC can look somewhat like this. Fortunately, on that occasion, I had a visitor who was familiar with amber from Scandinavian excavations and was able to identify mine, but I cannot help wondering how often comparable mistakes are made' (Reade 1987: 33; referring to excavations at Tell Taya).

Amber and other resins, though neither precious nor semi-precious ornamental stones, are most conveniently considered here since they were primarily used like gemstones in ancient Mesopotamia. Amber is a fossilized resin of extinct coniferous trees, naturally varying from yellow to brown in colour, which takes a good polish. It is not only attractive in appearance, but also pleasant to touch and to smell. Its magnetic properties, mentioned by Plato in the *Timaeus* (80C), gave it a reputation in antiquity for magical and amuletic power. It was also thought to have medicinal value. Amber does not occur naturally in Mesopotamia.

Though hard in comparison with other natural resins, amber only registers about 2.5 on the Mohs scale. Easy to carve without specialist tools, amber often contains faults and impurities which have to be avoided in larger pieces; but it is not liable to break up when carved and may easily be drilled and polished. Amber may be artificially stained other colours, such as black and green, and variegated colouring is also possible. It is also subject to slow colour change with the lapse of time (Strong 1966: 14–16). So far amber has rarely been reported from Mesopotamia, where it was used sporadically for amulets and beads, though not apparently for inlays or seals. The isolated amber statues reported from the region are controversial. Pliny refers to the use of amber for spindle-whorls in Syria (*Natural History*, xxxvii. 37) and it was sometimes used for handles in the Graeco-Roman world (cf. in general Strong 1966). It seems that amber was used by the Etruscans as a flux in colloidal soldering of goldwork; a search for eastern parallels or precursors has yet to be undertaken (Follett 1985).

(a) Historical survey

'Amber' is listed among the materials used for beads at Bouqras in the Neolithic period (Akkermans *et al.* 1982: 55), but this remains an isolated early occurrence. A small pendant, probably of the later third millennium BC, from a grave at Tell Asmar originally recorded as amber has recently been shown to be made of copal, a solid resin of medium hardness recovered from various trees in different parts of the world. This particular type has been identified as from Zanzibar, Madagascar, or the Mozambique region of East Africa (Meyer *et al.* 1991). At this stage it is difficult to assess the full significance of this discovery; but it highlights the importance of scientific tests to establish the true nature of 'amber'.

Amber beads were briefly noted in the original report on the bead deposits in the foundation levels of the main ziggurat at Assur (*MDOG* 54 (1914), 48), generally attributed to Shamshi-Adad I (c.1813–1781 BC); but they are not in the final report (Haller 1954). Even if the first report is correct, this deposit may have been

contaminated by objects from the Neo-Assyrian period (cf. Ellis 1968: 132–3). In one of the early second-millennium graves at Ur (LG/189) Woolley (1976: 251) noted what he identified as an amber bead. At much the same time at Tepe Hissar (IIIC) in north-east Iran amber is reported for the first time on the site in necklaces and in belt decoration (Schmidt, E. F. 1937: 223, 312, 325). Amber inlay was used with agate, cornelian, and lapis lazuli in the remarkable gold bowl of the early second millennium bc found at Trialeti in Georgia (Javakhishvili and Abramishvili 1986: pls. 5–6). Although amber beads have yet to be published from Kassite or Middle Assyrian graves, they (or resin beads) are reported in the Late Bronze Age in Syria, as at Tell Atchana and Ras Shamra (Ugarit) (Woolley 1955: 203, 208; Schaeffer 1939: 100, fig. 95; 1962: 97), in Cyprus (Strong 1966: 40, pl. 1), and at a number of sites in Palestine (Todd 1985). Contemporary 'amber' found in Egypt has been shown to include both Baltic amber and resinous substances (Lucas 1962: 387–8; Todd 1985). Amber beads have been reported from the wreck of a ship off the coast of southern Turkey in the second half of the fourteenth century; some have been identified as Baltic amber (Pulak 1988: 24–5). In the circumstances each find in the Near East will need to be scientifically examined before it will be possible to assess the relative role of amber, from whatever sources, and resinous substances in the Near East at this time.

Amber is reported among the materials for beads at Babylon in the mid- and later first millennium bc (Reuther 1926: 32, 211, 223, 264, pl. 95; 238, 'Parthian'; also probably Beck, H. C. 1929: 143; 1933: 183 (Nineveh)) and was used for seals in Cilicia and Syria in the Iron Age (cf. Boardman 1990: 4, figs. 1–2). But the outstanding object of amber attributed to the first millennium bc in Mesopotamia is a statuette (24.3 cm. high), of unknown origin. It represents a standing Assyrian king in ninth-century style and is made of Baltic amber (Beck, C. W., in Muscarella 1979: 15; now in the Boston Museum of Fine Arts: MFA 38.1396; Terrace 1962: no. 20). Although controversy has long surrounded it (cf. Muscarella 1977: no. 215; 1979: 4, 36), this statuette has an established place in articles and textbooks on ancient Near Eastern art (cf. Frankfort 1954: 81–2, pls. 80–1; Garbini 1959; Ghirshman 1964: fig. 30 'Urartu(?)'; Strommenger 1970: 27, pl. 16a, b); indeed, Frankfort judged it to be a much finer piece of sculpture than the famous stone statuette of Assurnasirpal II now in the British Museum (Frankfort 1954: pl. 82). In Kelly Simpson's view (cited in Harding and Hughes-Brock 1974: 169): 'it seems very likely that the statuette is in fact original but has been re-carved so that the details are essentially modern.' As Beck has pointed out, the use of Baltic amber is no help in establishing whether this figure is ancient or

modern, as it might have been available to a Neo-Assyrian craftsman. However, 'any single piece of Baltic amber of the size required to carve a statuette is a great rarity even now, and must have been much more so when the supply of amber was limited entirely to pieces thrown up on the beaches, rather than being mined from the amber-bearing layers of glauconitic "blue earth"' (Beck, C. W. 1979: 15). Even now this statuette is not entirely alone, as there is another amber statuette, 23 cm. high, of a god in a Neo-Assyrian (or derivative Neo-Assyrian) style, of unknown origin, in a private collection (Strommenger 1970: 28, pl. 16c; Orthmann *et al.* 1975: pl. XIII (colour)). Again its authenticity remains a matter of debate (cf. Muscarella 1977: no. 216; 1979: 4: 37). Beck (C. W. 1979: 14–16) has reported thus on the substance of which it is made: 'the closest agreement, however, is found between the spectrum of the statuette and some spectra of a natural fossil resin, viz. those of Lebanese amber'.

(b) Sources

Amber is obtained primarily from the coast of the Baltic Sea, but other varieties, differing from one another in colour and chemical composition, are known in many other regions, notably in Burma, Romania, and Sicily (cf. Strong 1966: 1–2). Within the Near East the presence of amber-like resins has only been investigated in the Lebanon, where they were first noted in the nineteenth century 30 km. east of Sidon (Beck, C. W. 1979: 16). Strictly speaking this is not amber, as it does not contain succinic acid, though it is very like true amber in appearance. Two Baltic amber beads from Tell el-Hesi and Tell Zakariya (Bliss and Macalister 1902: 27) in Palestine, dated to the Late Bronze Age, 'turned out later to be identical in material with a specimen in the Geological Museum in Jermyn Street London, brought from a resinous deposit near Mount Hermon (now Jebel esh-Sheikh, 33.24N 35.50E) by Sir Richard Burton' (cited by Beck, C. W. 1979: 17). Nissenbaum (1975) has described geological 'amber' deposits at four places in modern Israel; analyses indicated that it was fossilized *pinus* resin (Todd 1985: 293). Only a comprehensive programme of research on unworked samples and on artefacts from Syro-Palestine will reveal whence Mesopotamia received its fossilized resins (Todd 1985). In general, before the Late Bronze Age, when Baltic amber may have been traded in through the Mycenaean commercial network, the most probable source is the Lebanon. As Lucas (1962: 387–8) made clear, various resins, rather than amber, were what was most commonly employed in Egypt, which, despite ancient testimony (Pliny, *Natural History*, xxxvii. 11), apparently did not produce amber.

(c) Scientific fingerprinting

Although scientific research has been conducted into the sources of the amber used in prehistoric Europe

since the nineteenth century (cf. Beck, C. W. 1965, 1970, 1985; Strong 1966: 5–6), its rarity among artefacts in the East Mediterranean and the Near East in antiquity has not encouraged any such study save on spectacular objects of uncertain authenticity. The infra-red spectroscopy of amber is used to fingerprint it: 'like fingerprints no two amber spectra are ever exactly alike, but they do fall into groups which have one or more distinctive features in common, and these groups correlate statistically with areas of geographical origin' (Beck, in Harding and Hughes-Brock 1974: 171). This approach has been criticized (cf. Rottländer 1984–5); but, within the specific terms of reference he employs, Beck has sustained his defence of it, though fully acknowledging that 'it is much easier to tell with absolute certainty what a sample is not by interpreting its infra-red spectrum, than it is to say with more than reasonable confidence what it is' (Beck, C. W. 1979: 16). If the two Neo-Assyrian statuettes are accepted as genuine, then Beck has demonstrated through infra-red spectroscopy that both Baltic amber and Lebanese fossilized resin were current in northern Mesopotamia in the ninth to eighth centuries bc. If the Baltic amber came in through Greece, both might have arrived as a result of growing contact with Syria and Phoenicia at this time.

6. AMETHYST. See Quartz.

7. ANHYDRITE (Mohs 3–3.5). This mineral has the same chemical formula as gypsum, to which it alters by absorption of water. It is slightly harder and appears both white and in a variety of colours, shades of blue as well as pink to brown. Meyer (1981) lists its use for occasional cylinder seals.

8. AQUAMARINE. See Beryl.

9. ARAGONITE (see Calcite). It should be noted that this term is used to describe some cylinder seals cut from the columella of Meso- or Neogastropods (cf. Collon 1982; 1986; 1987: 101), since aragonite is 'the form of calcium carbonate commonly laid down in shells'.

10. AZURITE. Like malachite, this is a basic copper carbonate. It is distinguished by its rich blue colour. It is listed by Teissier (1984: nos. 71, 100) for one Akkadian and one Old Babylonian cylinder seal. Meyer (1981) has suggested that the rarity of the copper ores amongst the ornamental stones used in Mesopotamia may be explained by the fact that by historic times, if not earlier, all copper arrived already processed or semi-processed.

11. BASALT. This stone, which was primarily used for building, for monumental sculpture, and for vessels in Mesopotamia, appears sporadically in the repertory of beads, amulets, and pendants, as well as for seals (cf. Meyer 1981), from prehistoric times.

12. BERYL. The occasional reported uses of this stone in Mesopotamia (cf. Ward, W. H. 1910: 8; Tobler 1950: 192) before the Seleucid period need to be confirmed, since confusion with green feldspar or olivine is possible (cf. Lucas 1962: 390). Beryl (beryllium-aluminium silicate) occurs in various colours. The most common is green; the deeper-coloured and more transparent variety is termed *emerald*, the lighter-coloured and less transparent being *beryl*. The bluey-green variant is known as *aquamarine*. They have yet to be reliably reported in Mesopotamia before the fourth century bc, as is the case in Egypt, where the stone occurs naturally (cf. Lucas 1962: 390). When both emeralds and aquamarines appear in Western Asiatic jewellery, from the last quarter of the first millennium bc, classical authors, notably Pliny, indicate that the likely source of these gemstones was India; but beryl deposits are also reported in both Iran and Turkey (Ryan 1960: 67; Ainsworth 1838: 285).

13. BRECCIA. Beck (H. C. 1929: 144) recognized a red breccia cylindrical bead at Nineveh, though he believed this stone to have been uncommonly used for beads in Mesopotamia (cf. Campbell Thompson 1936: 123). If its use in architecture is any guide, its role as an ornamental stone is to be dated in the Neo-Assyrian or Neo-Babylonian periods. Ward (W. H. 1910: 7) remarked that 'a checkered red and white jasper, perhaps a kind of *breccia*, appears at an early period, and in the Kassite period a yellow and white *breccia*'.

14. BLOODSTONE. See Quartz.

15. CAIRNGORM. See Quartz.

16. CALCITE. As calcite is soft enough (Mohs 2.5–3) to be easily shaped, was locally available, is usually translucent, is both clear and available in various attractive colours (brown, green, grey, pink, and yellow), it served sporadically as a gemstone in Mesopotamia from prehistoric times to at least the middle of the first millennium bc. The pink 'coral limestone' of Woolley's Ur reports is tinted calcite. Calcite is often confused with *aragonite*, which shares the same chemical composition, but has a different atomic structure; both stones appear in the same natural deposits.

17. CHALCEDONY. See Quartz.

18. CHALK. This very soft porous form of limestone (Mohs 1), technically a fine-grained pulverulent deposit of calcium carbonate, is not really suitable for personal ornaments, but it was used occasionally for crude beads and seals.

19. CHERT. This stone could be ground to make beads and may also occasionally have been used for seals.

20. CHLORITE. See Steatite.

21. CHRYSOPRASE. See Quartz.

22. CITRINE. See Quartz.

23. COPAL. See Amber.

24. CORAL. Coral, composed of the skeletons of the coral polyp, is usually pink, red, or white in colour; the black variety does not appear to have been used in antiquity. Coral occurs in the Gulf (During-Caspers 1983: 39 ff.). As with pearl there is little evidence that coral was used in jewellery in Mesopotamia, or elsewhere in the Near East, before the Achaemenid period, when, again like pearls, it appears in a jewellery hoard at Pasargadae (Stronach 1978: 172, pl. 157d), both as beads and in an unworked state.

Among the stones he identified from Eridu, Williams (1981: 313) found 'fossil coral limestone, the coral being of the family Cyathophyllidae . . . the only known exposure of these rocks (of the appropriate geological age) in Iraq is found in the Sirwan gorge but no limestone is known to occur there'. There are, however, potential sources in Iran, Saudi Arabia, and Turkey.

25. CORNELIAN. See Quartz.

26. CORUNDUM (Emery). In chemical terms this is aluminium oxide. It can be found in a variety of colours, notably red (*ruby*) and blue (*sapphire*). It is extremely hard, registering 9 on the Mohs scale. Neither of these precious stones has been reliably reported in use as a gemstone in Mesopotamia before the final quarter of the first millennium BC, when rubies and sapphires were particularly associated with Sri Lanka and regions further to the east (cf. Casson 1989: 223). Of much greater importance in ancient Mesopotamia was emery, an impure form of corundum, not so much as a gemstone in its own right but as a vital abrasive in the production of beads and seals.

Heimpel (in Heimpel *et al.* 1988) has identified the Sumerian U₂-stone (Akkadian *shammu*) as emery, primarily on account of the relevant passage in the Sumerian *Lugal* myth (Dijk 1983: lines 423–34), where its reduction from solid rock to powdered abrasive (at times set in lead like modern sandpaper or emery boards) and its use for polishing and for piercing cornelian are clearly specified. In the administrative texts from Mari scrutinized by Heimpel, *shammu* is sometimes described as 'piercing' or as 'Sutean', presumably a reference to sources of emery in the Syrian steppe, and is again associated with lead. In classical texts Indian emery is especially commended and some indeed may have reached Sumer and Babylonia, at least during the peak of the Indus trade c.2350–1750 BC. But it is more likely to have come routinely from sources closer to hand on the line of the Euphrates in Syria or Turkey.

Emery in grit form is the most effective natural abras-

ive save for diamond grit, for which there is no evidence in Mesopotamia before the first millennium AD. Woolley (1934: 373 n. 2) reported emery from levels of the 'Sargonid Period' at Ur, but gave no details of the exact context. It has also been found in the Late Bronze Age at Ras Ibn Hani on the coast of Syria (Bordreuil *et al.* 1984: 398; cf. Lucas 1962: 68–72).

Gorelick and Gwinnett (1987: 38; also in Heimpel *et al.* 1988: 202 ff.), using scanning electron microscopy to investigate borings in hardstone beads and seals, have demonstrated the use of emery with metal drill-bits in Mesopotamia from at least the early second millennium BC, when haematite became so popular for cylinder seals. It was generally replaced in the second half of the second millennium by various ornamental types of quartz, which can be worked with quartz sand, but only slowly and tediously, so emery is likely to have been the preferred abrasive where available.

27. DIAMOND. This, perhaps the most renowned of gemstones in modern times, has not been reliably reported in use anywhere before the Roman Imperial period. It is pure crystallized carbon, famed for its hardness, registering 10 on the Mohs scale. It is likely that diamond drill-bits were not consistently used by gemcutters until the Sasanian period, when India was a primary source of diamonds (Gorelick and Gwinnett 1988; Casson 1989: 223).

28. DIORITE. Although best known for its use in sculpture, particularly when imported from sources in the Gulf, this dark hard stone takes a good polish and is occasionally reported as amulets, beads, and pendants (cf. Meyer 1981).

29. DUNITE. See Peridotite.

30. EMERALD. See Beryl.

31. EMERY. See Corundum.

31. FELDSPAR. This is the term used for a group of rock-forming minerals, silicates of aluminium either with potassium or calcium. Two ornamental varieties are particularly noted: moonstone and amazonite. The pale opalescent *moonstone*, from the orthoclase feldspar group, has not been reliably identified in Mesopotamia as a gemstone before the final quarter of the first millennium BC, when it is most likely to have come from India or Sri Lanka. Care is needed as, by eye, it is confused with chalcedony, gypsum, or milky quartz, all of which appear earlier in Mesopotamia.

Amazonite, from the microcline feldspar group, is a green or greenish-blue stone sometimes termed variously 'opaque green feldspar', 'alkali feldspar', or even 'mother of emerald', though there is no connection. It occurs in Egypt (Lucas 1962: 393–4); but it has been attributed to more distant sources, in Kashmir or the

Urals, when listed for Mesopotamia from at least the Ubaid period (cf. Woolley 1956: 8, 67; Collon 1986: 11). However, this is by no means certain and there may well have been more accessible sources north or east of Mesopotamia. Ward (W. H. 1910: 9) thought two Persian stones described by Pliny, the *tanos* or the *eumithres*, might be amazonite. Beck (1929: 143) identified it as the material of three undated beads from Nineveh, whilst Meyer (1981) lists one such bead 'purchased as from Ischali'. Heinrich (1936: 41) listed it as amongst the stones used for beads in late prehistoric Uruk. It was occasionally used for cylinder seals in the earlier second millennium BC. (cf. Collon 1986: nos. 202, 427, 632) and later (Ward, W. H. 1910: 8), and for beads in the first millennium BC (cf. Uruk: Limper 1988: nos. 304, 329).

33. FLINT. See Quartz.

34. FLUORSPAR (Fluor; Fluorite). Chemically calcium fluoride, this stone occurs in various colours, including green, yellow, and purple, which has led to confusions with amethyst. Beck (H. C. 1933: 182, pl. LXXIX.28, captioned 'calcite') identified a pendant from Nineveh as fluorite, believing it to be of the Achaemenid period. Meyer (1981) lists it earlier in use for beads and seals. If ancient *murrhine* is correctly identified as fluorspar, then the export of this stone from Cambay, according to the *Periplus*, may identify Pakistan as the ultimate source of this stone when it occurs in Mesopotamia.

35. GARNET. This term embraces a whole family of minerals, all silicates, varying from red to purple in colour. Examples have not yet been reliably reported among jewellery from Mesopotamia before the first millennium BC. However, garnets are reported with a banded agate bead of a type current in Mesopotamia in a necklace of the first half of the second millennium BC at Trialeti in Georgia (Javakhishvili and Abramishvili 1986: pl. 8).

Beck (1929: 144) gave no date for the four garnet beads he recognized at Nineveh. Campbell Thompson (1936: 164) quoted Beck's opinion that garnets were 'uncommon' as beads, but calls attention to Ainsworth's (1838: 262) report of garnets in the region of the Upper Euphrates in Turkey. The identification of garnet for cylinder seals in the Neo-Assyrian and subsequent period (Sax 1991) has been linked to a revival of trade with India, but this is an open question. It was used for beads in the Neo-Babylonian period (cf. Uruk: Limper 1988: nos. 329–30).

36. GRANITE. Meyer (1981) notes possible use of this stone for beads, whilst Beck also lists 'reddish granite' among the materials used for beads. Granite occurs in the mountains at the head of the Diyala river and south-west of Hamadan.

37. GREENSTONES (generally opaque). Serious mineralogical study of Mesopotamian cylinder seals has emphasized the difficulty of identification in the case of this category of stones, which was particularly favoured for seals in the Akkadian period (Collon 1982^a: 13–14). Sax (in Collon 1986: 8) adopts the following definition: 'greenstones are low grade metamorphic rocks which are composed of complex mixtures of minerals including quartz, feldspars and amphiboles. They are normally green in colour but some are brown, grey or mottled, the colour being chiefly due to iron.' As Meyer (1981) pointed out, *diabase* or *gabbro* (Mohs 6) is a fine-grained igneous greenstone, difficult to separate from a hard metamorphic greenstone, which is occasionally used in the third and earlier second millennium BC for beads and seals.

The matter is further complicated by loose use of the term *jade* (cf. Lucas 1962: 397–8) in relation to stone artefacts, including seals (cf. Ward, W. H. 1910: 8). Two minerals are commonly embraced by this term: *nephrite* (silicate with calcium, magnesium, and iron), reported as the material of at least one later second-millennium BC cylinder seal (British Museum Cylinder Seal Catalogue: forthcoming) and *jadeite* (predominantly a sodium-aluminium silicate). References to 'jade' in existing literature on Mesopotamian tools and gemstones are often confusions with amazonite, green jasper, green serpentine, or other greenstones (cf. Campbell Thompson 1936: 154–6). The 'jade' bead from the cave at Shanidar has been shown to be chrysocolla; but several jade nodules have been identified there (*BSTN* 11 (Apr. 1988), 4).

It is interesting to notice that in the later fourth and early third millennium BC certain greenstones were favoured by seal engravers working in Iran in the 'Proto-Elamite' style that are not encountered in Babylonia then or later (Lahaniér 1976; Sax and Middleton 1989). This is geologically altered tuffaceous rock, probably obtained from Iran.

It should perhaps also be noted in conclusion that the 'greenstone' regularly reported from sites in the Levant, from the Natufian period onwards, is another general term for a variety of minerals, this time including malachite, chrysocolla, rosasite, and turquoise. These green minerals are associated with copper-bearing strata, notably in the Wadi Feinan of Jordan, in the Timna area (of Israel), and in Turkey (cf. Garfinkel 1987).

38. GYPSUM. This is not strictly speaking a gemstone, but its slight translucence and occasional pinkish bands can give it an extra attraction. Its availability in Mesopotamia was a distinct advantage, though its softness (Mohs 2) means it does not wear well even if easy to carve and drill. Beck (1931) listed it as the commonest stone among those used for beads found at Nineveh.

However, he also identified several large 'buttons' as being of moulded gypsum plaster, which he thought might have been widely used for simple beads (Beck, H. C. 1929: 146, fig. 4f). Heinrich (1936: 41) lists it with the finer gemstones used for beads at Uruk in the later prehistoric period. Meyer (1981) recognized it in her sample from the Diyala sites and Nippur among the stones used for beads, pendants, and seals.

39. THE IRON OXIDES. The visual similarity of these stones is confusing. Proper mineralogical identification and the fingerprinting of haematite has only just begun. *Haematite*, the hardest (Mohs c.5.5–6.5), is a lustrous, grey-black mineral with a dark red 'streak'; it can take a higher polish than the others and then has a markedly metallic sheen. It is much used for production of iron. It was apparently the most popular of the iron oxides in Mesopotamia and appears to have been used for cutting seals of a consistently higher quality than are found made in goethite or magnetite. Despite recurrent opinions to the contrary, haematite could have been engraved with hand-held tools, perhaps an emery point set in a wooden handle, when there is no obvious sign of drilling or of wheel-cutting (cf. Collon 1987: 102). *Goethite*, hydrous iron oxide, is a brown-black mineral with a yellow-brown 'streak'. *Magnetite*, magnetic iron oxide, is a brownish-black mineral with a black 'streak'. These iron ores are widely available in Syria and Turkey.

Beck (cited in Campbell Thompson 1936: 82) noted that haematite was 'uncommon, except at certain periods' in the production of beads. The most accurate indicator of a chronological pattern of use is to be found among cylinder seals. Haematite's earliest regular appearance may not be confidently set before the Ur III period, when it is first reliably attested in use for seals on a small scale (Collon 1982a: 14). Woolley's (1934: 369) reference to its use for beads in graves he attributed to the 'Sargonid period' must consequently be regarded with caution. The geological probability that haematite reached southern Mesopotamia from sources in Syria or in Turkey accessible from the Upper Euphrates is strengthened by finds in a Middle Bronze I 'Burnt Building', c.2000 BC at Tell Selenkahiyah, 83 km. east of Aleppo on the right bank of the Euphrates. Here Loon (1968: 31) reported:

I am here referring to haematite, of which many pieces were found, both unworked in the shape of roughly cylindrical natural formations and worked into polished barrel-shaped weights or polished cylinders ready to be carved into seals. The nearest source for haematite is the central Taurus range between the Euphrates and the Cilician Gates.

Meyer (1981) reports on one piece of raw material in her Diyala sample: the section of a concretion of haematite which points to formation in a cave or hollow

or pocket in limestone. In the first four centuries of the second millennium BC, haematite was by far the most common stone used for fine cylinder seals in Mesopotamia, Syria, and Turkey. Goethite was also used in the same period, but magnetite, at least in Mesopotamia, may only have been used during the second half of the nineteenth and the first half of the eighteenth century BC (Collon 1986: 9). It is possible that haematite was adopted in Syria as a result of the transit trade between Assyria and Cappadocia (Karum Kanesh) at this time. Isolated earlier appearances may be misidentifications (Collon 1986: 82). Beck (cited in Campbell Thompson 1936) thought magnetite was rarely used for beads.

XRF analyses of second-millennium haematite cylinder seals in the British Museum have indicated that a number of distinct groups, perhaps representing distinct sources, may be distinguished through trace elements (M. Cowell Report, 1985–6; cited by kind permission of the Keeper of Western Asiatic Antiquities).

- 1a. A stone used in Babylonia before 2000 BC.
- 1b. A stone used by cutters of seals in the elaborate Mitannian style, c.1500–1250 BC.
2. A stone used in Mesopotamia and Syria from nineteenth to sixteenth centuries BC.
- 2b. A stone used by cutters of seals in the elaborate Mitannian style.
3. This may derive from two sources; it was used both in North Syria and in Mesopotamia in the first two centuries of the second millennium BC and for Cypriot seals in the late second millennium BC.

Although haematite is reported for some 33 per cent of later second-millennium cylinder seals in the British Museum, only 3 per cent are of magnetite and 2 per cent of goethite, to some extent repeating the earlier pattern of use (British Museum Seal Catalogue: forthcoming). Thereafter it is rare amongst seal materials in Mesopotamia, though used for stamp seals in the Neo-Hittite city-states of Syria in the ninth to seventh centuries BC (Boardman and Moorey 1986).

Apart from beads and seals, the iron oxides were most consistently used for weights from the late third millennium BC, presumably because the hard stone wears well and it would be immediately apparent if it had been modified in shape. It appears from time to time in use for maceheads, when its metallic appearance would have been an advantage; but its use for pendants is rarely reported. A remarkable example from Tell Billa was thought to be of the Neo-Assyrian or Achaemenid period: 'an exquisitely made miniature bull (the dimensions are 29 by 29 mm.) done in metallic blue and red haematite. No feature of the body was ignored by the painstaking artist. Bands of gold are wound around the body, ending in a loop on the top

to serve for suspension . . .' (BASOR 46 (Apr. 1932), 4).

40. JADE, JADEITE. See Greenstones.

41. JASPER. See Quartz.

42. JET. Jet is a black variety of brown coal or lignite so far rarely reported as beads (cf. Oates and Oates 1989: 202 ('possibly'), Tell Brak (Akkadian)). Jet was used for beads in the Maikop Culture of Caucasia and may have reached Mesopotamia from sources to the north.

43. LAPIS LAZULI. This is the best-known, most easily recognized, and the best-documented of gemstones in Mesopotamia (Rosen 1988; 1990). Lapis lazuli is an opaque semi-precious stone consisting mainly of a blue mineral, *haüynite* (of which *lazurite* is a variety), a brassy-yellow material, *pyrites* ('fool's gold'), and a white mineral, *calcite*, together with relatively small amounts of other minerals. Its beauty lies wholly in the blue mineral, and the degree of beauty is a measure of the extent to which this mineral is present. Pieces vary from a rich deep blue, speckled with brassy-yellow spots, now avoided, but much admired in antiquity, to a pale mottled blue and white. In 1964 in Afghanistan Herrmann reported that lapis lazuli was graded in five quality categories, defined by the purity of blue, ranging in price from 365 to 60 US dollars a kilo.

After years of discussion (cf. Brown, S. 1991) it is now accepted that Akkadian *uqnû* (Sumerian *ZA.GIN*) primarily denoted lapis lazuli, though at times other stones that were not necessarily blue passed under this name. In antiquity different qualities were carefully distinguished (Cohen, S. 1973: 157 ff., 286 ff.; cf. Oppenheim 1970: 12); various types of lapis lazuli were vividly described as 'multi-coloured', 'wild-donkey coloured', or 'wine-coloured' (Röllig 1983). The stone's iridescence is indicated in descriptions by comparing it with the neck feathers of ravens and doves, whilst 'star-like or starry' presumably describes the gold specks. The only type of lapis lazuli attested outside the word-lists is 'the lapis-lazuli which has green dots is called *Marhashu*-stone lapis-lazuli'. *Marhashu*, somewhere in south-central Iran, was renowned for a variety of stones (Steinkeller 1982: 249 ff.; Vallat: 1985).

In hardness lapis lazuli registers 6 on the Mohs scale, though, as some of its ingredients vary (for instance, *calcite* registers only 3 and iron *pyrites* 6.5), pieces have to be selected carefully for fine engraving. It was not ground up and used as a pigment in either paint or glazes in antiquity in Mesopotamia. Ultramarine, the pigment made from lapis lazuli, seems first to be documented about AD 500 in wall-paintings in Central Asia. In Mesopotamia it appears at Ctesiphon in the sixth to

seventh centuries AD (Ullrich: personal communication). Lapis lazuli is of relatively restricted occurrence. The most commonly cited sources today are those in Afghanistan, Burma, Chile, the United States (Colorado and California), and the former USSR (the Pamirs and in the vicinity of Lake Baikal).

The surviving objects of lapis lazuli from Mesopotamia are predominantly small: personal ornaments, amulets and seals, and fragments of inlay. Of the larger objects mentioned in lexical and literary texts (Röllig 1983: 488 ff.) the rare survivors are concentrated in the Royal Cemetery at Ur, where a spouted cup, a dagger-hilt, and a whetstone were recovered (Woolley 1934: pls. 151, 174). The great prestige and value of lapis lazuli lent it a special role in cult, as in its use for foundation inscriptions (Ellis 1968), gave it a wide metaphorical role in literature, and ensured its place in magic texts. 'Lapis-like' was a standard metaphor for unusual wealth from early in the extant literary tradition, and this stone was for long synonymous with gleaming splendour, an attribute of gods and heroes. Although the stone was imported into Mesopotamia, the majority of manufactured lapis lazuli so far recovered from ancient sites there is recognizably local in style.

(a) Sources and procurement

(1) *Archaeology and texts*: No written evidence from Egypt (Lucas 1962: 398 ff.) nor from anywhere in the Near East (Röllig 1983; Rosen 1988, 1990; Brown 1991) provides unequivocal evidence for the ultimate source of the lapis lazuli so much prized throughout this enormous area in antiquity. Whenever texts offer any guide, this stone is seen to reach Babylonia from the east and Egypt from Babylonia, passing through ports like Byblos and by land through Sinai. There is no force, geological or textual, in the arguments of Nibbi (1981: 44 ff.) for mines yielding lapis lazuli in Sinai. According to Sumerian texts of the third millennium BC, lapis lazuli reached Mesopotamia from regions such as *Aratta*, *Dilmun*, and *Meluhha* within Iran or on the sea-route down the Gulf and across the Indian Ocean to Iran's eastern neighbours; the references are not explicit enough to distinguish primary from secondary sources with complete confidence (Pettinato 1972: 77–8).

In common with a general tendency in Mesopotamian texts to locate the source of raw materials in specific mountains, there is a 'lapis lazuli Mountain' (cf. Reiner 1956). The name of this mountain is usually given as Mt. Dapara. An inscription of the Assyrian king Esarhaddon names the lapis mountain as Mt. Bikni (Borger 1956: 55: 47), generally identified with modern Kuh-i Alwand in western Iran (cf. Röllig 1983: 488). Darius I attributes the stone to Bahtar Mountain or Sogdia (Scheil 1929: 8; Vallat 1971). Save in the last instance

there is no reason to take these as direct references to Badakhshan (see below). The annals of Esarhaddon (c.680–669 BC) list lapis among the tribute of the Median tribes of central Western Iran 'close to the great salt desert' (Luckenbill 1927: sections 540, 566; Wiseman 1958: 11); a region upon which Tiglath-Pileser III (744–727 BC) had earlier imposed a substantial demand for the stone (Luckenbill 1926: section 768). Neo-Assyrian royal inscriptions refer to 'lapis lazuli hewn out of the mountain' (Oppenheim 1970: 12). Unless there was indeed a source of lapis lazuli within Iran (see below), it has to be assumed that the Medes controlled the western end of land routes by which the stone was brought from Afghanistan. Lapis lazuli is not reported among finds from such richly equipped sites as Hasanlu and Marlik in north-west Iran in the earlier Iron Age (cf. Muscarella 1980: 215).

In the absence of a comprehensive scientific 'fingerprinting' of ancient lapis lazuli (see below), it has long been customary to identify the mines supplying Mesopotamia by process of elimination, taking the known, geologically attested sources in turn and assessing their degree of probability. On such arguments it is assumed (Herrmann 1968: 28) that the Lake Baikal source, where the lapis lazuli may generally have been of poorer quality, was too remote. The lapis lazuli in the Pamirs has been similarly excluded, whilst it presents the additional problem of the great height, above 16,500 feet, at which the stone appears. Local tribesmen in modern times have spoken of mountain sickness in attempting to reach it.

Consequently, it has been almost universally agreed in recent years that the most famous Old World lapis lazuli mines, those on the upper reaches of the Kokcha river, a tributary of the Oxus, in the Badakhshan district of modern Afghanistan, described by Marco Polo (Yule 1929: i. 157), were the primary source for the ancient Near East and Egypt. Evidence for exploitation of these mines in the third millennium BC has been strengthened by the discovery of raw lapis lazuli and evidence of bead manufacture at Shortugai (I) on the river Oxus (Francfort and Pottier 1978; Francfort 1987) in a settlement where the material culture is described as largely 'Harappan'. This information, however, complicates understanding of the role of lapis lazuli in the Indus Valley Civilization, where it is rarely reported in excavations (Rosen 1990: 15–16). Was the lapis exploited through Shortugai by 'Harappans' trading only into Asia or to Mesopotamia by a land route through northern Iran? Or did it bypass the cities of the Indus by going overland through southern Iran for shipment direct up the Gulf to Sumer? (Ratnagar 1981: 135 ff.)

Before the Badakhshan source is examined in more detail, its claims now have to be set in a wider frame. There is reported to be a seam of lapis lazuli in the

marble-rich area of the Chagai hills, south-west of Quetta, astride the border between Pakistan and Afghanistan (Berthoud *et al.* 1982: 41 n. 21; Tosi and Vidale 1990, fig. 1). It is said to yield a type of lapis lazuli tinted greenish-blue by its diopside content, possibly the phenomenon associated by the ancients with the lapis lazuli of *Marhashu* (see above). This source is a valuable reminder that minor local sources may have been used more than is currently assumed.

Some old collections of lapis lazuli samples have examples attributed to Iran, but without reference to a specific source in the country. Raw lapis lazuli from Russia or Afghanistan might easily have been acquired in Iran in the last few centuries. But the case for Iranian lapis lazuli mines may not so easily be dismissed, even though modern professional geologists tend to discount them and sceptics invoke the possibility (real enough) of confusion with other blue-coloured minerals (Herrmann 1968: 27; Brown, S. 1991). It is medieval references in particular that still encourage us to leave the question open. Hamd-Allah Mustawfi of Qazvin, State Accountant of Sultan Abu Said (AD 1316–35), reported that 'the best mines of this stone (i.e. lapis lazuli) are in Badakhshan, but there are mines also in Mazanderan, and others at Dizmar in Azerbaijan, and there is also one in Kerman' (trans. Strange 1919: 197). If the geological map of Iran is scrutinized for areas of non-oil-bearing metamorphized limestones or marbles, in which lapis might occur, in the north, Azerbaijan seems more probable than Mazanderan. Kerman is also possible and this is the region highlighted by a second medieval reference. The Chinese traveller Č'an Te, sent in AD 1259 by the Mongol Emperor Mangu to his brother Hulagu, reported that lapis lazuli was found 'on the rocks of the mountains in the south western countries of Persia' (Laufer 1919: 520; cf. Morgan 1900: 49; 1905a: 53; 1905b: 118). There is archaeological evidence for lapis lazuli at the site of Shahdad, near Kerman, in the third millennium BC in a region some scholars argue was the location of ancient *Aratta* (cf. Hakemi 1972: 14; Majidzadeh 1976).

In the Enmerkar-Lugalbanda Sumerian narrative poems (not to be taken as they stand as if they were historical documents referring to the earlier third millennium BC), the people of *Aratta* are noted for the quarrying and processing of stones from their mountains (Wilcke 1969: 409 ff.; Cohen, S. 1973: lines 39–41, 49–50, 80–8). Lapis lazuli is generally implied to be amongst these stones. The inhabitants of the region are specifically said to 'cut pure lapis lazuli from the lumps' (Cohen, S. 1973: line 40). If *Aratta* was a geographical reality, rather than a literary concept like 'El Dorado', as seems more likely (Michalowski 1986), then an identification with Kerman is more plausible than with Badakhshan, since the epic cycle requires Uruk to be in reasonably regular overland contact with

Aratta. Badakhshan is some fifteen hundred miles from Mesopotamia; a round trip by camel of at least six months (Herrmann 1968: 36 n. 75), but far longer with the asses used for transport in the third millennium BC.

A literary text, *The Hymn to Ninurta* (Cohen 1975: 31; cf. Pettinato 1972: 135; Muhly 1973: 449 n. 543), refers to 'the cornelian and lapis lazuli in the land of *Meluhha*'. Gudea of Lagash (c.2150 BC) (Cylinder B XIV:13) also describes his procurement of 'blocks of lapis lazuli . . . bright cornelian from (the land of) *Meluhha*'. It is commonly assumed (cf. Pettinato 1972: 78) that both stones were coming from *Meluhha* by ship up the Gulf. However, the Sumerians would not have had the means, or probably the interest, to distinguish lapis lazuli mined in *Meluhha* from that mined elsewhere and simply shipped through its ports, which are usually believed to have been on the shores of the Indian Ocean in modern Iran (Baluchistan) or Pakistan. It was this lapis, presumably, which passed through *Dilmun* (Pettinato 1972: 121 ff.; cf. Leemans 1960: 23 ff.; Heimpel 1987: 51) until the collapse of the Gulf trade with the Indus region some time in the second quarter of the second millennium BC.

The mines of Badakhshan are reasonably well documented (Wyart *et al.* 1981). Even now this is an inhospitable region of barren mountains and deep rocky ravines. There are a few widely scattered settlements thereabouts linked by rocky trails open for less than half the year to donkey or horse caravans, but not to camels. Herrmann (1966: 7) reported that 'the mines are situated 330 metres above the valley bottom on a steep mountain-side, and can only be reached by a long zigzag path, which, like all the other paths in this area, has to be reconstructed each spring after being swept away by the savage winter rains and snows. Mining can only be undertaken during the three months of summer, after the last year's snow has melted and before the next falls.'

The method of mining was concisely described in the last century by John Wood (1838: 265):

Camelthorn and tamarisk twigs were collected from the valley below and were carried up the steep path to the mine. When sufficient fuel had been collected, it was piled against the rock face and a fire was lit. When the rock was hot, cold water, which also had to be carried up the 350 m. ascent, was thrown onto it. The rock cracked and split, enabling further work to be done with the primitive tools available—pick, hammer and chisel—to extract the lapis lazuli from its marble matrix.

There is no ancient textual information on the overland routes followed by lapis lazuli as it was traded westwards into Mesopotamia. It is likely that different routes would have been used at different times according to the prevailing economic and political conditions, taking best advantage of a number of alternative routes through the Zagros mountains. Plotting the passage of

lapis lazuli through its occurrences on excavated sites, between Badakhshan and Mesopotamia, gives only the most approximate and generalized indication of lines of trade. Despite much comment to the contrary, it is not surprising that the evidence for lapis lazuli on Iranian archaeological sites at present appears to relate more to local working and consumption than to a transit trade which, by its very nature, would leave little or no trace in the material record. Consequently, distribution maps of sites where lapis objects have been retrieved, virtually the only sites excavated, offer no hard evidence for trade routes. In any convincing account not only the presence/absence factor, but also the relative quantities, which will mirror the direction and intensity of down-the-line or trickle-trade, must be considered. Lapis lazuli, moreover, was a rare luxury commodity likely to have been concentrated in particular parts of any settlement and in rich graves only. Consequently, reliable estimates of trade patterns require much more comprehensive archaeological evidence than is at present available from Iran.

The logistics of the trade are also obscure; much came no doubt as tribute or war spoils and was constantly stored and recycled in Mesopotamia. A third-millennium literary text contains the phrase 'the *garash*-merchant from the (eastern)-mountain(s) brought the lapis lazuli' (Biggs 1966: 175 n. 6; cf. Cohen 1973: 27 n. 156). This presently isolated passage suggests that the Sumerians may have been largely dependent in commerce on the foreign agents or intermediaries, who had presumably first brought lapis lazuli to their attention.

(2) *Scientific determination*: Chemical fingerprinting of lapis lazuli has not yet proceeded very far. No definitive criteria have emerged for sourcing the lapis lazuli found on archaeological sites in Mesopotamia. Herrmann (1968: 29) reported that three tests had failed to distinguish Afghan samples from Lake Baikal samples of the stone. Keisch (1972: 96–8) used sulphur-isotope analysis to distinguish samples from Afghanistan, Chile, and Siberia, as well as artificial ultramarine. Hogarth and Griffin (1976) reported differences in percentages of MgO and K₂O in a range of lapis samples from Afghanistan, Burma, Italy and the USSR. Following identification of the source near Quetta, Tosi's (1974: 148) report that thin-section microscopy and sulphur-isotope analysis allowed attribution of archaeological samples of lapis from Ur, Hissar, and Shahr-i Sokhta to the mines of Badakhshan may need to be considered in the light of a wider sampling and testing programme.

(b) *Processing*

Lapis lazuli was generally exported from source uncut, but with most of the calcite matrix removed. The Sumerian narrative poem now called *Enmerkar and the*

Lord of Aratta includes references to 'lumps of lapis lazuli' and '[Let them cut] the pure lapis lazuli from the lumps' (Cohen, S. 1973: 113). Further work was undertaken either at transit stations or in Mesopotamian workshops. Excavations sporadically reveal lumps of raw lapis lazuli as in the mid-fourth-millennium BC settlement at Djebel Aruda on the Upper Euphrates in Syria (Driel and Driel-Murray 1979: 19 ff.); at Susa (de Morgan 1905^b: 124); in the third-millennium BC royal tombs at Ur (Woolley 1934: 372) and in the palace at Tell Mardikh (Ebla) in Syria (Matthiae 1985: 44, pl. 36d; Pinnock 1986; 1988); on Tarut Island in the Gulf (Zarins 1978: 67); in the early second-millennium BC 'Treasure of Tod' from Egypt (cf. Porada 1982); and in the hoard of semi-precious stones, many inscribed, from Nippur, where the raw lapis lazuli bore Kassite royal votive inscriptions (Brinkman 1976: E. 2.7: 107; L.2.8: 154-5 n. 8), one of Burnaburiash (c.1359-1333 BC), the other of Kadashman-Turgu (c.1281-1264 BC). Lapis was systematically recycled, as may be observed in the progressive decrease in the average size of lapis lazuli cylinder seals in the third millennium BC (cf. Collon 1986: 101; Bussers 1984: 72) and their reuse as beads (cf. Herrmann 1968: 51).

The working of lapis lazuli is best known at present in an earlier fourth-millennium BC context at Mehrgarh 2 in Pakistan (Tosi and Vidale 1990); in the later fourth-millennium workshop sites at Tepe Hissar in north-east Iran (Tosi 1989: 15-16); and in the third-millennium activity areas at Shahr-i Sokhta in south-east Iran (Tosi and Piperno 1973). The stone is likely to have travelled from the mines to workshops in a semi-processed state.

At Shahr-i Sokhta 'flotation of all the earth fill in the excavated rooms allowed for the recovery of a huge quantity of lapis lazuli waste and of a certain number of finished beads as well as beads broken during the various working phases, in close association with a good number of microlithic implements' (Tosi and Piperno 1973: 18 ff.). In tomb G.12 of the third millennium BC there was the same association of lapis lazuli and stone tools. This made it possible to determine the various stages in the separation of lapis lazuli from its matrix, through the forming of beads to the final polishing stage. The following stages were evident: the purer material was first separated from the cortex; part of the surface was polished, an incision with an average depth of 1 mm. was made at the dividing line between limestone and lazurite using a flint microblade with a trapezoidal or triangular section; separation was then effected by striking the block at the point of incision at a certain angle; by repeating three operations of smoothing, incising, and chipping on the lapis block the rough shape of the desired bead was finally obtained and then finished by polishing; drilling was then done

by microlithic borers; numerous partially perforated beads show how hazardous this stage was.

Since it has been suggested that finished beads of lapis were shipped from eastern Iran to Mesopotamia, it is significant that of the 45 types of beads found by Woolley in the contemporary Royal Cemetery at Ur only three types have been found in eastern Iran and they are the cylindrical, spherical, and discoidal types with plain surface, the simplest and least typical types in the Royal Cemetery, which abounds in biconical, barrel-, and axe-shaped beads of lapis lazuli. However, close examination of lapis beads and mosaic inlay fragments of lapis from Ur shows the typical flaking furrows recognized at Shahr-i Sokhta, reinforcing other evidence for the view that lapis was shipped in small blocks or semi-processed lumps, but telling us nothing about the role of Shahr-i Sokhta in this trade. It may merely have been a local distribution centre.

(c) *Historical survey*

There is an isolated report of lapis lazuli beads at Yarim Tepe (level 8: early Hassuna period) in northern Mesopotamia in the later sixth millennium BC (Merpert *et al.* 1976: 40). It is reported earlier in the seventh millennium, closer to the Badakhshan or Quetta source, at Mehrgarh (I: MR3) in Baluchistan (Jarrige 1985: 285). There is also a cylindrical bead and a pendant from Samarra (Herzfeld 1930: 4, pl. XLV; despite his later denial: 1933: 29) at an early date. However, it is not until the first half of the fourth millennium BC that lapis lazuli is regularly reported in Northern Mesopotamia. The evidence at present is thus hardly adequate for establishing the earliest date at which the lapis trade commenced, particularly when there are times and places, as in the Indus (Fairervis 1983: 12), where azurite has sometimes been confused with lapis.

Lapis is stratified in tombs of Gawra X; a fine unstratified lapis stamp seal has been stylistically attributed to Gawra XI (Tobler 1950: 189, pl. LXXXVIIIc; Herrmann 1968: 129-30). However, beads of lapis lazuli are cited from Gawra XIII (Tobler 1950: 192) in the final phase of the northern Ubaid period. To the same broad chronological horizon probably belong beads from the deep sounding at Nineveh (level IIc or III) and from Arpachiyah (Campbell Thompson and Mallowan 1933: 179 n. 2; Mallowan 1935: 97). It is, however, the richly furnished burials of Gawra X that give the first clear indication of the status of this stone in the later prehistoric period, with its use for various personal ornaments (Tobler 1950: 88, pls. LIXa, CVI.37-8, 46). In Gawra levels IX and VIII there is a marked decline in reported lapis (Tobler 1950: pls. XVIc.1-3, LIVc.2, LVIa).

The attribution of the earliest lapis lazuli objects within the time range Uruk IV-III in the south is still debatable, but this stone was certainly among a variety

of coloured semi-precious stones exploited in the temple workshops of Uruk from the early or middle fourth millennium BC for cylinder seals, amulets, pendants, and inlays (Heinrich 1936: 26, 28, 29, 41, pls. 13e, 17a,b, 30e, 34e). By Uruk III (Jamdat Nasr period) lapis is also reported throughout Mesopotamia for small personal ornaments from Ur (in the problematic 'Jamdat Nasr' graves), Telloh (Genouillac 1934: pls. 42-3), in the Diyala (cf. Perkins 1949: 147), and at Brak (Mallowan 1947: 100, pls. IX.1, XX.15). Perhaps significantly, Mackay (1931: 272, 291) noted its absence at Jamdat Nasr, where cornelian was also rare.

It is only in the middle of the third millennium (in texts, cf. Biggs 1966), above all in a few graves at Ur, that it is possible to observe the use of lapis lazuli beyond the routine and almost timeless production of amulets and beads. It is employed for inlays in jewellery at Ur (Woolley 1934: pl. 133) and Telloh (Margueron 1965: pl. 42). As inlays it is found at Ur in the sounding boxes of musical instruments, in gaming boards, gaming pieces, toilet boxes, 'sceptres' and ostrich-egg vessels (Woolley 1934: pls. 91-3, 95-8, 103, 108-16, 153, 156). A pair of rampant he-goats, whose original function is unknown, particularly illustrate on a small scale the use of lapis lazuli for inlays and overlays on composite statuary (Woolley 1934: pl. 87). In animal and human statuary it provided both the colour for eye or eyebrow inlays and beards, as well as for animal horns (Woolley 1934: pls. 107, 110). The Early Dynastic III palace at Eridu produced a very beautiful roundel of mother-of-pearl inlaid with petals of lapis lazuli (Quarantelli 1985: no. 54 (colour on p. 305)). It was used for small-scale human statuary or for heads alone, some extremely small (Watelin 1934: pl. XXXI.2; Moortgat-Correns 1967; Porada 1980). It is only in the Royal Tombs of Ur that a range of luxury objects in lapis, known from texts, have survived, notably a dagger-handle, a whetstone, and a spouted bowl (Woolley 1934: pls. 151, 174). At this time lapis lazuli also first appears as plaques carrying royal inscriptions (Parrot 1956: 52 ff.; Sollberger and Kupper 1971: no. IA4a) or elaborate beads similarly inscribed (Parrot: 1968). Many of the composite objects and much of the finest jewellery exhibit the Sumerians' love of lapis lazuli in combination with gold, which in objects and texts epitomizes splendour and high status. The texts from Ebla indicate how much lapis might be used in composite statuary: a god's head was made of 4,230 kg. (valued at 1,410 kg. of silver), a king's head of 6,775 kg. (Archi 1990: 102).

There is, at present, no satisfactory way of charting fluctuations in the use of lapis lazuli; but a gross indicator is provided by cylinder seals as they, alone among lapis lazuli objects, may be dated relatively closely and they occur often enough to provide an appropriate basis for chronological assessment. The following comments

are based on tables drawn up by T. F. Potts (1987: 230 ff.). In Uruk III a mere 0.9 per cent of cylinders were of lapis; even less in Early Dynastic I when a few 'brocade style' seals are in this stone (cf. Legrain 1951: nos. 51, 53, 61). By Early Dynastic II some 5 per cent of seals from collections and excavations are of lapis. Early Dynastic III appears to represent the peak in its use for seals. In the Royal Cemetery at Ur almost 50 per cent of the reported seals are lapis at this time; but on a wider basis of evidence the figure lies somewhere between 15 and 20 per cent. All sources, collections and excavations, show a marked drop in the Akkadian period to less than half the figure for Early Dynastic III (8 per cent): a figure based on large totals. The combined figure of collections and excavations for Ur III period is very close to that for the previous period (7 per cent). The increasing rarity of lapis lazuli in the repertory of seal stones during the Ur III period is highlighted by its virtual restriction to seals of high-ranking officials (cf. Bussers 1984: 72 ff.). The steady decline continues into the first half of the second millennium, settling at around 3 per cent in the Isin-Larsa/Old Babylonian periods.

Since it is generally argued that lapis was travelling overland in the third millennium BC through Iran, evidence for local use is instructive. The largest quantities may be those from the virtually unpublished graves at Shahdad (Hakemi 1972). The seal count for Susa is surprising (Amiet 1972): 0.2 per cent in the Jamdat Nasr to Proto-Elamite horizon; none reported for Early Dynastic II-III; 1.3 per cent for Akkad and Post-Akkad; 10.9 per cent for Ur III; dropping to 1.7 per cent in the earlier second millennium BC. At present there is more archaeological evidence for local production of lapis lazuli beads and other personal ornaments than in Mesopotamia. As has been noted, there were stone drill-bits with lapis traces, lapis waster flakes, and raw lapis lumps up to 0.5 kg. in weight at Shahr-i Sokhta (Tosi 1974a: 17; Tosi and Piperno 1973); comparable evidence was recovered from Shahdad (Salvatori and Vidale 1982) and Hissar (Bulgarelli 1979). Raw lumps of lapis and unfinished beads were recovered from levels of the mid- to later third millennium at Tepe Malyan (Anshan) (Sumner 1986: 204). There is no reason to suppose any of this production was for long-distance trade.

Further east, in regions whence overland routes from the Badakhshan or Quetta sources might have passed, the general picture varies. Lapis remains rare in sites of the developed Indus Civilization (Ratnagar 1981: 132-5) and a proportion of this may well be azurite (Fairervis 1983: 2). However, research steadily increases evidence for the use of lapis lazuli in Baluchistan and Pakistan before the third millennium BC. Sporadic finds extend from the seventh millennium BC at Mehrgarh I—a site which with Mundigak particu-

larly well illustrates the earlier history of this stone (Jarige 1984; Ratnagar 1981: 135). At least two early Indus sites (Jalipur and Rahman Dheri; Dales 1977) yielded significant quantities of worked and unworked lapis lazuli. The discovery of microlithic phthanite borers used for drilling lapis beads at Mehrgarh I–III and Mundigak I–4 illustrates the long prehistory of the appropriate technology close to source (Lechevallier 1984: 46). It is possible that the apparent decline in the appearance of lapis on sites of the mature Indus Civilization is related to the great profit to be obtained from exchanging it, through trade up the Gulf, with the Sumerian city-states of Early Dynastic III. If so, the inhabitants of such Iranian sites as Shahr-i Sokhta and Shahdad may have been primarily consumers of lapis, not middlemen in its trading. If only the stone they did not want themselves penetrated westwards, this might account for the dearth of lapis lazuli in the contemporary settlement at Susa. Texts of the eighteenth century BC from Mari associate the acquisition of lapis lazuli with the procurement of tin, indirectly through Elamites or more directly in Elam itself (Villard 1986: 406).

With the eclipse of the Indus trade c.1750 BC, the presence of lapis lazuli in the surviving material culture of Iraq declines sharply to the point where it may be suspected that the primary source was recycled stocks, rarely replenished with 'fresh supplies from the east. Such a hoard is not known from this phase in Mesopotamia, but the phenomenon is well illustrated by the Tod Treasure in Egypt which contains over 200 items of lapis, comprising pieces of unworked stone as well as miscellaneous lapis seals and ornaments, some of Iranian manufacture. This was placed in four copper or bronze chests inscribed with the name of Amenemhat II (c.1929–1892 BC) (cf. Porada 1982). At Mari in the eighteenth century BC, 1 sicle of lapis was equivalent in value to 2 of best silver (Durand 1983: 191). Even potentially rich sites like Assur and Mari only produced small quantities of lapis in excavations. It is used for amulets and seals, beads and inlays. But finds in the complex of buildings at Ur identified as the mausolea of the kings of the IIIrd Dynasty (Woolley 1974: 100, pl. 46e), where lapis had been an element in the architectural decoration, indicate how much may be absent from the surviving material evidence for a stone that would have particularly attracted plunderers at all times.

In the later Kassite period (c.1400–1200 BC) good documentary evidence and a relatively high representation of lapis among prestige and votive objects may indicate a level of popularity and availability comparable to that in the middle of the third millennium BC. As there is no explicit evidence for the source of lapis at this time, it is not clear whether it came by land through Iran or whether a revival of Gulf trade through Bahrein, with which the Kassites had good contacts,

accounted for its apparent availability in the courts of Mesopotamia. Most of the 'mountain lapis lazuli' listed in the Amarna Letters in the fourteenth century BC is sent to Egypt from Mesopotamia; Assurballit I of Assyria sends small objects of it (Knudtzon 1915: 15: 13; 16: 11), whilst Burnaburiash II of Babylon despatches ten lumps and personal ornaments of lapis (Knudtzon 1915: 11: r 24–5). Tushratta, King of Mitanni, is no less generous to the Pharaoh with objects of gold inlaid with lapis or just of lapis alone (Knudtzon 1915: 19: 80–1; 21: 36; 22: i. 52; 25: i. 20–1; 25: ii. 27; 25: iii. 43). In Hittite royal correspondence, Babylonia is regarded as an important trading centre for lapis lazuli (Oppenheim *et al.* 1970: 11). Everywhere direct royal involvement in securing supplies of the stone is evident. At Karnak in Egypt on the reliefs of Tuthmosis III (c.1479–1425 BC) in the Temple of Amun unworked lapis lazuli is represented among tribute or spoils from Western Asia both as rough fragments and as barrel-shaped pieces (cf. Harris 1961: 125).

The distinction in Akkadian between the genuine stone, ('lapis lazuli from the mountain') and its imitations in glass ('lapis lazuli from the kiln') begins to appear in the second half of the second millennium BC. As the real thing was so difficult to obtain and consequently so highly priced, there was great incentive for artisans then pioneering new developments in glass manufacture (see p. 197 here) in court workshops to produce imitations. Surviving examples, particularly from Nippur (Peters 1897: 131–6), and recurrent distinctions in lists between real and imitation lapis, illustrate how successful they were. Other phrases at this time such as 'lapis produced by boiling' and lapis 'mixed with *busu*-coloured glass' emphasize the wide currency of glass replicas (Oppenheim *et al.* 1970: 13).

It may be misleading to take the use of lapis for cylinder seals at this time as a rough indicator of popularity since such seals overwhelmingly concentrate into a relatively brief phase at the end of the Kassite period, and even then are predominantly unprovenanced finds. But, as in the earlier second millennium BC, lapis seals remain much rarer than they had generally been in the third millennium in Sumer and Akkad. Lapis does not account for more than 2–3 per cent of published 'Kassite' seals, despite prominent concentrations like that at Thebes in Greece (Porada 1981–2), which illustrate the role of lapis cylinder seals as a form of international currency, easily transported and hoarded, passing by weight like gold and silver, and almost as easily recycled if necessary. Dark blue glass cylinder seals are recorded from Middle Elamite contexts at Tchoga Zanbil in Khuzistan (Porada 1970) and from the island of Failaka at much the same time, when glass seals were particularly used for the so-called Pseudo-Kassite style (cf. Matthews, D. M. 1992: 4).

The remarkable history of a single lapis lazuli cylin-

der seal illustrates very well the manner in which manufactured items in this stone were regularly passed back and forth. The actual seal is not known, but a tablet from Nineveh records its history (Grayson 1972: 127, no. 29). It was originally in the possession of Shagarakti-Shuriash (c.1245–1233 BC), King of Babylon. It was carried off by Tukulti-Ninurta I of Assyria (c.1243–1207 BC) to Assur, when he campaigned in Babylonia. It found its way back to Babylonia and was again taken by Sennacherib (c.704–681 BC); each ruler had his inscription cut on the seal.

At Nippur, in a store-room ('booth') which seems to have been part of the main city temple, Peters reported finding the remains of a wooden box. It had included among its contents 'quantities of small round coin-like tablets of lapis lazuli'; other examples were found in the vicinity (Peters 1897: ii. 132, 144). They are a few centimetres in diameter and less than a centimetre thick, inscribed with royal votive texts. Between twenty and thirty examples are published (cf. Hilprecht 1896: nos. 49, 53–4, 58–62, 64, 71, 133, 138, 141–2; Legrain 1926: nos. 52–3, 55, 57, 59–64; all in Brinkman 1976, plus his 0.2.4:176, U.2.8:264, U.2.16:265). If some of those inscribed for Kurigalzu refer to the first ruler of that name, then they date from the earlier fourteenth to the mid-thirteenth century BC. Various deities are invoked. The date of the store-room is debatable. The lapis disks may well have been assembled there in Kassite times for storage, since all the published finds appear to be of that date, or possibly much later in the Parthian period as much for the value of the raw material as for their cult significance. Blocks of raw lapis lazuli were also included in the board. The same hoard included votive axeheads of deep blue glass (Barag 1970: 148; Saldern 1970: 215, no. 8). A lapis lazuli votive disk similar to those from Nippur, inscribed for Kurigalzu, has been reported from Babylon (Wetzel *et al.* 1957: 36, no. 5, pl. 42.1; Brinkman 1976: Q.5.13:246).

In general, lapis lazuli ornaments are not commonly reported at this time. There is an isolated bead at Nuzi (Starr 1939: 454), beads of uncertain date at Ur (Woolley 1965: 105–8) and a much richer representation of the stone, including a cylinder seal, in the exceptionally rich grave 45 at Assur (Nagel 1972). Textual sources, however, reveal how restricted an impression this gives of the range of use. The Qatna inventories (Bottero 1949) list among other things a gold dagger with lapis hilt and human figurines; an inventory from Nippur (Legrain 1922: 102 ff., no. 80) refers to gold caskets with lapis lids. A lapis lazuli macehead fragment in the British Museum is inscribed for Tukulti-Ninurta I (c.1243–1207 BC) (Luckenbill 1926: 67). Kassite use of lapis for inlays is illustrated by a piece, inscribed for Burnaburiash, that has in relief 'what may be an animal's ear' (Grayson 1987: 6). As in the Royal Cemetery at Ur over a millennium earlier, when lapis was avail-

able in quantity in the Kassite period it was widely used for personal ornaments and the elaboration of gold objects of all kinds.

In the earlier first millennium the evidence of material culture remains extremely sparse, with beads in graves at Assur (Haller 1954: *passim*) and Nimrud (Mallowan 1966: 141). However, when properly reported, the recently discovered royal tombs at Nimrud are likely to add considerably to the history of lapis (see p. 222). Layard recovered a model comb in lapis at Nimrud (BM 55–12–5, 470). In so far as a count of cylinder seals is possible, there is little more than 2 per cent of lapis in published collections of Neo-Assyrian cylinder seals. A fragmentary votive axehead of lapis from Tell Haddad in the Hamrin is inscribed for Shalmaneser III (Quarantelli 1985: no. 211 (colour, p. 320)). In view of the quantities of lapis received by the court as tribute, it is clear that the stone was much more widely used than archaeology at present indicates. In a mudbrick house under a Parthian building at Babylon, a bead manufacturer, perhaps of the Seleucid period, had assembled his raw material. It had been kept in two baskets and included ancient objects of various precious and semi-precious stones, including lapis lazuli. Most notable among the lapis objects were two unusually large cylinder seals, up to 20 cm. in height. One was inscribed by a contemporary of Shalmaneser III (c.853–824 BC) as an ornament for the necklace of a statue of the god Marduk, whilst the other was dedicated by Esarhaddon (c.680–669 BC) to the same god (Koldewey 1900: 4–6, 12–15; 1914: 221). Similar unusually large cylinder seals were found, in the 'Treasury' at Persepolis (Schmidt, E. F. 1957: 56 ff.). Since the Achaemenid rulers had more direct access to the lapis source on their eastern frontier than any of their predecessors in the Near East, it is hardly surprising that the stone is regularly encountered at this time in jewellery and seals, though various substitutes for it were ever more popular. Inscribed votive beads provide a crude guide to the relative popularity of lapis lazuli in Assyria during the first millennium BC. Of the 77 published examples for this period only 13 are of lapis lazuli; but over 50 per cent are in stones of the chalcedony group (Galter 1987: table 1). The same increase in the popularity of cornelian and agate, as against lapis lazuli, is evident at Ur in the Neo-Babylonian and Persian periods (Woolley 1962: 105).

Better perhaps than any of the other ornamental stones used in Mesopotamia, the history of lapis lazuli reveals a number of general trends:

1. Exchange was clearly conducted over enormous distances in special commodities of high value; but this wide distribution was compatible with small-scale production, particularly in Iran, as has been the case with Persian carpets in more recent times.

2. Even in luxuries the scale of inter-regional trade was probably not large, even by Graeco-Roman standards let alone by modern ones, since transport overland was almost invariably dangerous and consequently expensive. Whenever a sea-route was open, as in the Gulf trade, it is likely the quantity of lapis moved was proportionally larger.

3. Much lapis lazuli came by booty-raiding and tribute-exaction and much of what came was immobilized or frozen by deposit in temple treasuries for the service of the gods, unless released by acts of war.

4. Objects of lapis lazuli were regularly recycled at home and collected in distant places, as at Thebes in Greece, for similar treatment.

Note on Lazulitel-sodalite: This blue silicate of sodium and aluminium occurs in masses closely resembling lapis lazuli, though the colour is usually a paler blue and it does not have the gold flecks of iron pyrites. It is not certainly recorded among the stones used in antiquity in Western Asia before the Achaemenid period when it appears as an inlay in one of the finest bracelets in the 'Oxus Treasure' (Dalton 1964: 34, no. 116). It has been used recently by forgers seeking to imitate lapis lazuli as cheaply and effectively as possible.

44. LIMESTONE. Although this would not normally be classified as a gemstone, the coloured types particularly made it a recurrent choice for beads (cf. Beck, H. C., cited in Campbell Thompson 1936: 123) and seals from prehistoric times. It is also likely to have been readily available within the river valley from sources on the northern and eastern periphery. It was combined with bituminous limestone to make attractive 'mosaic' necklaces (cf. Delougaz 1942: 254, fig. 198; Quarantelli 1985: no. 43, illustrated).

45. MALACHITE. This hydrous copper carbonate is distinguished by its attractive green colour; it is also relatively soft (Mohs 4) and takes a good polish. Although malachite appears amongst the stones used for the earliest beads and pendants in Mesopotamia, on Beck's authority it was rare amongst the later beads he studied from the region (cf. Campbell Thompson 1936: 154 n. 1). This appears to be the pattern with the copper ores among the ornamental stones (cf. azurite). Malachite was also rarely used as a gemstone in Egypt (cf. Lucas 1962: 400-1) and may indeed have been generally more common in powdered form as a cosmetic. However, there are spectacular reported examples of its use for pendants on a Middle Assyrian necklace at Assur (cf. Maxwell Hyslop 1971: 168, 170) and it has been unofficially reported among the inlays in gold jewellery found in the recently discovered Neo-Assyrian royal tombs at Nimrud.

The fact that two different wholly unrelated

materials, malachite (green) and turquoise (varying from blue through greenish-blue to green), may occur naturally in the same place has led at times to confusions, as in Sinai (cf. Lucas 1962: 401), where malachite has been referred to as 'turquoise matrix'.

46. MARBLE. Limestone when subjected to high temperature and pressure is metamorphosed into marble. It is often hard to distinguish by eye, though the description is regularly encountered in the literature with reference particularly to amulets, beads, and seals that may well, in fact, be of calcite or limestone, whilst the well-known 'Mosul Marble' is a type of gypsum. Marble was not available in the Mesopotamian plain, but occurs in the Zagros mountains and deeper into Iran, as is evident from its ornamental use in the very early settled communities of northern Mesopotamia and the Zagros, particularly for finely made bracelets (for example: Mortensen 1970: 47 ff.).

47. MOONSTONE. See Feldspar.

48. NEPHRITE. See Greenstones.

49. OBSIDIAN. As obsidian was primarily used for tools, it is fully discussed on pp. 63 ff., where reference is also made to its recurrent employment as an ornamental stone from prehistoric times through into the first millennium BC. In prehistory even obsidian cores were drilled for use as beads (cf. Ogden 1982: fig. 9:12). It also appears sporadically as one of the stones used for cylinder seals in the second millennium BC (Collon 1986: nos. 178, 183, 291, 396, 655).

50. OLIVINE. This is a magnesium-iron silicate named after its olive-green colour. The best transparent gem variety, *peridot*, is rarer even than olivine as an ornamental stone. It is hard, 6 to 7 on the Mohs scale, and occurs as small pebbles only suitable for small items. As it occurs in basic igneous rocks, olivine might have reached Mesopotamia from Iran, where it appears amongst the stones found on necklaces of the later first millennium BC and thereafter in Dailaman (Oda, in Egami *et al.* 1965: 34).

51. ONYX. See Quartz.

52. OPAL. When water is present in a chalcedony-like substance, the material is hydrous silica, known as opal. It occurs in many colours. In Mesopotamian contexts it has been reported by Meyer (1981) as a possible identification for three beads among her sample from the Diyala sites and Nippur.

53. PEARL. Pearls (3.5-4 on Mohs scale) are calcareous concretions of a distinctive lustre built up in the body of various molluscs, primarily the pearl-oyster, which is found in the Gulf. In Mesopotamia, as in Egypt (Lucas 1962: 401), the pearl appears only to have fea-

tured in jewellery very rarely if at all until the second half of the first millennium BC, though the use of mother-of-pearl reached back into prehistoric times. References to actual pearls in earlier periods need to be checked individually, as misinterpretation of references in texts have confused their early history. This is particularly the case with the 'eye-stones' (cf. Oppenheim 1978: 663 n. 185; Carter, T. H. 1986), referred to in mercantile and other texts from the later third millennium BC, which are more likely to be cut stones of the agate family than oyster pearls (Campbell Thompson 1936: 53 n. 2; Ratnagar 1981: 138-40). The suggestion that etched cornelian beads was meant (During Caspers 1983: 50) is less convincing.

The small string of pearls from the late prehistoric horizon at Uruk remains an isolated find (Heinrich 1936: 42, pl. 37; Limper 1988: no. 71, pl. 7). There were a number of exceptional materials at this time in Uruk; if copper was already coming from Oman to Sumer, pearls might have come too. An earring with a pearl published long ago by Layard (1853: 590, 597) from Nineveh is most likely to be post-Achaemenid in date, perhaps Parthian. The earliest pearls that may be identified with confidence are a necklace of between 400 and 500 from a female grave of the fourth century BC at Susa in Khuzistan (Morgan 1905: 51-2, pls. II, V) and those on an earring from a hoard of silver jewellery, contemporary in date, from Pasargadae (Stronach 1978: 172, 177, 206). Examples from Seleucia (Umar) are Parthian (Braidwood 1933: 72, pl. 24, fig. 1).

The rarity of pearls on Bahrein (cf. Bibby 1970: 165) and among the settlements of the Indus Valley, in concert with the absence of evidence from Mesopotamia, serves to confound speculative reconstructions of pearl-fishery as a major enterprise in the Gulf, largely based on hypothetical reconstructions of elements in the Gilgamesh Epic (cf. During Caspers 1983: 31 ff.), before the first millennium BC. Nor is the suggestion that the early absence of pearls is to be accounted for by their tendency to disintegrate easily in the earth a cogent one, since they have survived well enough in later contexts and their chemical composition is identical with mother-of-pearl, which survives well in the soils of Mesopotamia.

54. PERIDOTITE. This stone, which weathers readily to serpentine, is a dark, coarse-grained igneous rock with much olivine, little feldspar, and no quartz. It has a hard (Mohs 6-6.5), uneven texture which makes it difficult to carve into small objects, though Meyer (1981) reports it both for seals and weights. It is more favoured for vessels. *Dunite*, a variety of peridotite, consisting mainly of olivine and generally green in colour, is reported by Meyer (1981) as a stone used for amulets and pendants, seals, 'pounders', and vessels.

55. PLASMA. See Quartz.

56. PYRITES AND MARCASITE. Pyrites and marcasite are two forms of iron disulphide (the former is the more common) reported from Iran and Turkey. Pyrites is best known from its golden colour and metallic glint as 'fool's gold'. Iron Age beads from Iran in pyrites retain the natural cubic form of its crystals (cf. Ogden 1982: 105; cf. Oda, in Egami *et al.* 1965: 34). There are no mineralogical reports of such beads from Mesopotamia at present, but its presence is likely.

Marcasite entered the literature of Assyriology as a possible translation of *marhashu*-stone (Campbell Thompson 1936: 100). This stone, which may have taken its name from the region of *Marhashi* in Iran, was soft, used for vessels and containers, figurines and inlays, perhaps a chlorite/steatite (cf. Steinkeller 1982: 251 n. 50). Marcasite would be wholly unsuitable for most of these objects (see also p. 50 here).

57. QUARTZ. Quartz (silicon dioxide) is now considered as a parent of the enormous number of silicate minerals, since its atomic structure is similar to them. It occurs as transparent crystals in a variety of colours or as translucent to opaque masses made up from minute fibres or grains. The varieties of quartz often merge into one another, particularly in stones of poorer quality. Quartz is one of the hardest minerals (Mohs 7). It is very suitable for seals and for fine beads once the methods of working it have been mastered. It is only recently that attempts have been made to develop a consistent system for the description and identification of quartz objects in Mesopotamia and its use is for the moment restricted to reports on cylinder seals in museums (Sax and Middleton 1992). This system is based on a primary division into macrocrystalline types of quartz (amethyst; smoky quartz; rock crystal) and microcrystalline quartz (agate, cornelian, chalcedony, chert, plasma), with subvarieties. As microquartz is slightly porous, resistant to acid, and to a lesser extent to heat, it may be dyed a variety of colours and etched. The proper investigation of these processes in so far as they involve Mesopotamia is only just beginning (for etched cornelian see p. 171).

In reviewing the materials used for cylinder seals it has already been pointed out that quartz was used with increasing frequency after c.2000 BC; the same may be true of beads made locally. Before the end of the third millennium BC rock crystal alone seems to have been used for seals, perhaps because it may have been locally available and had long held a place in local chipped stone industries (see p. 171). Jasper appears from the Akkadian period onwards, increasing in use in the second half of the second millennium BC. Chalcedony and other varieties of microquartz were particularly popular in the first half of the first millennium BC. As quartz occurs widely, in igneous, metamorphic, and sedimentary rocks, identifying the sources upon which

Mesopotamian craftsmen drew will always be a complex problem.

57.1 MACROCRYSTALLINE QUARTZ

57.1.1. AMETHYST. Amethyst is a transparent quartz, coloured deep purple or violet by some compound of manganese or iron. It was largely used in Iraq in the form of beads and pendants, appearing sporadically in the published record from the fourth to the mid-first millennium BC, when it is particularly conspicuous. Tosi (1980-3: 247) commented that 'amethyst, probably of Egyptian origin, occurs very late in the Mesopotamian countries and in very small quantities'. Although this quantitative assessment may be accepted as sound, relatively speaking, both the chronological span and the source of the amethyst used in Mesopotamia are still better left as open questions.

Amethyst has not been reported to occur naturally in Mesopotamia, nor is there any evidence at present, textual or chemical, that reveals the ultimate source of the amethyst used there in antiquity. *Algameshu*-stone (CAD 'A' I: 337 ff.) cannot be amethyst, as argued by Campbell Thompson (1936: 167-8), since this word is used to describe a stone employed for a variety of everyday objects, vessels and spindle-whorls amongst them, for which an easily carved stone like steatite or chlorite is more likely.

Amethyst is reported from a number of sources in Egypt (Lucas 1962: 388-9), but its use there was sporadic. It was already manufactured into beads in the pre- and proto-dynastic periods, when it was even used for vessels (Payne, J. C. 1974). It is virtually absent from the published material record between Dynasties II and XI, reappearing in Dynasty XII as beads, pendants, and seals (scarabs); thereafter it appears intermittently in the same role (Ward 1978). Whilst Mesopotamian import of Egyptian amethyst is not impossible, the probability of closer sources within the peripheral highland zone of Anatolia or Iran, as Tobler (1950: 192) implied when identifying it in a fourth-millennium context at Gawra, is more probable in view of the chronological pattern of its use in Mesopotamia.

As Tosi indicated, appearances before the second quarter of the first millennium BC are extremely hard to trace and even those that are on record as earlier may be misidentifications or mistaken chronological attributions. Tobler (1950: 192) reported amethyst with agate, lapis, quartz, turquoise, and a number of other ornamental stones appearing for the first time at Gawra in level XIII, early in the northern Uruk period, and he regarded them all as imports from the adjacent highlands. It is also reported as beads in Uruk itself (Heinrich 1936: 41; Limper, 1988: 103). Handcock (1912: 340) lists this stone as part of the bead repertory recovered by the German excavators from Early Dynastic graves at Tell Farah; whilst Meyer (1981) cautiously identified

one unfinished bead from the Early Dynastic II Shara Temple at Tell Asmar as amethyst. Beck (in Vats 1940: 398; cf. Beck 1929: 143 (Nineveh)) commented that 'again amethyst beads, also absent from Harappa, are found in reasonable numbers in Mesopotamia, but much more frequently at Taxila and in Egypt;' but he gave no guide to the time range he had in mind.

Amethyst is first reported for cylinder seals in Iran, perhaps manufactured in Fars c.2000 BC (cf. Porada 1990: 172); then in Iraq in the Later Old Babylonian period, when the stone's appearance has been related to its increased use in Egypt about this time for seals (Collon 1986: 10, 199; cf. Ward, W. A. 1978: 86, 1984: 39). However, the stone may have come from Iran at this time. Although amethyst was listed by Peters (1897: ii. 143) among the ornamental stones represented in a substantial cache of objects found at Nippur, royal inscriptions of the latter Kassite dynasty included, it is not certain that this is a closed deposit of that period. However, its recorded, if rare, use for cylinder seals in the Kassite period (British Museum: one example) strengthens the suggestion that amethyst was available in the second half of the second millennium BC. At Ur Woolley (1965: 41) reported two unengraved cylinders, one of amethyst, one of crystal, from below the Kurigalzu pavement in Room 52 of the *Giparu*. Two other amethyst beads which he attributed to 'Kassite' buildings might be of more recent date (Woolley 1965: 64, 66, 107: U.17852, 17898).

In the second quarter of the first millennium BC evidence for the use of amethyst in jewellery becomes more plentiful and it seems to have reached a peak of popularity (and perhaps accessibility) in the Neo-Babylonian and Persian periods (cf. Limper 1988: 97-114: Uruk). In an important cache of jewellery found at Ur 'under the Persian and above the Nebuchadnezzar pavement in room 5 of *Enunmah*' (Woolley 1962: 106-8, U.457-500), over 900 beads were of cornelian, some 170 of agate, about seventy of lapis, a dozen of malachite, and at least thirty of amethyst or amethystine quartz in Woolley's identifications (this is Tosi's 'unpublished' group: see Tosi 1980-3: 247). The British Museum has other examples from Ur graves attributed to the sixth and fifth centuries BC. In a seventh-century context in area WC at Nippur, Gibson (1981-2: 43) reported about thirty-five pieces of unworked or partially worked amethyst buried in (or under) the threshold of a building. Although such ornamental stones were a regular constituent of foundation deposits, this might be workshop debris.

57.1.2. CITRINE. This quartz, yellow to brown in colour, does not seem to appear as a gemstone in Mesopotamia before the Seleucid period. It is sometimes confused with brownish-grey smoky quartz ('Cairngorm').

57.1.3. CAIRNGORM (properly Cairngorm Stone). This

is a quartz of a brownish or smoky shade of yellow. According to Beck (in Vats 1940: 398): 'cairngorm beads have not been found much in Mesopotamia', but they are numerous on post-Achaemenid sites like Taxila in Pakistan.

57.1.4. ROCK CRYSTAL (see also p. 71). This stone, sometimes simply referred to as crystal, is a colourless macrocrystalline variety of quartz. Although Pliny (*Natural History*, xxxvii, 23) attributes the best rock crystal to India, whence it might have come at various times to Mesopotamia, it was one of the few ornamental stones available much closer to home. Williams (R. B. 1981: 315) writes of a sample from Eridu: 'such clear rock crystal quartz is not found in the widespread manner described in notes 31, 33 and 34 [quartz pebbles]. It occurs, rather in restricted localities. One such area is found along the southern slopes of the mountains of Kurakazhaw and at places east of Barzinja, about 15 miles S.S.E. of Choarta. Here, water-clear, double-ended crystals of quartz are picked up quite frequently after the snows melt and after rain. . . . These crystals are never more than 1 to 2 inches long.' In noting that there were no rock crystal beads at Harappa in the sample he had, Beck (in Vats 1940: 398) remarked that 'rock crystal beads are fairly common in Mesopotamia'. It was also available in Iran, Turkey, and Cyprus (Oliver 1973; Tosi 1980-3; Rova 1987).

As rock crystal is both hard (Mohs 7) and brittle, it is one of the most difficult ornamental stones to work, particularly for seals, but already in the prehistoric period, from at least the sixth millennium BC, this stone's hardness had been mastered for the production of beads and vessels (Tosi 1980-3; Rova 1987), so that fine examples appear by the Uruk IV-III horizon in north and south (Tobler 1950: 192 'quartz'; Heinrich 1936: 41, 44, pl. 32A; Eichmann 1986: 111, figs. 14-15). It was also being cut to produce cylinder seals (cf. BM 89413; Wiseman 1962: pl. 3h). Unfinished beads of rock crystal were found in a working area just north of Eanna at Uruk in association with cornelian and chalcedony wasters and stone drills (Müller, H. 1963). Lumps of rock crystal and cornelian were found at Mereijib, ten miles south of Ur, in levels dating to about 3000 BC (Woolley 1956: 84).

At Ur in the third millennium BC Woolley noted crystal 'occasionally' among stones used for beads in graves he attributed to the Akkadian period, when it was again used for cylinder seals (cf. Collon 1982a: 14). In the earlier Cemetery A at Kish, in Early Dynastic IIIB to Early Akkadian times, crystal beads are also rare and appear only in richer graves. Rock crystal is reported as a material for vessels in the Early Dynastic period (cf. Delougaz 1942: 181, 183, 208-11). It was used for the head of a tiny statue (Moortgat-Correns 1961) and for an inscribed macehead attributed to the

Akkadian period (Amiet and Lambert 1973: 158-9, fig. 2). When rock crystal was used for cylinder seals in the Akkadian period, designs were sometimes ingeniously painted in red pigment in the perforations (Sax 1991). Rock crystal is among the stones recurrently placed in foundation deposits (cf. Delougaz 1940: 85 ff.; Andrae 1935: 57).

By the first quarter of the second millennium BC, when rock crystal continues to be used for beads (cf. Woolley 1976: 86, unfinished) and cylinder seals (Collon 1986: 6), evidence for the range of its manufacture increases. At Acemhöyük and at Kültepe in central Turkey, vessels and small objects of rock crystal were recovered from palaces (Özgüç 1983; Rova 1987). Similar fine vessels appear also to have been available in Mesopotamia, to judge by a cup inscribed for Rim-Sin of Larsa (c. 1823-1763 BC) formerly in the Behague Collection (*Sotheby Monaco*, 5 Dec. 1987, no. 66 (colour plate); for comparable inscription cf. Hallo 1961: 11 (Chicago A. 1803)). In this case, as the inscription mentions, the lip is lined with gold, the foot with silver. Rock crystal remained in use for fine jewellery, as in the pendants from tomb 45 at Assur in the thirteenth century BC (Haller 1954: fig. 66, pl. 34a, f); but is less commonly encountered as cylinder seals from the middle of the second millennium (Rova 1987: 135-6, n. 137).

In the second quarter of the first millennium rock crystal was particularly favoured as a luxury material. Its status and value may be gauged by a bead, perhaps a worked 'pebble', dedicated to Assur by Shamshi-ilu, *tartanu*. This is almost certainly the man who held this powerful office as administrator of the western provinces of the Assyrian Empire (c. 780-752 BC) (Reade 1987^a). Evidence for rock crystal vessels with cut decoration is both direct, as with a bowl fragment from Nimrud (Mallowan 1966: 209; pl. 143; cf. earrings with rock crystal pendants: *ibid.*: pl. 28), and indirect, as with its imitation in clear glass (cf. Oliver 1973). This tradition continued through into the Achaemenid period, as finds at Persepolis make clear (Schmidt 1957: 91, 144-52, pl. 65, figs. 7-11). The authenticity of a unique decorated rock crystal bowl, said to be Achaemenid and now in Cincinnati, has been questioned (Kantor 1967; contra: Muscarella 1977: 182, no. 142). The use of rock crystal fittings for furniture is illustrated by 'portions of the crystal throne of Sennacherib' (Budge 1922: 237) and in a hoard at Babylon: 'from a throne, and apparently from the projecting end of the chairback, comes a thick piece of rock crystal the size of a hand, bored through with irregularly disposed holes, to which at some time other separate ornaments were attached', (Koldewey 1914: 222). Crystal working-debris found at Sardis in Turkey indicates a production centre there during the seventh to fifth centuries (McLauchlin 1989: 250).

The finely worked pommel of rock crystal, probably not of Egyptian origin (cf. Lucas 1962: 403), on the hilt of the iron dagger from the tomb of Tutankhamun has been associated with a passage describing a dagger in the list of Tushratta of Mittani's gifts to Amenophis III to suggest that *hilibû* may denote rock crystal (Stech-Wheeler *et al.* 1981: 264 n. 92). The *Chicago Assyrian Dictionary* (H: 186a) describes it as a foreign word for a precious stone; the *Akkadisches Handwörterbuch* (1796) renders *dušû* as rock crystal, but, as this stone was the colour of tanned leather, this translation seems very unlikely. *Hilibû* is virtually confined to the description of decoration on a series of small objects in the letters of Tushratta. Oppenheim (*et al.* 1970: 16 n. 31) translated *elmēshu*-stone as rock crystal.

57.1.5. ROSE QUARTZ. This pink-coloured quartz has occasionally been reported in Mesopotamia. The Ashmolean Museum (1910.125) has a Neo-Babylonian 'pommel' inscribed for Enlil and Ninlil which a geologist has identified by eye as quartz. Langdon (1910) mistakenly described it as agate. Ward (1910: 8) noted that 'some cylinders are found of this material, but rather late and probably from the north'.

57.2. MICROCRYSTALLINE QUARTZ. The general term *chalcedony*, a word of uncertain origin, embraces the compact varieties of silica composed of silica in minute crystals (quartz) and hydrated silica in an amorphous form (opal). The hardness is about 7 on the Mohs scale. The structure and nature of the impurities with which they are commonly impregnated give them a variety of colour, appearance, and texture; all these characteristics have been used at one time or another to distinguish them. Strict definition is consequently difficult. Colour, as it happens the criterion most familiar in Akkadian terminology, is the simplest (cf. Ogden 1982: 108-9). Among the ornamental stones used in ancient Mesopotamia, the various forms of microcrystalline quartzes or chalcedonies are subject to the greatest lack of descriptive uniformity in publications.

A. *Chalcedony* itself is used for the stones in this category which are translucent and rather waxy in appearance, of white or greyish-white colour, often with a bluish tint. The more richly coloured stones have their own names:

Cornelian (less properly carnelian; from the Latin *cornum*: cornel-berry, not *carnis*: flesh) is a translucent chalcedony of reddish or reddish-brown colour (see below).

Sard is the brownish variety and may derive its name from the city of Sardis, capital of Lydia in Turkey. This is rarely identified specifically in the existing literature for Mesopotamia. Woolley (1934: 369) reports it as

occurring sometimes in the 'Sargonid' graves of the Royal Cemetery at Ur.

Bloodstone (heliotrope) is a dark green chalcedony with small flecks of red. It has been said to appear among cylinder seals and has been geologically identified among beads of the later third millennium from Ur (BM 120635: Reade 1991: fig. 73 (in colour)). This stone may have reached Sumer through the Indus trade, perhaps as ready-made beads.

Jasper is an opaque quartz coloured according to its impurities either red, yellow, green, or brown; in *ribbon-jasper* the colours run in stripes, in *Egyptian-jasper* in zones (see below).

Chrysoprase is a pale apple-green variety of chalcedony and *plasma* is a darker green, sometimes flecked with white spots. I have not traced reliable references to either in the Mesopotamian repertory of gemstones before the Seleucid period.

Flint is an opaque, dull-coloured chalcedony. It is commonly thought of as the ancient utilitarian stone *par excellence*, but rare uses of flint (or chert) for seals and beads have been identified in the past (cf. Ward, W. H. 1910: 8) (see also p. 60).

B. *Agate* has a distinctive banded structure. It is white and brown, sometimes with a little blue. The bands may be irregular and ill-defined, but are usually more or less concentric (see below).

Onyx is milky-white alternating with black; the bands are generally straight and regular. This term is sometimes misapplied to varieties of calcite ('cave-onyx' or 'onyx' as in Schlossman *et al.* 1976: 27-8).

Sardonyx is white alternating with reddish-brown or red; in fact this is onyx stratified with bands of sard (cornelian). Here again the bands are generally straight and regular.

Chalcedonyx is white banded with grey.

For the purposes of the present study, in the absence of comprehensive mineralogical identifications the treatment of the *chalcedony* group of gemstones will be restricted to the name-stone itself, to *cornelian*, and to *jasper*. The *agates* will be taken thereafter as a single category for the same reason.

57.2.1. CHALCEDONY. This translucent bluish-grey stone is not conspicuous in the Mesopotamian repertory of ornamental stones until its outstanding popularity in the sixth and fifth centuries BC for stamp seals. Its earlier sporadic use for beads, seals, and even mace-heads is noted by Meyer (1981) in her sample from the Diyala sites and Nippur. It is listed by Heinrich (1936: 41) amongst the stones used for beads at Uruk in the late prehistoric period. A Mari text indicates that *pappardillû*, sometimes translated chalcedony, was coming from *Burullum* in north-east Iraq (Durand 1987).

In reporting the beads from Nineveh, Beck (1929: 148) commented that 'amongst the odd stone beads is a plano-convex barrel of hard stone with a brilliant yellow vein in it. Dr Thomas of Jermyn Street Museum and Dr Campbell Smith at South Kensington are both very puzzled by this specimen: the only suggestion they can make is that it must be some form of yellow chalcedony, although no such material has previously been found.'

57.2.2. CORNELIAN. Cornelian is a stone whose attractive hardness, sheen, and colour made it much appreciated in ancient Mesopotamia, usually ranking second only to lapis lazuli for beads and amulets. It was occasionally used for cylinder seals, sometimes in distinctive bead-like shapes (Tosi 1976-80^a).

(a) Sources

Specific sources of cornelian are difficult to pinpoint, since this stone tends to occur widely as pebbles in minor alluvial deposits. Pliny (*Natural History*, xxxvii. 31, where sard is included with cornelian) reported that 'the principal source is Babylonia . . . From India three different types are sent . . . The Indian *sarda* is transparent and light passes through it; the Arabian is less transparent. Others are found in Egypt.' This distribution, with the exception of the reference to Babylonia, closely matches that given in modern mineralogical reference books for the same area. 'Babylonia' may signify no more than the existence of a lively redistribution of Iranian and Indian cornelian in Pliny's day through Mesopotamia.

As alluvial pebbles, cornelian is now widely reported from Iran, across the central plateau and in the Elburz mountains; at Bushire on the Gulf there is a source of large cornelian blocks (Beale 1973: 136-7; Whitehouse 1975; Tosi 1976-80^a). As pebbles are only useful for small beads, they may well have been exploited primarily for local or regional use. Cornelian is reported in western Arabia and in Oman, in Western Sind and Gujarat in the Indian peninsula, in Anatolia, and in the Egyptian desert (Lucas 1962: 391-2; Ratnagar 1981: 128). The Indian sources have been so important for so long (cf. Arkell 1936) that there has been a tendency to regard cornelian objects from neighbouring regions as certainly of the Indian stone. As Whitehouse (1975) pointed out, in view of well-attested sources in Iran and elsewhere in Western Asia this need not be so, particularly when cornelian was used in Mesopotamia millennia before there is hard evidence for contacts with the Indus region. Woolley (1934: 372), without specific justification, attributed the cornelian used at Ur to the Gulf area.

Textual evidence when it is available from Mesopotamia indicates use of cornelian (*sāmtu*: Pettinato 1972: 74) from sources both in the Indian subcontinent and in Iran, at least in the third and in the second

millennium BC. It should be noted that these texts are from Sumer or Babylonia, not the north of the country. Cornelian is reported from *Meluhha* in Gudea's inscriptions, c.2150 BC (Cylinder A 16:22; B 14:13), in the *lipšur* litanies (Reiner 1956: 132-3), in the Sumerian myth 'Enki and Ninhursanga' (Steinkeller 1982: 248 n. 37), and in various other texts (Leemans 1960: 10; Cohen, M. E. 1975: 28, line 38). It is specifically mentioned in relation to trade with *Dilmun* though the ultimate source is not given (Leemans 1960: 23 ff.). From within Iran it is associated with such regions as *Aratta*, *Gutium*, *Marhashi*, *Marhalum* (Leemans 1960: 10), but whether they were source regions or transit zones is not made clear. According to these texts one type of cornelian, believed to come from *Marhashi* in south central Iran, was characterized by green spots, another was 'spotted (like) obsidian/flint' (Steinkeller 1982: 250 n. 46). This matches well the natural variations possible with chalcedony. Early in the second millennium BC, cornelian is bought at *Akshak*, near the Tigris-Diyala confluence, again indicating an eastern connection (Al-Adami 1967: 154).

Many such references are taken to be to semi-processed raw material, but manufactured beads, notably etched cornelian beads (see p. 171), are likely also to be embraced by some at least of them (Heimpel 1987: 51). Among tithes paid by merchants returning from Dilmun to Ur were kidney-shaped cornelian beads and pieces of the stone (Leemans 1960: 23 ff.). A text from Ur of the Isin-Larsa period (Oppenheim 1954: 12 n. 21) refers to a monkey figurine of cornelian, commonly attributed to trade with *Meluhha* (Leemans 1960: 163; Ratnagar 1981: 149 ff.). Local manufacture of cornelian is evident at Larsa (Chevalier *et al.* 1982) and Uruk (Aue 1985).

Outside texts from south Mesopotamia, evidence for the sources of cornelian is extremely meagre. Its presence in Turkey is marked by its reported presence among merchandise at Kültepe early in the second millennium (Lewy 1930: 18); Kültepe is not far from the region where in remote prehistory, c.6000 BC, the raw stone was already being worked at Kumartepe, near Samsat (Roodenberg 1986: 185 n. 83).

(b) Procurement

Foster (B. R. 1983: 161) has called attention to a text of the Akkadian period referring to cornelian that seems to be a rare exception to the general absence of documents from Mesopotamia indicating the role of merchants in the acquisition of foreign goods. The source is not indicated.

(c) Concise historical survey of use

As has already been noted, raw cornelian, presumably from a source relatively close to the site, was already being used for the manufacture of ornaments c.6000 BC in Anatolia (Roodenberg 1986: 185 n. 83). The cor-

nelian resources of the Indo-Iranian borders were also exploited at an early date. Production areas with phthanite borers have been excavated at Mehrgarh I-II and at Mundigak (Jarrige 1981: 10 ff.; Lechevallier 1984: 46). There is then every possibility that northern Mesopotamia drew on sources to the north of Iraq, whilst southern Mesopotamia drew upon the cornelian of the Indo-Iranian area from the earliest appearance of the stone in each region.

By at least the Hassuna period in northern Iraq cornelian is recorded among the more exotic hard coloured stones used for beads (cf. Yarim Tepe I: Merpert *et al.* 1977: 83). Thereafter it is regularly reported as a material for beads throughout the prehistoric period. As it appears early at Choga Sefid (Hole 1977: 241 ff.), it may well have been current earlier in southern Iraq than is at present apparent. Even at an early stage, as at Tell es-Sawwan (Al-Wailly and Abu es-Souf 1965: 25 ff.), recurrent colour combinations may be detected and perhaps had a special significance. At Sawwan turquoise and cornelian were frequently blended as lapis lazuli and cornelian were to be later, once the dark blue stone became regularly available to the élite in Mesopotamia. The appearance of cornelian is, however, neither universal nor predictable. At Jamdat Nasr, for example, at the end of the fourth millennium BC, Mackay (1931: 272) noted that 'a very curious feature is the rarity of cornelian, a stone which may be said to have been the most favoured material for beads from just before 3000 BC down to comparatively modern times'; but it appears among beads at Uruk (cf. Heinrich 1936: 41).

The remarkable sequence of third-millennium graves in the Royal Cemetery at Ur allows more to be said about the use of cornelian for beads than at any other period. This is the period when tools, debris, and unworked lumps of cornelian provide evidence of manufacture in the Iranian hinterland at Tepe Malyan (Sumner 1986: 204), at Shahdad (Salvatori and Vidale 1982: 8 ff.), and at Shahr-i Sokhta (Tosi 1976-80: 449-52). At Ur cornelian appears in about 20 per cent of the earliest graves, of Early Dynastic IIIA. Necklaces including metal beads were commonest at this time; but, when metal beads are absent, it is cornelian that frequently accompanies the enormously popular lapis lazuli (Pollock 1983). Again in Early Dynastic IIIB it is cornelian that with lapis lazuli predominates among jewellers' stones. Even in the following Akkadian period, when the variety of materials for personal ornaments is greater, these two stones continue to appear most often among precious stones (cf. Nissen 1966, pl. 22). Cornelian was certainly imported to Ur at this period for local working (Woolley 1934: 372-3). 'It is quite common to find unfinished beads of cornelian . . . and in the poor grave PG 958 we came on a bag containing the stock-in-trade of a bead-maker'; among the fur-

nishings of this grave Woolley (1934: 207) listed 'a collection of small chips of cornelian'.

Throughout its history in Mesopotamia cornelian seems not to have been used for anything other than beads, amulets, and a few seals. Both the exiguous archaeological and textual evidence for the second and first millennium BC may be combined to indicate that cornelian (with agate and lapis lazuli) remained one of the three most popular ornamental stones (cf. Meyer 1981: *passim*; Steinkeller 1982: 250 nn. 144-5). The only consistent thread of evidence is provided by amulets and beads (cf. Maxwell Hyslop 1971: *passim*); with particularly fine examples on a Middle Assyrian necklace at Assur (cf. Nagel 1972: figs. 19 ff. in colour). Cornelian was only very rarely used for cylinder seals cut in the Old Babylonian and Kassite styles and even they may have the profile of a biconical bead (cf. Moorey and Gurney 1978: no. 29). Cornelian also appears commonly, both unworked and worked as beads, among the valuable materials placed in the foundations or structure of buildings for ceremonial or magical reasons (Ellis 1968: 132 ff.; also Hansen 1978: 77). Reference is made to this stone in a number of texts relating to such deposits, primarily in temples, but also in some secular buildings (Ellis 1968: 134 ff.). Royal votive beads of cornelian have survived, particularly from the Kassite period (cf. Brinkman 1976: 54; E. 2.8; Q. 2.94; V. 2.5). The consistency in popularity of lapis and cornelian is reinforced by Layard's (1853: 358) comment on the gemstones he found at Nimrud: 'several inscribed fragments of agate, lapis-lazuli, cornelian, and other precious materials'. In sum, there is no reason to dispute Beck's comment, reported by Campbell Thompson (1936: 123), that cornelian was generally very common among the ornamental stones used for beads in Mesopotamia. Earlier Beck (1929: 143) had pointed out that at Nineveh: 'the majority of the beads found are of this material (i.e. cornelian). Many are very rough in workmanship, but this does not always mean an early date.'

57.2.3 JASPER. Jasper is relatively frequent in the Near East as large outcrops or as washed sediments. It may be found almost anywhere along the ophiolitic belts of the Irano-Arabian and Arabian mountains with major concentrations in the southern Elburz, in the central Zagros, and in Makran within Iran and in northern Oman (Tosi 1976-80). It was used for working tools in Iran (cf. Piperno 1973) and widely for ornamental purposes. Although red and yellow jaspers are recognized with reasonable accuracy by eye, mistakes may more easily be made with its varieties in green, brown, and black.

Within Mesopotamia jasper seems to have been less popular than chalcedony, though Beck listed red jasper as a 'fairly common' material for beads (Campbell

Thompson 1936: 123). Meyer (1981) also lists it for amulets, beads, pendants, arrowheads, and weights in her sample from the Diyala sites and Nippur. Fine examples of green jasper appear among the pendants on a necklace from the rich Middle Assyrian tomb 45 at Assur (Nagel 1972: figs. 19, 29-30, 35: all in colour). Jasper is represented amongst the materials for Neo-Assyrian/Neo-Babylonian beads at Uruk (Limper 1988: 105, 108-9, 114).

As the green variety was occasionally used for cylinder seals in the Lebanon in the Bronze Age and for scarabs in the same general area in the Iron Age, there may have been a source in that region (cf. Collon 1986; Buchanan and Moorey 1988: 72). Indeed, Perrot and Chipiez (1885: 633) reported lumps of green jasper on the shores of the Dead Sea.

57.2.4 AGATE AND OTHER BANDED CHALCEDONIES. When textual evidence is any guide it indicates that Mesopotamia received agate from sources to the east in Iran or the Indian subcontinent. If *dushû*-stone is indeed agate (Steinkeller 1982: 249 ff.), it is associated with *Marhashi* in Iran, which was either a source zone or an important staging post on the transmission route of the stone from further to the east. It is likely that sources in India or Pakistan were particularly important from some time in the third quarter of the third millennium BC. It is now generally argued that when texts refer to 'fish eyes' as items in the Gulf trade c.2000 BC (Oppenheim 1978: 663 n. 185) they mean not pearls, as was formerly argued, but rather banded agate beads cut to look like the eyes of fishes (see no. 53 (Pearl) here). It is also possible that Turkey provided some agate. Agate ranks with lapis lazuli and cornelian as the most popular gemstones in Mesopotamia, most commonly appearing as amulets, beads, and pendants.

Its earliest appearance is hard to pin down. The proper date of the agate bead 'from the pre-flood layer' at Ur, identified by Beck (1930) for Woolley, is obscure. Agate is recorded as a rarity among seal stones in late prehistoric contexts at Tepe Gawra (Tobler 1950: 178) and at Jamdat Nasr (Mackay 1931: 272) and for beads at Uruk (Heinrich 1936: 42). In Early Dynastic I it is listed with cornelian beads in isolated graves at Khafajah (Delougaz *et al.* 1967: 82, 86). It was used for some fine beads in Queen Pu-abi's grave (RT 800) at Ur in Early Dynastic IIIA, when it has been attributed to sources in the Indian subcontinent (Woolley 1934: pl. 130: U.10977). By contrast, agate has been taken as the stone characteristic of the Akkadian period at Ur when Woolley describes it as 'common' (Woolley 1934: 369; cf. Maxwell-Hyslop 1971: 6). It first appears in high-status graves and then more frequently, but always in small quantities, in lower-ranking burials (cf. Pollock 1985). In the time of the Third Dynasty of Ur (c.2100-2000 BC) small beads of agate capped with

gold became increasingly popular (Maxwell-Hyslop 1971: 68 ff.); Woolley (1974: 3) reports the occurrence of 'fragments of inlay in banded agate . . . in room 5' of Shulgi's so-called mausoleum at Ur. A particularly fine set of agate beads appears in the necklace of the priestess Abbashti found at Uruk (Nöldeke *et al.* 1937: pl. 39; Limper 1988: no. 141). The wide currency of such beads at this time and in the following few centuries is illustrated by their appearance in barrow VIII at Trialeti in Caucasia (Kuftin 1941: pl. XCIV; Javakhishvili and Abramishvili 1986: pl. 8), in tombs at Geoy Tepe in north-west Iran (Crawford, H. E. W. 1975: 12) and in north-east Iran at Tepe Hissar (IIIC; cf. Schmidt, E. F. 1937: pl. XXXV). A fine agate bead inscribed to Inanna for the life of Shulgi illustrates the status of banded agate by the end of the third millennium (Pohl 1947; Merhav (ed.) 1987: no. 28).

The use of agate for the votive eyes with royal dedicatory inscriptions, popular in Babylonia but rare in Assyria (cf. Galter 1987: 16), may be traced back to the first half of the second millennium BC, whence it continued into Neo-Babylonian times (Langdon 1923; Lambert, W. G. 1969). Over half the examples so far published belong to the rulers of the second half of the Kassite Dynasty. Many of them were found at Nippur. One or other of the kings named Kurigalzu is the predominant donor and Enlil is the deity cited most frequently in their inscriptions (cf. list in Brinkman 1976: 134, 225-7). A varied group of eye-beads from the temple at Tell Rimah dates to broadly the same period (Carter, T. H. 1986: 307), whilst examples from the Gulf are more varied in date (*ibid.*: 307).

The precise role of these inscribed eyes is still debated, since no example has yet been found in the eye-socket of a deity statue, though this might appear to be an obvious role. They are not well suited to be strung as beads nor to be sewn on to the garments which adorned deity statues (cf. Lambert, W. G. 1969: 70-1). Nor are they always quite what they might appear. At Nineveh Beck (H.C. 1929: 143, fig. 2b) recognized an example 'made with a white agate back plate, on to which is cemented an obsidian front so as to represent one of the typical onyx eye beads'.

Agate is unofficially reported among the inlays on gold bracelets and other jewellery in the recently discovered Neo-Assyrian royal tombs at Nimrud. More than 50 per cent of published Neo-Assyrian votive beads with royal inscriptions are of stones of the agate group, including banded agate, onyx, sardonyx, and chalcedony (Galter 1987: table 1). Of the 36 beads of Sennacherib (including six of uncertain attribution), all but one fall in this category, wholly eclipsing lapis lazuli (but see below on imitations), which had previously been the preferred ornamental stone. Varieties of calcite ('alabaster') play a conspicuous subsidiary role. In a hoard of jewellery found at Ur between the Nebuch-

adnezzar and the Persian periods pavements of Room 5 of the *Enunmah*, at least 1,230 beads were of cornelian, some 170 of agate and related stones, some 66 of lapis lazuli, 30 odd of amethyst and amethystine quartz, and about a dozen of malachite (Woolley 1962: 108; U.500, figures approximate). This relative scale of popularity is also found among necklaces of the third quarter of the first millennium BC recovered from Ur by Woolley (1962: 105 ff.; cf. Uruk: Limper 1988: *passim*).

Objects of agate other than amulets, beads, and seals have rarely survived, although those that have embrace a wide variety of functions from statuary through stone vessels to 'knobs' (Brinkman 1976: Q.2.70), 'tablets' (Brinkman 1976: Q.2.63), and a remarkable Neo-Babylonian sceptre for a deity statue found at Babylon (Meyer, G. R. 1962: 7-9). Outside Mesopotamia, at Tell Mardikh (Ebla), a rich tomb of Middle Bronze II, c.1800 BC, contained a sardonyx vase and another of 'whitish opaque stone' (Matthiae 1979: 61, fig. 62a-b).

Not all 'agate' beads are what they appear to be. Sollberger (1987) published an inscribed bead naming the stone of which it is made as *pappardillû*, property of Sennacherib (c.704-681 BC). This would usually be rendered 'banded agate', as indeed the stone appears to be; but expert examination showed it to be chert or chalcedony 'artificially stained at the dark ends, and that these parts had been subjected to heat'. The inscription speaks of '*pappardillû*-stone of Assyria'. Since there is no recorded source of banded agate in Assyria, this may indicate that the technique for faking it, using more readily available hard stones, was an Assyrian speciality at this time. As Sollberger points out, a Middle Babylonian recipe for making artificial *pappardillû* (Oppenheim 1966), in a process using honey, milk, red alkali, and wine under heating and soaking, is very close to the modern prescription for such procedures in which sugar replaces the honey and an acid the alkali and/or wine.

58. QUARTZITE. (See also Sandstone). Under pressure or heat sandstone is changed to the metamorphic rock known as quartzite. The term is sometimes used to describe an ordinary sandstone which has merely been cemented together more tightly than usual. Although its hardness varies, it generally registers 7 on the Mohs scale. Meyer (1981) lists its use for beads, weights, and a macehead. Of the beads she remarks: 'most of the beads are of a special lentoid shape. They are pure white, chipped into shape. The tight correlation of the infrequently used stone and the uncommon shape suggests that these beads were imported from elsewhere.'

59. RUBY. See Corundum.

60. SANDSTONE. Locally available, at least in northern Mesopotamia, sandstone does not take a polish or fine

detail, but it is easy to work and, on account of many impurities, varies very much in colour. It was consequently used for relatively low-grade beads and seals. Heinrich (1936: 41) lists it among the stones used for beads in Uruk IV-III and Meyer (1981) records it for beads, pendants, and seals.

61. SAPPHIRE. See Corundum.

62. STEATITE, CHLORITE, AND SERPENTINE. Although this group of stones has been considered elsewhere (p. 46), it has to appear here again since from prehistoric times they were particularly used for seals and to some extent for beads and amulets. As proper identification requires laboratory methods, confusion is everywhere apparent in the literature. They are all varieties of hydrated magnesium silicate, although chlorite usually contains aluminium and iron. According to Beck (cited in Vats 1940: 410), 'the Indus civilization, as far as beads are concerned, is primarily a steatite civilization. More beads were made of this material than of all the other materials put together, whilst in Mesopotamia, with the exception of the small beads from grave 55 [in the Royal Cemetery at Ur], very few beads of steatite have been found.' The Ur examples might well be imports from the Indus region.

62.1 STEATITE. This, the compact form of the soft mineral *talc*, registers only 1 on the Mohs scale. Impurities, and sometimes heating, have hardened the varieties chosen for carving in antiquity. It appears in a variety of colours for which very crude geographical distinctions may be hazarded:

62.1.1 WHITE OR GREYISH WHITE: Egypt (cf. Lucas 1962: 421) and the Indus civilization (see above).

62.1.2 RED, coloured by iron oxides, is sometimes encountered among beads and seals of the later prehistoric period (cf. Ogden 1982: 110) in Mesopotamia.

62.1.3. DARK GREEN TO BLACK, with a greasy, soft feel. This is commonly encountered in Syria and northern Mesopotamia for beads and seals from prehistoric times through into the first millennium BC. Thence it reached deep into Sumer and Babylonia where it is encountered as beads, seals, and amulets.

62.2. CHLORITE. Steatite was used interchangeably with *chlorite*, which is harder (2 to 2.5 Mohs). It is again green to black with a vitreous to pearly lustre. As it carves easily and takes a high polish, it was recurrently used for ornamental purposes.

62.3. SERPENTINE. Much of what is reported in the literature as serpentine turns out on a mineralogical analysis to be something else, as it has become almost a standard colloquial term for any greenish-black stone with a

greasy surface. Serpentine registers 2-5 on the Mohs scale and comes in various types, few of which have yet been reliably recognized in Mesopotamia. Beck (cited by Campbell Thompson 1936: 123) listed red serpentine beads as 'uncommon'.

63. TURQUOISE This is a hydrous aluminium phosphate produced in the presence of copper salts which give it its typical varying shades of blue. It is commonly found in small, compact, opaque lumps or as filling in the cracks of altered rocks. It is basically a surface mineral found in points of emergence of copper-bearing veins like azurite and malachite; sometimes also in outcrops of lead veins. Turquoise is always present with a very wide range of colours even over a small area. The blue varieties, differing in tone, have conventionally been the most prized for their brightness, hardness, and resistance to wear. The green varieties have a large range of tones from dark green to yellow. The white varieties are too soft and crumbly for proper working. Pliny wrote of this stone: 'Subsequently, the stone is shaped by the drill, being in other respects [apart from difficulty of getting at it] an easy stone to deal with. The best stones have the colour of emerald (*smaragdus*), so that it is obvious, after all, that their attractiveness is not their own. They are enhanced by being set in gold, and no gem sets off gold so well. The finer specimens lose their colour if they are touched by oil, unguents or even undiluted wine, whereas the less valuable ones preserve it more steadfastly. No gemstone is more easily counterfeited by means of imitations in glass' (*Natural History*, xxxvii. 33. 111 ff.). The stone's name is derived from Turkey, whence supplies came to Europe; but their ultimate source is likely to have been Iran.

In both the *Akkadisches Handwörterbuch* and the *Chicago Assyrian Dictionary* turquoise is not specifically identified. Vallat (1983), on the evidence of a fragmentary text of Darius I from excavations at Susa, was able to show convincingly that the Sumerian: NA₄ AŠ.GÌ.GÌ (Akkadian: *ashgikû*) is turquoise. The full text of this inscription is well known, recounting the sources of the raw materials used in palace construction at Susa in the early Achaemenid period; but the rendering of the stone from Chorasmia, listed between the lapis lazuli and cornelian of Sogdiana and the ebony and silver of Egypt, had long been uncertain, some supporting turquoise, others haematite, etc. Vallat's demonstration allows another instructive passage in the series *abnu shikinshu* to be rendered correctly (CAD A: II. 427) 'The stone looks like green obsidian but has no lines'; that is, green as distinct from blue turquoise. Texts indicate the use of this stone in jewellery, as a charm, pulverized for medicinal purposes, and reproduced in glass (CAD, s.v. *ashgikû*; Oppenheim *et al.* 1970: 47-8). No Mesopotamian text yet indicates, as clearly as does an Egyptian one referring to turquoise

from Sinai, the particular character of this stone. Egyptian references to 'new' turquoise would be inexplicable had not its vulnerability to heat and light been clearly understood there and counteracted whenever possible (Harris 1961: 107).

Tosi (1974: 148) lists three main source regions likely to have contributed to the turquoise circulated in the ancient Near East:

1. *Sinai*, where turquoise occurs notably at Wadi Magharah, Gebel Adeida, and Serabit el-Khadim. The turquoise nodules are embedded in seams of Nubian sandstone (Lucas 1962: 404). Černý (1955: 3 ff.) admirably summarized the evidence for Egyptian involvement in the mining and distribution of turquoise from this source. More recent research by Israeli scholars, during occupation of the region, has significantly broadened the basis of evidence for exploitation of turquoise mines by local inhabitants from at least the Ghassulian period of the fourth millennium (Beit Arie 1980: 56 ff.). Although there is no evidence for Egyptian interest in mining activity in Sinai before the Third Dynasty, Beit Arie has argued that previously 'it seems most reasonable to assume—particularly in view of the almost complete absence of turquoise objects in Palestinian excavations—that the turquoise mined in Sinai was destined mainly for Egypt'. Although evidence of mining tools appears early, there is no firm evidence for semi-processing at the mining sites. It appears that raw nodules were traded into the Nile Valley. In view of its rarity in Syro-Palestine, it is unlikely that turquoise from Sinai reached Mesopotamia.

2. *Iran*, where turquoise appears, or has been reported, at a number of places in the central and north-eastern regions of the country (Beale 1973: 135, map). None has yet yielded hard evidence for ancient workings, so their early exploitation remains no more than reasonable assumption. Pliny (*Natural History*, xxxvii. 33. 110) reported that 'a far purer and finer stone (*callaina*) is found in Carmania' (the general area of Kerman); the very same region was recorded by Marco Polo (i.xiv) as a source 'of the precious stones that we call turquoises'. A number of old turquoise mines are said to lie between the modern town of Yazd and Kerman (Pogue 1915: 40). Prehistorians have tended to pay more attention to the better-known mines of Madan, 32 miles north of Nishapur in the eastern Elburz mountains, where medieval mine-shafts are said still to be recognizable (Tosi 1974: 148). There is no firm evidence for earlier exploitation, though it has been suggested on the basis of the appearance of turquoise from the fourth millennium BC at sites in the region like Tepe Hissar (Schmidt, E. F. 1937: 122 ff.) and others on the Iranian plateau (see below), and beyond, even earlier. In the enigmatic section 35 of Theophrastus' *De Lapidus* there may be a reference to

turquoises collected from the surface of the desert in north-east Iran after exposure by high winds (Eichholz 1965: 112); some authorities, however, assume a reference to coloured quartz (Caley and Richards 1956: 133).

3. *The Inner Kizil Kumy, south-east of the Aral Sea*: here the turquoise mines are in isolated mountains to the north of Zerasvan between the Amu Dar'ja and the Syr Dar'ja. Research hereabouts by Vinogradov and his colleagues has been summarized by Tosi (1974). This has demonstrated exploitation in the third millennium BC followed by a long interruption from the early second millennium BC; peak activity occurred in the Middle Ages. As in Sinai, the early exploitation was linked to copper-working. There seems to be no reason to suppose that turquoise mines in the mountainous region of Ilak, now known as Karamazar, were worked in antiquity. Tosi (1974: 161) concluded from his study of turquoise in Western Asia that 'during the 3rd millennium, turquoise was thus a product for which there was little demand and whose area of consumption moved along a north-south axis from Kyzyl Kum to Sistan crossing, but never joining, the great lapis lazuli route'. Even at Shahr-i Sokhta in Sistan, in the third millennium, when there was evidence of local bead production from imported semi-precious stones, there was 90 per cent lapis lazuli and 8 per cent cornelian compared with only 2 per cent turquoise (Tosi 1974: 154-5). At Tepe Hissar the relative percentage of turquoise is even lower; 'it is consequently hard to imagine that the nearby mines of Nishapur were active at the time' (Tosi 1974: 159).

4. *Afghanistan* has a potential source at Kuh-i Dasht, south of Herat, not yet investigated (cf. Tosi 1974: 150). Turquoise is conspicuous in the jewellery of the Seleucid to Parthian periods in Afghanistan (cf. Sarianidi 1985).

Turquoise appeared at an early date in Iraq. It may have been used for beads at Jarmo ('light aquamarine beads look very much like turquoise': Braidwood, L. S. *et al.* 1983: 298). In noting its use for beads at Hassuna the excavators commented that it was rare 'in early periods in Iraq' (Lloyd and Safar 1945: 269, pl. XI.2, 26), but at Tell es-Sawwan in the later sixth millennium BC, 'green' turquoise was reported as only slightly less common for beads than shell, blue adirite, and marbly limestone (Ismail and Tosi 1976: 107). On sites of the Hassuna and Halaf periods in the Sinjar Plain it appears sporadically as beads (Merpert *et al.* 1977: 83; 1978: 36; Ismail and Tosi 1976: 107 n. 7). Whence the stone came it is impossible to say. In view of its virtual absence from sites in Syro-Palestine (Beit Arie 1980: 58), Sinai seems improbable; Iran (as is usually suggested) seems much more likely. Turquoise was used for beads in the sixth-millennium BC village at Tepe Zagheh on the Iranian plateau (Shahmirzadi

1977: 269) and at Ali Kosh (Hole 1969: 349); in the fifth millennium BC it is reported at Bakun (levels III/IV) (Langsdorff and McCown 1942: 75) and at Tepe Yahya (VI/V) (Lamberg-Karlovsky 1970: pls. 37H, 38A). Thereafter, through sites like Tepe Hissar, it is possible to detect its continuing presence on sites in Iran as a material for beads, more often than not in association with lapis lazuli.

By the later third millennium BC at Gawra in Iraq turquoise is found in tombs 109 and 110 of period X, 124 of period IX, and 24 and 31 of period VIIIC, but none was reported from settlement levels (Tobler 1950: 88; Ismail and Tosi 1976: 108). 'The pins (ivory) from tombs 109 and 24 were long and pointed at both ends, altogether resembling a porcupine quill, and were elaborately decorated, with numerous lozenge-shaped inlays of lapis lazuli and turquoise in the thick, middle portion' (Tobler 1950: 86, pl. LIVc: 2). Ismail and Tosi (1976: 108) describe this as 'the last appearance of turquoise in Mesopotamia'.

So rare is the stone in the following three millennia that this appears, to all intents and purposes, indeed to be the case in so far as the material evidence is concerned; but it is not an absolutely closed case. References in texts, and isolated finds, indicate that turquoise was present later. It is possible that this was all recycled stone which had originally reached Iraq in prehistoric times, as Ismail and Tosi (1976) argued in the case of an amulet, inscribed for King Ninurta-apil-Ekur of Assyria (c. 1191-1179 BC), which is without an archaeological context. But it does not seem likely to apply to all known cases (if the identification holds).

As turquoise is not a suitable stone for seals, its absence in that respect is not surprising. Its absence from the Royal Cemetery at Ur is more remarkable, as it continued to be used sporadically in third-millennium Iran and is evident in the Harappan civilization (Ratnagar 1981: 154), though rarely. Towards the end of the third millennium BC it is recorded among coloured inlays in a necklace carved on a statue fragment from Telloh (Louvre: AO 298: Sarzec and Heuzey 1884-1912: 345, pl. 44ter 1a, b) and on the necklace of the priestess Kubatum from Uruk (Nöldeke *et al.* 1937: 23-4; Limper 1988: 65). In a hoard of objects from Nippur bearing inscriptions of Kassite rulers, one at least, for Kurigalzu, is said to be cut on a fragmentary 'turquoise' tablet (Peters 1897: ii. 132; Hilprecht 1893: 50; Brinkman 1976: 223). A tiny turquoise amulet, shaped like a bull-calf's head, in the Louvre, is inscribed for King Kadashman-Turgu of Babylon (c. 1297-1298 BC) (AO 4633; Brinkman 1976: 2.10; for material: André Leichnam 1982: no. 50). Rather further afield, Bibby (1970: 165) reported tiny turquoise beads in graves at Qalat Bahrein, with snake bones, beneath floors of the 'Assyrian Palace', c. 700 BC. Isolated turquoise beads appear at sites like Kish, Ur, and Uruk (cf. Limper

1988: no. 303) in Babylonia on necklaces in graves of the mid-first millennium BC, as they do in northern Iran (cf. Oda, in Egami *et al.* 1965: 33-5). Turquoise is unofficially reported among the inlays in gold jewellery from the recently excavated Neo-Assyrian royal tombs at Nimrud.

There have been various explanations for the rarity of turquoise as a gemstone in Mesopotamia after the prehistoric period. Tosi argued that the Irano-Afghan sources of turquoise were not worked in or before the third millennium BC. The earliest supply zone seems rather to have been the inner Kyzyl Kum in Central Asia (Tosi 1974: 148-50, 159), whence the early urban centres of South Turkmenia (Namazga III-V) were supplied; but not, it appears, the cities of the Indus Valley where turquoise is rarely reported (Ratnagar 1981: 154). As an essentially inland resource, turquoise may then have been outside the catchment zone for the Gulf trade-network supplying Mesopotamia in the early historic periods, superseding the trans-Iranian land routes of the prehistoric period which had brought it into Mesopotamia then. Within Iran it was still distributed through the exchange networks supplying sites like Shahr-i Sokhta, Hissar, and Tepe Malyan (Anshan) (Sumner 1986: 204).

Meyer (1981) has suggested that the conspicuous absence of turquoise in historic times might, like the similarly surprising rarity of the copper ores among ornamental stones, be explained in part by the fact that, in contrast to the prehistoric period, all copper was now arriving in Mesopotamia already processed or semi-processed. Tosi (1974) has sought to explain the remarkable rarity of turquoise in Mesopotamia after about 3000 BC as a conscious rejection of green stones. Since turquoise varies greatly in colour, and green is not otherwise known to have been regarded as 'unlucky', it is more likely that its deficiencies as a gemstone, as well as the availability of cheap substitutes, first in faience, then in glass, contributed more to its displacement.

Even a survey of this type cannot hope to embrace, even superficially, the great variety of stones used at one time or another as gemstones. One example makes the point unusually well. In the Nabu Temple at Nimrud Mallowan (1966: 270, pl. 252: ND 4304) found a 'brown pebble about 8 cm. across and perforated for suspension'. It was engraved, like a Neo-Assyrian seal, with a panel showing a worshipper before deity symbols and a panel of inscription mentioning the god Nabu. Only with the application of systematic mineralogical study to beads will it be possible to appreciate the range of materials used and to move closer to defining the primary source zones.

2. Manufacturing Techniques

(i) SEALS

The cylinder seal is the most distinctive artefact created by the Sumerians. In the prehistoric period sealing with stamp seals had already become an important part of administrative procedures throughout Mesopotamia and beyond. In the middle of the fourth millennium BC in circumstances that remain obscure the cylinder seal and a primitive writing system first emerged in southern Mesopotamia as controlling mechanisms in the economy of local city-states. This coincidence is unlikely to be fortuitous. At this stage and in this context it is unlikely that the other roles of seals, as amulets, ornaments, and votives, were critical factors in the change. In explicitly functional terms the new form of seal, which was rapidly to supersede all others in Mesopotamia and to survive there unchallenged for the best part of three thousand years, was ideally suited for rolling not only on clay sealings and bullae, but also on the newly introduced clay tablets.

Confusion and uncertainty surround the stratigraphic contexts of the earliest evidence from Uruk for cylinder seals. It has been generally assumed that the first were unusually large cylinders engraved in the manner and style of contemporary stamp seals. To some scholars the great size (e.g. 52 × 36 mm.) of these initial cylinder seals, very rarely found thereafter, is a key to the immediate origin of their distinctive shape:

They seem to have appeared at the same time as a renewed fashion for fine vessels of stone, which, in turn, may have been connected with an improvement in the technique of drilling stone. Is it possible that the bore cores of such vessels were used for cylindrical beads and seals? It may be noted that the heavy work with the drill in the engraving of what may have been the earliest cylinder seals suggests that the craftsmen were persons who ably used that mechanical tool, which was certainly employed by the makers of stone vessels. The idea implied here is that the makers of stone vessels may have developed the cylinder seal (and the crudely drilled stamp seals of related style), rather than that engravers of finely carved stamp seals introduced a variation in the shape and carving of their seal stones.

(Porada 1977: 7)

This plausible argument presupposes that a tubular copper drill, fed with abrasives, was used at this time in vessel production to extract a solid cylindrical core that might subsequently be used for cylinder seal production. Even if, in the first instance, cylindrical cores from vessel manufacture facilitated the emergence of cylinder seals, the modifications in size that were to characterize their subsequent history began early and persisted. However, it remains possible that cylinder seals were always to some degree cut from longer cylindrical rods. Most examples in collections are so well finished that it is usually impossible to tell from their ends whether they were once part of a longer stone

rod. However, one or two of the squat cylinder seals from Jamdat Nasr may show signs of having been cut in this way (examples in the Ashmolean Museum, Oxford).

Gorelick and Gwinnett (1981: 18) have postulated that the earliest cylinder seals 'were a combination of the engraved stone stamp seal and the cylindrical bead . . . By 3300 BC when cylinder seals were invented, stone beads in all sizes, shapes and hardness, many with decorative incisions, were being made by the thousands by stoneworker specialists . . . stone stamp seals were being engraved by specialists as well. The marriage was fortunate and prolific.' This view is not incompatible with Porada's, but emphasizes the important point that there was a merging of existing stoneworking techniques rather than the appearance of wholly new methods.

Techniques of seal manufacture have to be deduced from the seals themselves. No workshop used by a seal-cutter has yet been excavated on a Mesopotamian site. However, such a workshop at Malia in Crete, dated to Middle Minoan I-IIB (c. 1800-1750 BC) provides a coherent picture of the tools that might be expected in such a context: copper alloy saws for cutting stones; blades of obsidian (Mohs 5); copper alloy gravers for gouging; remnants of copper alloy drills; bone points and scrapers. Lumps of clay, associated with a water basin, were probably for taking impressions to check the work in progress (Poursat 1978). A text of the Achaemenid period indicates that an apprentice seal-cutter then served for 'four years . . . he will teach him the stones pertaining to the whole of the seal-cutter's craft' (Lambert, W.G. 1979: 89).

The closest the Mesopotamian evidence goes at present to Malia is with chance finds from Diqdiqqah, some 1,500 metres north-north-east of the Temenos at Ur (Woolley 1976: 81). Here Woolley believed there was

a regular manufacturing quarter of the town . . . shown by the cylinder seals. It has been said that these were too numerous to be accounted for as coming from the plundered graves: definite evidence that they were made here is available. In the first place there are the gem-cutters' trial-pieces . . . These fragments of pottery or stone on which the jeweller has sketched a design for the subject of a cylinder seal were found in various parts of the Ur site, but nowhere were they so common as at Diqdiqqah; in themselves they are good evidence of local trade, but in one instance (U.16927) they form part of a group of objects found all together which is decisive. In the group there are no less than four typical trial-pieces on limestone . . . and with them were a number of cylinders in shell, limestone and steatite all unpierced and uncarved . . . and to show that the craftsmen did not confine himself to a single line of business there were with these a quantity of unfinished beads of rock crystal (U.16927D), unpolished and some unpierced, and the shell iris of an eye for a statue (U.16927E)

(Woolley 1976: 86)

This evidence, of the earlier second millennium BC, included a tiny fragment of a steatite statuette cut about in such a way as to suggest that it 'was being re-used, probably by a maker of cylinder seals' (Woolley 1976: 252: U.18339). It is likely that many sherds of steatite or chlorite vessels found on the Island of Failaka at much the same time were being recycled as stamp seals in the distinctive local style (Kjaerum 1980).

The precise role of the Old Babylonian trial-pieces from Diqdiqqah is not obvious. They show figures or combinations of figures crudely cut into fragments of limestone; one at least had formerly been a piece of pink limestone inlay. They seem more likely to be the work of trainee craftsmen than of skilled seal-cutters. In one case at Diqdiqqah a whole scene had been roughly incised on a pottery sherd, and from the surface at Ur came part of a stone vessel 'on each side of which is a gem cutter's sketch for making a cylinder seal; on one side a seated figure of a goddess, on the other a similar figure and some cuneiform signs' (Woolley 1962: 131, pl. 25 = Woolley 1976: 253: U.20053; Woolley 1976: 252: U.18307).

It is remarkable how little evidence of engraving procedures may be deduced from finished seals. They rarely show any trace of preliminary layouts, errors, or deviations from a design that might indicate drafting, etc. (cf. Collon 1987: figs. 451-2). No sketch in any other medium has yet been certainly identified as a pattern made preparatory to seal-cutting. In any one period the repertory of motifs was standard, so seal-cutters and their customers could easily have worked from patterns provided by collections of existing stones or impressions of them, modifying as required. Such may indeed have been the purpose of the hoard of clay seal-impressions of the Achaemenid period found in a coffin at Ur (U.18124: Woolley 1962: 29; Legrain 1951: nos. 701-832; cf. Porada 1960).

It is possible that seals, particularly in variegated stones, were covered with a layer of clay or plaster to take initial guidelines. It is unfortunate that blank or partially cut cylinders tend to be ignored, save for passing comment, in excavation reports and have never appealed to collectors (cf. Legrain 1925: nos. 122, 218). They appear both pierced and unpierced. There are cases of vertically split seals, with finished designs, that look as if they were broken when a central boring was attempted after engraving (cf. Neo-Assyrian Billah: Philadelphia University Museum 30-20-398; Collon 1987: fig. 449). Examples occur partially bored and with a scene partially cut (Ur: U.11507 = Philadelphia 30-12-30, also 30-12-64, 31-43-15), as if they were either apprentice pieces or work rejected by a skilled hand when something went wrong. A rock crystal blank from Diqdiqqah at Ur (U.16743 = Philadelphia 31-43-46), unbored, has the moulded caps cut into the upper and lower part of the seal, leaving a central panel plain

for the engraved scene. Ready-made blank unbored cylinders seem to have travelled, to judge by examples in haematite found in excavations at Selenkahiyah in Syria *en route*, presumably, for workshops further south along the line of the Euphrates (Loon 1968: 31).

Procedures in other ancient areas of seal production, as in Crete and Egypt, indicate that the seal was fixed into some kind of frame or a block of adhesive for cutting and the composition lightly sketched on the surface to position it. However, Mesopotamian cylinders with unfinished designs often show only a single element in the design, as if modelling or engraving was restricted to one part of a composition at a time, not to advancing the whole design in parallel (cf. Collon 1987: fig. 452). In view of the minute scale and rich detail of many seal designs, it has often been argued that artificial visual aids must have been used. Some rock crystal disks, including one from Layard's excavations at Nineveh (BM 90959), with one flat face and a planoconvex back, have been identified as possible lenses. It has been shown experimentally that they distort too much to be of any assistance to a seal-cutter, though they may magnify slightly (but see Sines and Sakellarakis 1987). Such rock crystal disks were probably no more than decorative inlays. Lenses and eyeglasses do not appear for certain before the thirteenth century AD. It is more reasonable to assume that close work was done by short-sighted craftsmen; a skill that ran in families with this characteristic. They can see small objects magnified and with clarity by being able to bring them closer to the eye.

In only one case so far, at Tell Asmar in the Akkadian period, has a cache of copper alloy tools been reported that might have been those of a seal-cutter (Frankfort 1939: 5; but see Collon 1987: 103 n. 14). This find of borers, engravers, and chisels has not yet been published in detail. The scarcity of surviving tools, and the absence of any relevant documentary evidence, has stimulated microscopic study of the unpolished areas of designs and the borings of cylinder seals through silicone impression techniques, with controlled replication, by Gorelick and Gwinnett (1978, 1981; Gwinnett and Gorelick 1987). This has proved very illuminating. Attention was first concentrated on the borings. They were found to be started from both ends with a flared opening; borings varied from tapered to nearly straight and parallel. They had been made with drill-bits fed with abrasives which may sometimes have become embedded in the tool. It is probable that a horizontal spindle driven by a bow ('bow-lathe') was used to drill the bores as early as the late prehistoric period (Gorelick and Gwinnett 1981: 28 ff.), when stones as hard as rock crystal were already used for small cylinder seals. With a true lathe the work is turned and a tool is held against it; with a horizontal spindle the work is held and brought to the rotating tool, whether a

drill, disk, or tube. It is generally agreed that a rotating cutting disk could only have been used on a horizontal spindle (cf. Nissen 1977). This tool increased the speed and visibility of engraving and has been used by lapidaries ever since. This innovation had previously been attributed to the Kassite period, about two thousand years later.

Its invention simply required that the vertical bow-drill, already in use for millennia, should be turned sideways and supported at both ends. It would have been driven by the same kind of bow round the same kind of spindle, whilst allowing for the use of disks varying in shape and size. This is essentially the equipment still used by Indian (and other) lapidaries, since it can be controlled more easily than would be the case with a vertically mounted drill operating on a smooth surface. The horizontally mounted drill allows for the right amount of pressure to be exerted at exactly the right point. The methods for creating stone disks had already been pioneered in the manufacture of disk-shaped beads. As neither contemporary representations nor survivors exist at present, it is not known how wheels and disks were hafted, though the contemporary introduction of vehicles with wheels set on axles may have offered patterns and stimulus. The only available guide is a broken fragment of a stone relief of the second century AD from a gem-cutter's tomb in Lydia in Turkey showing a bow-lathe; unfortunately, the depiction of the cutting edge is lost (cf. Charleston 1964: 85, fig. 2: the drawing is a reconstruction).

Collon (1986: 14; 1987: 102) has argued that the prevalence of undisguised wheel and drill cuttings on Old Babylonian seals could be due to the introduction of wheel-driven rather than bow-driven tools. This would have allowed for faster continuous action rather than stop-and-start movements. However, the conversion of reciprocal to continuous rotary motion does not appear for certain elsewhere until the later Middle Ages in Europe.

When the cylinder seal first appeared, chipped stone microdrills and wooden points fed with abrasives were the materials used for drilling (Gwinnett and Gorelick 1987). The marked trend towards greater use of hard stones in the later third millennium BC may have required a change in the materials used for drill-bits: copper or copper alloys fed with abrasives, perhaps emery in oil. Research has not yet proceeded far enough to describe a pattern in the use of metal, stone, or wood for drill-bits. On softer stones all three are likely to have been used throughout as circumstances required. On harder stones a greater use of metal might be anticipated with iron gradually supplementing bronze from about 1000 BC. It has been argued that stone drill-bits would be particularly susceptible to breakage in manufacture and use; but it is stone to which Herodotus (vii. 69) makes reference in this

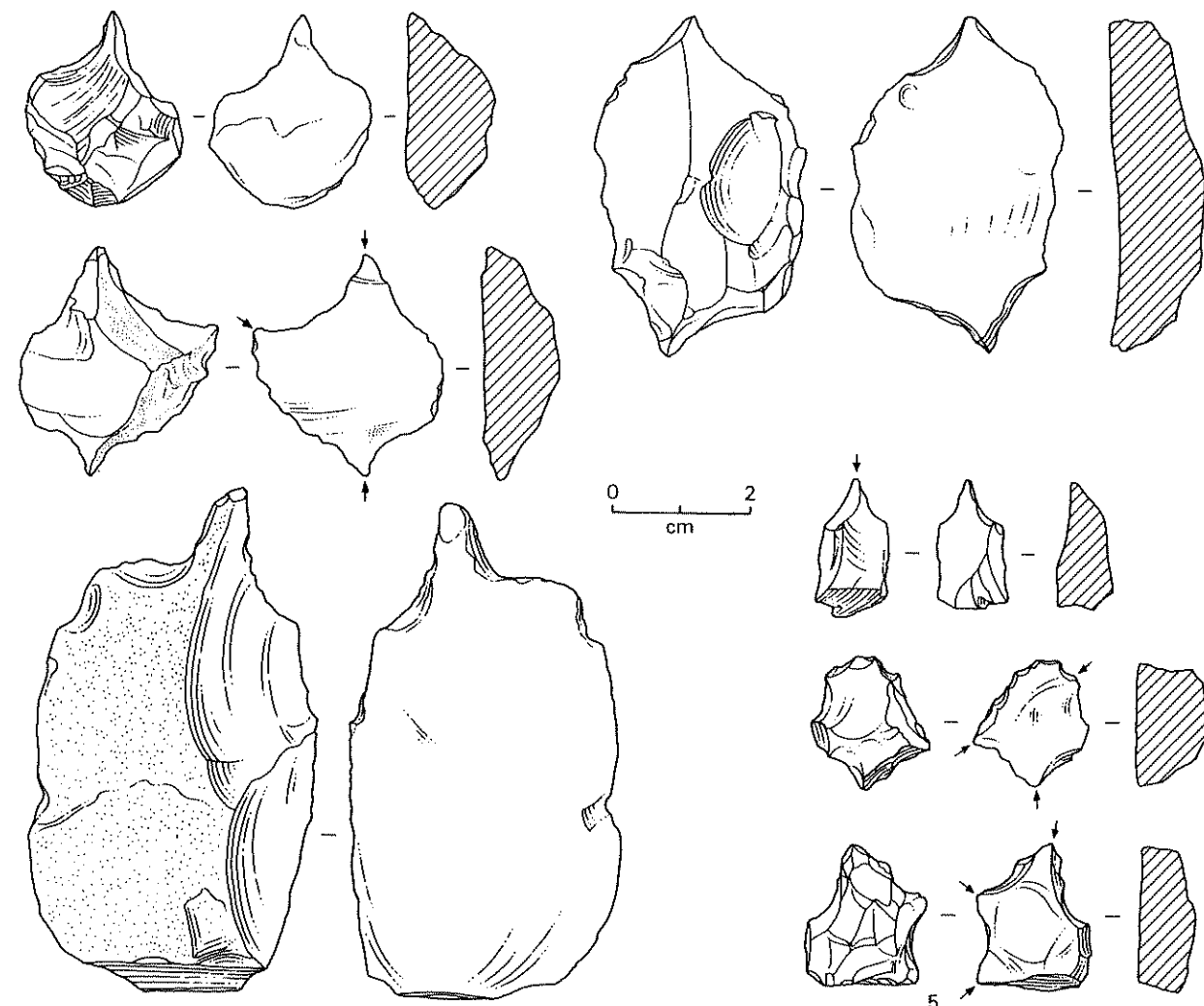


Fig. 6. Flint borers, probably for shell manufacture, c.3000-2600 BC from Kish (after Payne, in Moorey 1978: fiche 2: D11, E03).

context. Metal allows for finer points and cutting edges, whilst it can be sharpened recurrently and reused. Although hard stones (Mohs 7) can be drilled with wood, the amount of time and worn drill-tips consumed would tend to favour the use of metal, where it was available.

Engraving was frequently, but as we have seen not invariably, the final step in the manufacture of a cylinder seal. Here again, as with drilling, millennia of experience before c.3500 BC with engraving, using bone, copper, and stone, underlay the techniques employed. How, when, and what kind of copper alloy, or later iron, tools were used by seal-engravers are questions still in need of detailed research. Throughout, the work was a combination of drill-driven and hand-held tools, used even on the hardest stones (cf. Collon 1987: 102).

(ii) BEADS

(d) Drills and drilling in Mesopotamia

No systematic study of a beadmaker's workshop in Mesopotamia has yet been made, though caches of material attributed to beadmakers have from time to time been reported, notably at Babylon and Nippur (Koldewey 1914: 221, cf. *MDO-G* 5 (1900), 4 ff.; Peters 1897: 131-6). These consist primarily of small objects, often inscribed, in semi-precious stone gathered for recycling. At Ur, among the poorer mid-third-millennium graves of the Royal Cemetery Woolley (1934: 206-7) identified what he believed to be the burial of a beadmaker, whose grave included the tools of his trade (PG 958):

In front of the chest, clustered together as if they had all been in a bag which had decayed and left no trace of itself, were a number of objects which can only be explained as the working stock-in-trade of a bead-manufacturer. These

... were as follows: (1a), (1b), two pieces of a broken palette(?) of white limestone; (2) pounder or rubber of white pebble; (3) flint flake to which is attached by corrosion a long strip of thin copper (broken), 0.013 m. wide; (4) a large flat chip of white limestone; (6) a roughly shaped cube of steatite; (7) fragment of alabaster, attached by corrosion to the copper strip; (8) flat oval pebble; (9) fragment of a rod of alabaster; (10), (11), (12), (13), flint-knives; (14) underlying most of the above, some large flint chips; (15) a collection of small chips of cornelian and lapis lazuli, all rough except one piece of lapis which has been roughly shaped as a ring bead and half-pierced, some small flints, some lumps of red pigment ... and fragments of a very small copper drill. U.11414.

About the same date is Payne's (J. C. 1980: 112) find at Abu Salabikh of a surface concentration of small flint borers 'together with fragments of lapis lazuli, cornelian and shell, and small chunks of the raw material of these beads'. Traces of cornelian bead manufacture were recovered at Larsa and the production techniques were deduced from them (Chevalier and Inizan 1982).

In these circumstances it is the identification of appropriate chipped stone borers, and deductions from them, combined with study of wear traces on artefacts, that presently underpin the meagre and scattered literature on the manufacture of beads in ancient Mesopotamia. Ethnographical studies, particularly in relation to agate and cornelian bead production, have also been brought to bear on the problem since the 1930s as, more recently, have studies of ancient workshop practices in prehistoric Iran and Pakistan.

The craft of the lapidary in ancient Mesopotamia has been most closely studied in recent years by Gorelick and Gwinnett, particularly with reference to the drilling techniques used in seal manufacture (see pp. 105 ff.). In the study of beads this is, of course, most relevant to the boring of suspension holes. This research technique primarily involves deducing the type of drill employed from the drill marks left in the drill holes on the bead or seal, as information about missing bullets is derived from the bullet holes. Whereas chipped stone drill-bits have survived, those of wood have not, and where those of metal have, they tend to be so badly corroded as to defeat diagnosis.

On the basis of their work Gorelick and Gwinnett (1987) postulate the following critical innovations in the development of drills and drilling:

1. *Hand-held drills.* From a remote period in hunter-gatherer communities the use of microlithic chipped stone drill-bits, hafted to a bone or wooden handle to form an awl, had greatly facilitated the use of hand-held drills for the low-speed, partly rotational drilling with quartz or softer stones. Microwear evidence for hafting is not always as easy to distinguish as has sometimes been assumed (cf. Unger-Hamilton *et al.* 1987).

2. *Bow-drills.* Some time early in the Neolithic period

if not before, the marriage of the hafted microdrill-bit and the wooden fire-stick rotated between the palms of the hands increased rotational speeds, perhaps by as much as 40 times. A critical transformation of this procedure was achieved with a string wrapped round the hafted drill-bit and pulled backwards and forwards to turn alternately clockwise and anticlockwise. When the string was held in a bow and the string wrapped round the awl shaft to turn it rotationally, speed might be increased as high as 850 r.p.m. 'Cap stones' were then needed to hold the shaft steady and vertical. Combined with a remarkable knowledge of the properties of stones and increasing mastery of abrading, drilling, and polishing, the beadmakers of the Neolithic Near East were capable of exquisitely delicate work on medium to hard ornamental stones.

At present the best evidence for the basic stone technology that was to endure for millennia in Iraq is to be found in stone personal ornaments from Jarmo. Moholy-Nagy (1983: 298) has described the manufacture of stone beads there through study of broken or unfinished examples. They were first blocked out by sawing or grinding against a coarse-grained stone. The perimeters of disk-beads were often chipped into shape. Long beads were always biconically perforated, but short ones may have been drilled through from one face. The smallest recorded perforation was 1 mm. diameter; but none of the drill-like artefacts could have achieved less than 3 mm. Moholy-Nagy suggested a method akin to that of the North American Indians for making the finest perforations. For this a drill of thorn would be mounted in the end of a stick, which could be rotated with the hands and used in combination with a fine abrasive and water.

Subsequently Gorelick and Gwinnett (1990) investigated the use of loose abrasive (quartz or emery) in combination with flat-ended flint drill-bits driven by bows at Jarmo to pierce hard stones like agate, cornelian, haematite, obsidian, and rock crystal, all stones foreign to the Jarmo area and thus imported for bead-making there. This investigation also showed that quartz (cornelian) beads were initially shaped by chipping, soft stones by abrading. Surface patterns on artefacts at Jarmo were examined microscopically. A shell pendant was decorated with 'a perfectly round groove with a central drill hole (e.g. Moholy-Nagy 1983: fig. 142: 15) ... suggesting the use of a tubular drill and abrasive ... made of bone or reed' (Gorelick and Gwinnett 1990: 31).

The lapidary techniques used at Jarmo were to have a very long life in Mesopotamia, both in the north and in the south. The chipped flint spindle-tipped bits of the Early Dynastic period in Sumer have received the most attention from students of technology. They have been reported from a number of sites, usually with evidence of shell- or stoneworking, as at Abu Salabikh

(Payne, J. C. 1980; Unger-Hamilton *et al.* 1987), Kish (Payne, J. C., in Moorey 1977: fiche 2 (of 4)), Tell al-Ubaid (Hall and Woolley 1927: pl. 13.5), at Ur (Mackay 1937: 7 n. 12) and Uruk (Müller, A. 1963: fig. 4: 5–10). These borers are distinguished by a long narrow point or spindle made by direct retouch on burin spalls and pressure-flaked bladelets. They have a central ridge. Analogy suggests that they were used with bow-drills as has been postulated millennia earlier at Jarmo. The sign for *zadim*, perhaps already evident in the earliest pictographs in the later fourth millennium BC (Green and Nissen 1987: no. 614), may be interpreted as representing a bow-drill. It was used to denote a bowmaker (*sasinnu*) after the Ur III period rather than a lapidary, its basic meaning (cf. Loding 1981: 14). Microwear studies by Unger-Hamilton and others (1987) tend to confirm the use of these bits with bow-drills, but they did not certainly elucidate how they had originally been hafted.

The production of cornelian beads has been particularly elucidated by studies of a workshop producing them at Kumartepe, near Samsat in Turkey, in the second half of the sixth millennium BC. Cornelian was clearly accessible to this site, where it was found in various stages from the raw material to finished beads. Grace (1989–90: 149) has reconstructed the drilling technique used to produce disk beads of cornelian: 'after the blanks were prepared, pecking would have been used to provide a slight indentation in the centre . . . (this) would then allow the drill to be placed in position . . . Drilling would then be used to perforate approximately halfway through the blank. The completion of the perforation seems to have been achieved by the removal of a conical flake . . . a drill-bit is placed in the hole and struck, producing a conical fracture scar, and this completes the perforation.' Exactly the same technique for making cornelian disk beads in the earlier third millennium BC in a workshop at Larsa had earlier been recognized by Chevalier and others (1982). It is a good example of the persistence of basic stoneworking techniques from the Neolithic period through into historic times (see below).

3. *Abrasives and drill-bits.* Gorelick and Gwinnett (1987: 37) have emphasized particularly the importance of abrasives in the development of drilling techniques: 'In effect, each abrasive particle functioned as a minute microdrill. The original chipped pointed microdrill was the least efficient carrier of this abrasive because there was no bearing surface to press the abrasive into the work. What was needed, was something that was flat and soft enough to permit the abrasive to become temporarily embedded and firm enough not to wear away too rapidly.' They showed by experiment that wood had its limitations as a drill-bit but 'the answer to the limitations of wood as a drill came with the experience in working with copper . . . Copper was ideal because

it was not breakable in the way that flint microliths were; it could be reused and it was soft enough so that the loose abrasive became embedded or "charged" temporarily when it was used as a drill. It could also be mass produced.'

Although evidence is not yet available for direct study of the emergence of metal drill-bits in Mesopotamia, it has been found further east. The preparation of beads in lapis lazuli, turquoise, and steatite is evident at Mehrgarh in Baluchistan in the seventh millennium BC, bored with flint drill-bits. About 4000 BC a new type of borer in phthanite (a type of jasper) is evident (Jarrige 1985: 285 ff., fig. 1), probably used with some type of bow-drill. At the beginning of the third millennium BC in Baluchistan, at Mehrgarh, and at Mundigak, and in Pakistan at Chanhu-daro, there are examples of spirally threaded copper drill-bits (Jarrige 1985: 290 fig. 2), previously thought to be an innovation of the Iron Age. Copper drill-bits of more conventional form had begun to replace those of quartz at about the same time. A lapis lazuli bead was actually found at Mehrgarh with the copper drill-bit still in place after breaking in the course of production, c.2600 BC (Jarrige 1985: 290, fig. 4).

For Mesopotamia, Gorelick and Gwinnett (1987: 37) have deduced the transition from stone to metal through drilling marks on dated seals:

We also feel that the copper drills were not pointed, indeed they would be dysfunctional in that shape. Copper has a Mohs hardness of 3 and its point would be useless and rapidly disappear on any stone harder than Mohs 3. However, if the shape were rod-like with a flat leading edge, a more efficient bearing surface would result. Therefore, the use of copper drills and loose quartz abrasives resulted in the increased use of harder stones in the Mohs range 4–6.

As the rate of drilling with copper or a tin-copper alloy was shown to be the same, Gorelick and Gwinnett (1987: 38) argue that it was the introduction of emery (Mohs 9), a loose abrasive more effective than crushed quartz (Mohs 7), or obsidian (Mohs 5–6), that primarily explains improved drilling rates in the Bronze Age, from about 3000 BC. It may well be that increasing use of decorative quartzes for beads and seals through the second millennium owes something to this change.

It is not yet possible to define the stages through which copper drill-bits came to supersede those of chipped stone, as these are evident well into the third quarter of the third millennium BC (Payne J. C. 1978; 1980) and may well have survived in use much longer into periods when study of stone tools has been much neglected by excavators in Mesopotamia.

4. *Iron drill-bits.* The emergence of the iron drill-bit in Mesopotamia is still undocumented and extensive use of it may well post-date the Achaemenid period. So long as iron was forged rather than cast, its use

for drill-bits was unlikely to supersede long-established techniques with copper, copper alloys, stone and wood. In Gorelick and Gwinnett's (1987: 38) experiments they were able to drill soft stones with forged iron bits, but none harder than Mohs 4–5.

As has been suggested in discussing techniques at Kumartepe, at least one distinctive percussion technique is known in Mesopotamia in addition to the more widely studied drilling methods for creating bead holes. Debris from the surface of sites like Larsa and Tell Senkereh and third millennium disk beads from places like Kish, Mari, Ur and Uruk have allowed Chevalier (and Inizan 1982; cf. Müller, A. T. 1963 for Uruk) and others to identify this procedure. The biconical perforations in roughed-out cornelian disk beads were produced by first pecking a cavity on one side, then striking the base of this depression so as to remove consistently a cone-shaped piece of stone from the opposite side. The flint reamers used in this operation have been found among related working debris on the surface at Larsa. The recognition of this technique may supersede Mackay's (1937: 9) suggestion for a boring technique to manufacture comparable near-contemporary beads at Chanhu-daro in the Indus Valley.

Miller (R. 1980; 1984) has described a bead-making industry at Teima in north-west Arabia from the second half of the first millennium BC. Pliny regarded Arabia as one of the primary sources of gemstones (*Natural History*, xxxvii.15). The borers used there were still of flint: 'this is a short, stubby chunk of coarse-grained flint which has been shattered . . . rather than flaked . . . to produce a pyramidal chunk which is retouched on one, two, or three corners to make drill-bits. These drill-bits are sometimes sharpened with a burin blow . . . and begin tool life as a short sharp edge at right angles to the axis of rotation, a typical form of drill-bit in iron tools from a west African stone beadmaking industry of modern times . . . With continued use, the flint bits found at Teima developed a rounded tip' (Miller 1984: 146). These were comparable to the ball-shaped drills (*outil demi-rond*) postulated by Gorelick and Gwinnett to start and enlarge the site of drillings in ancient Mesopotamia.

(b) *Bead production in the Indus Valley: foreign beads in Mesopotamia*

For over half a century much attention has been paid by archaeologists and anthropologists working in the Indian subcontinent to reconstruction of ancient bead-drilling techniques through observation of contemporary craftsmen using the same sources for their raw material as were exploited in antiquity and a minimum of equipment. Mackay (1937), on the evidence of unfinished third-millennium BC beads from Chanhu-daro in the Indus Valley, described a series of stages in the production of long barrel-cylinder cornelian

beads, fine examples of which have been recovered in excavations in Mesopotamia. As Mackay had first-hand experience of excavating such beads at Kish, his views are particularly cogent; to him (as still today) it was not clear whether some, or all, such beads were imported into Iraq ready-made. Mackay (1937: 3 n. 5) believed the absence of unfinished examples indicated foreign manufacture; but this is a hard line of argument to check exhaustively. At Chanhu-daro the raw material, both cornelian and agate, of varying colour, some roasted to intensify the colour of the interior of a nodule, was certainly drawn from local sources (cf. Arkell 1936).

In order to obtain as long a bead as possible, the nodule of agate or cornelian was split along the longer axis to produce a number of slips or rods, square or slightly rectangular in section. At each end every slip has part of the original surface of the nodule from which it was struck, and this sometimes also remains along one side of the slip . . . one or two grooves along the exterior angles of most of them show that the nodules were first sawn longitudinally and then cleaved into sections when the cuts were deep enough.

(Mackay 1937: 4)

Mackay believed that some kind of metal had been used; recent discovery of a copper helicoidal drill-bit at Mundigak strengthens the view that a metal tool-kit was already available to beadmakers as well as the traditional stone one (see above). A more even shape was produced by coarse flaking; finer flaking removed sharp angles; careful and minute flaking gave the bead an almost round section (Mackay 1937: pl. I. 8); final shaping was achieved by rubbing on a piece of coarse sandstone (Mackay 1937: pl. II. 13). The ends were then ground flat for boring. The centre was roughened, so that the drill-bit would not slip (Mackay 1937: pl. III. 1), with chert ribbon flakes terminating in a point. Stone drill-bits rather than metal ones appear to have been used for boring (Mackay 1937: pl. II. 5), averaging 1.5 inches long by 0.1 to 0.12 in diameter. They were of chert with a little magnetite, registering 7 on the Mohs scale. They would have been used with an abrasive; a slight cavity in the points of drills was probably intended to secure it. Beck reported that at least one such drill-bit had been found by Woolley at Ur (cf. Mackay 1937: 7 n. 12). What type of mechanism had motivated the drill is an open question, for which various modern parallels have been cited (Possehl 1981: 41; Wright, P. W. M. 1982). All the beads examined by Mackay were drilled from both ends; on completion they were finely polished.

The matter of heating has not yet been investigated for chalcedony in Western Asia in antiquity; but in modern bead manufacture the purpose is twofold. As it causes physical change in the stone, it makes chipping an easier task (cf. Possehl 1981: 42). It is also used with

chalcedony and agate to modify colour, as Arkell (1936: 296) reported: 'in its natural state the agate is of a dull cloudy brown or yellow colour. After being dug out of the mines they are divided into two classes, those which should and those which should not be baked. The former are spread out in the sun, and are then baked in earthen pots by means of a fire made with goat- or cow-dung cakes. By exposure to the sun and fire, the colours of the stones are deepened and become more pronounced.'

With the increasing revelation of cultures ancestral to those of the Indus Valley cities of the third millennium BC, the long history of bead manufacture in the sub-continent is ever better understood. Rehman Dheri, where Carbon-14 dates of 4400 ± 110 BC (PRL-675) and 4520 ± 110 BC (PRL-676) are given for the earliest levels, is said to possess 'the richest bead industry of the contemporary sites on the subcontinent. The few round furnaces, lumps of lapis, cornelian, agate, and turquoise, and the availability of unfinished beads with stone drills intact would suggest that bead manufacturing was carried out at the site . . . The beads show great variety of shapes and forms . . . lapis lazuli, a common material at Rehman Dheri, has never been so abundant on Early Bronze Age sites on the subcontinent' (Durrani 1981: 204). The rich contemporary lithic industry of flint, jasper, chalcedony, and agate included microdrill heads. A cornelian bead with a drill still in the half-finished perforation confirmed their use (Durrani 1981: 204, pl. III), as at Hissar and Shahr-i Sokhta in eastern Iran.

Typical drill procedures have been described by Tosi and his colleagues (cf. Tosi 1976-80; 1989: 17-20), primarily on the basis of third-millennium BC evidence from Shahr-i Sokhta. Initially, square-sectioned backed blades, up to 14 or 15 cm. long, were detached from a core; these were further reduced by chipping. Disks or short cylindrical beads were outlined by segmenting the

long blades with one or more transverse blows. Then the beads were more finely shaped by polishing with abrasives. This might opacify the colour, but this could be restored by final polishing and heating at low temperature. The delicate process of drilling followed initial polishing. In Iran jasper or flint (chert) drill-bits (2-4 cm. long) were used, working in turn from each end of the bead. A number of small boards of poplar and of tamarisk found at Shahr-i Sokhta in association with tools and bead blanks have been identified as devices for holding small beads during drilling (Costantini 1979: 116). Drill-bits were manufactured by the same technique of strike and retouch as the beads.

Even now precisely how the long cornelian beads of Mesopotamia and the Indus Valley in the third millennium BC were drilled is debated. The task requires great dexterity. Tosi (1976-80^a: 452) reconstructed the process thus: 'This was possible when the drill was almost completely smoothed. It was fastened on the top of a thin wooden pivot and the drilling was carried out alternatively on each end of the bead, never for more than 1 cm. at a time in order to minimize lateral drift that could crack the stone. The holes were progressively shorter and thinner, but at the end the worker had drilled for a total length of 3 to 7 times the one of the drill.' Chevalier and colleagues (1982: 63) are not so certain of the success of this technique for the largest among these remarkable beads. They cite an example in the Louvre 6 cm. long and with a perforation of less than 1 mm.: 'quel type de mèche peut avoir cette longueur et ce si petit diamètre—certainement pas une mèche en silex-graminées, épinés avec abrasif?'

(iii) INLAYS

The only consistent body of evidence for inlays with ornamental stones is that provided by gold jewellery, which is considered below (pp. 228 ff.).

3

WORKING WITH BONE, IVORY, AND SHELL

IN ANY STUDY OF ANIMAL MATERIALS AND manufacture in Mesopotamia based on the evidence of archaeology and art, the distinction between durable and perishable is fundamental, for the latter remain almost exclusively a subject for documentary research. On the one hand stand antler, horn, and bone with various types of ivory and shells, on the other feather, hair and wool, gut, leather, and parchment. Leather has been the subject of study on the basis of textual evidence (cf. Stol 1980-3; Mieroop 1987), whilst catgut is recorded in the hands of leatherworkers for a variety of purposes (Mieroop 1987: 33). Felt (cf. Steinkeller 1980; Mieroop 1987: 35-7) and textiles (cf. Waetzoldt 1972) are also already the subject of a considerable literature. Neither for the leather nor for the textile industries in Mesopotamia, important as they were, is the material evidence for the equipment or processes of manufacture yet accessible enough to make it in any sense complementary to the kind of information available in texts. Even where 'workshops' for the leather or textile industries have been identified, as at Tell Asmar (Delougaz 1967: 181, 196-8, pls. 36-7) or Telloh (Gros 1910: 100-8), hard evidence is absent. What archaeological evidence there is on textiles is most accessible in Barber's (1990) comprehensive study.

1. Antler

Antler is an outgrowth of bone, but for all practical purposes a significantly tougher material, better able to sustain shocks. It can be softened in water to facilitate working (cf. MacGregor 1985: *passim*). Antlers are carried by most members of the deer family (*Cervidae*) and are usually limited to the stags only. Buren (1939: 37 ff.) recognized three species of deer in the art of ancient Mesopotamia: 'an unspotted species with long branching horns which resembles the red deer of Europe (*cervus elaphus*); a spotted fallow deer with more or less palmated horns (*cervus dama*); and the roebuck (*cervus capreolus*), more squarely built, with big ears which stick far out on each side of the head and squarely-shaped horns'. From prehistoric to Achaemenid times it was either the red deer or the

fallow deer which she recognized in art, rarely noting the roebuck.

Published information on unworked antlers from Mesopotamia remains meagre and scattered. Buxton (1933: 178) reported the jaw, teeth, and antler of a red deer at Nineveh in what may have been a late prehistoric context. Hilzheimer (1941: 20-2) published three antler fragments of the Early Dynastic III to Akkadian periods from Tell Asmar. He identified them as in all probability *Dama dama* Linnaeus. 'Two of these . . . are with burr, each about 50 mm. long and cut off at the distal end . . . In any case the fact that both fragments are cut off distally proves that the Sumerians must have used the antlers in some way or other, presumably for implements.' He also noted in Berlin two antler fragments of *Dama mesopotamica* from the Uruk excavations and complete antlers of this species from von Oppenheim's excavations at Tell Halaf. A fragmentary antler of fallow deer (*Dama mesopotamica*), identified by the distinctive brow tines at its base, was reported in Early Dynastic Lagash (al-Hiba) (Mudar 1982: 28). Parker (1955: 116 n. 1) drew attention to Zeuner's identification of a red deer's antler from a Neo-Assyrian house at Nimrud.

Worked antler is even more elusive in the archaeological record. The use of antler, suitably modified with a shaft-hole, as a digging tool is illustrated in the early second millennium BC at Isin (Hrouda 1977: 55, 114, pl. 12) (IB 166). It is equally appropriate as a handle and for other purposes and was used from the aceramic Neolithic, wherever it was readily available (cf. Campana 1987: 121).

2. Horn

Horn is a modified, non-deciduous skin tissue more prone to decay and disintegration in the ground than either antler or bone, so finished objects and workshop debris are always likely to be meagre. Delicate application of heat renders horn soft and malleable for working. As with antler, horn from a variety of domesticated and wild animals would have been readily available for manufacture in Mesopotamia. The textual evidence,

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from the second millennium BC onwards (*qarnu*: CAD 'Q': 136 ff.; *AHW* II: 904), refers primarily to the role of horns as natural containers for liquids, notably oil, for which they need little modification (cf. Egypt: Petrie 1909^a: 7, pl. XXV). Ceramic and metal imitations of them (*rhyta*) are equally elusive in the Mesopotamian archaeological record (cf. Calmeyer 1979). Ox or bull horns are recorded in this role.

The role of gazelle horns in Mesopotamian manufacture is still obscure, although they are now recurrently reported, unmodified, from occupation levels of the Early Dynastic to Akkadian periods as, for instance, at Tell Asmar (Hilzheimer 1941: 23), al-Hiba (Mudar 1982: 28), Abu Salabikh (Clutton-Brock and Burleigh 1978: 95), and various sites in the Hamrin area (Amberger 1987: 122 ff.; Boessneck 1987: 152 ff.). Bones are now generally reported with them, though in the older reports their presence was doubted. They are thought to come from wild *Gazella subgutturosa* hunted for food; but, as Mudar remarked of the finds at al-Hiba (Lagash), 'there is a relatively large proportion of horn cores present. This may be due to the utilization of gazelle horn-cores for purposes other than food consumption, such as handles for tools.' Gazelle horn cores are also reported in levels of the earlier second millennium BC at Isin (Boessneck 1977: 115; 1981: 141 ff.). A horn, possibly gazelle, has been reported from levels of the fourteenth to early twelfth centuries BC at Meskéné-Emar carved in low relief with encircling friezes (Margueron 1986^a). It is not only complete horn cores that may have served craftsmen, since as early as the settlement at Jarmo horn core tips were being worked (Watson 1983: 355-6).

3. Bone

Although there has been a marked increase in recent years in the proper recovery and expert publication of unworked animal bones from excavations in Mesopotamia, bone artefacts have not been so well served, particularly on sites of the Early Dynastic and later periods, when it is extremely difficult to assess the extent to which bone was still used as a material for manufacture. The standard repertory of bone objects and most production techniques were well established by the time of the earliest village settlements in Mesopotamia (cf. Watson 1983) and the industry was not subject to radical change in the next four or five thousand years. What happened after about 3000 BC is far less clear, when it was not so much a matter of innovation as of displacement. Copper or copper alloys replaced bone in many artefacts, but at a rate and to a degree that it is still impossible to assess with any degree of accuracy.

Even in prehistoric Mesopotamia, bone relative to stone (and also in the south to baked clay) does not

appear to have been as much used for tools and personal ornaments as might be anticipated; but there are likely to have been marked variations in time and place and from industry to industry, so far concealed by inadequate data for assessment. At present the contrast with Turkey, for example, is striking. There, not only in the Neolithic settlement at Chatal Hüyük (Mellaart 1967) but also at Boghazköy in the second millennium BC (cf. Boehmer 1972: 181 ff.; 1979: 44 ff.), there is material evidence for considerable and varied bone manufacture, including small sculpture, to a degree at present unparalleled in Mesopotamian reports.

It is not only the published archaeological record that is uninformative for the historic periods. There is also a marked absence of terms in the written record describing bone objects of daily use (cf. Salonen 1965: *passim*), perhaps because this material always had a low status, superseded by ivory or fine wood in the contexts most often described in the texts (cf. Caubet and Poplin 1987: 290). It must also always be borne in mind that 'bone' and 'ivory' are not invariably distinguished correctly in the reporting particularly of inlays, personal ornaments, and seals.

Bone-tool manufacture was one of the primary craft traditions inherited by the earliest settled communities in Northern Mesopotamia from their predecessors. As Campana (1987) has shown, although the bone tool-kits of the Syro-Palestinian Natufian Culture and of the Zawi Chemian Culture of the Zagros are comparable (simple pointed implements of similar form fashioned on long bones), manufacturing techniques are different. In the west shaping was generally done with flints (shaving), in the east with abrasives (grinding). Shaving is the slower and produces well-shaped objects less easily; it may have been developed first for the manufacture of wooden tools. As shaving was used for other purposes in the Zagros and abrasion to produce personal ornaments in the Natufian, the techniques were apparently chosen ones.

The bone tool-kit of Zawi Chemi, c.10,000 BC, embraces various pointed implements and pointed fragments, with a number of tools made on long bones with the epiphysis as a handle, with broad spatulate tips, perhaps for wood or hide working. An elongated tool with flat section may have been used in basketry or weaving. Various small pin-like forms occur and bone hafts for chipped stone blades. As most implements are highly worked, the identity of the animal source and means of obtaining the bone blank is hard to establish. Grooving and splitting, twist-fracture, shattering, and perhaps heat-aided splitting are all evident. Shaping was by rubbing against abrasive stones of a moderate coarseness. Burin-like flint facets were used to cut grooves and to incise; hand-held borers cut perforations.

There is no study of the manufacturing techniques for later traditions nor is there a systematic study of any stage in the history of the use of bone for tools in Mesopotamia. Indeed, the recent publication of the late prehistoric bone tool repertory from Tell Gubba (Ii 1989: figs. 15, 30-2, pls. 51-3) is virtually unique for the attention paid to types and contexts. It serves to illustrate that, in terms of awls and other piercing tools, forms and manufacture had changed little from the pre-ceramic Neolithic. This and later sites indicate a recurrent *ad hoc* use of unmodified or only slightly modified animal bones as tools. Only the general repertory of manufactured bone may at present be described.

(i) TOOLS

The long bones, primarily of sheep and goats, but also at times of wild animals like gazelle and rabbit, were used for light or heavy duty awls, worked for the purpose in a variety of ways involving breaking, cutting, and polishing (cf. illustrations in Doyen 1986: 34-7). The techniques that had been developed by the end of the Palaeolithic had persisted through into historic times (cf. Jarmo: Watson 1983: figs. 143: 4 ff. and Matarrach: Braidwood, R. J. *et al.* 1952: 22-3; with Early Dynastic examples: Gibson (ed.) 1981: pl. 51: 13-14; Moorey 1978: microfiche 2: D07). Generally they were made by breaking a sheep or goat metapodial, then splitting one of the pieces lengthwise or cutting it obliquely some distance below the articulation. Normally the articular end served as the butt, whilst the other end was sharpened for use. Even more common and various were the slighter awls made from slivers of bone, abraded or whittled at one end to provide a point. They were given baked clay or bitumen handles (cf. Lloyd and Safar 1945: pl. X. 2; Mallowan 1935: pl. XIIa; Tobler 1950: pls. XCIXa: 1, XCVIIIb: 5; Perkins 1949: 85, 149; Woolley 1956: 191, pl. 15: U.18477). Less easily classified are a heterogeneous range of bone points and gouges. They, and awls, are intermittently reported through the historic periods at Nippur (McCown 1967: 101-2). In the absence of full publication it is not yet clear what tools were involved in Frankfort's remark about the third-millennium BC private houses at Tell Asmar, 'bone objects . . . must also have been in common household use, for they were found in great numbers'. This contrasts instructively with their general rarity in the many graves of the late prehistoric and Early Dynastic periods now published.

Bone *needles* are an equally ancient and persistent tool from the earliest villages (cf. Watson 1983: 351) through to the end of the prehistoric period at least (cf. Mackay 1931: 268, pl. LXXI: 1-7). Needles were among the earliest tools to appear in copper and copper alloys (as indeed were fine awls; cf. Tallon 1987: i. 192-3). The persistence of bone needles into historic times

is less easily traced; but it is likely that they remained current in view of the relative value of metal. As Woolley (1934: 310, pl. 231) appropriately observed, 'needles are rare, probably because they were out of place in a grave'; they are also amongst the most vulnerable of bone tools.

It is not easy to document the use of bone for *knives*, though Woolley (1956: 82) reported 'a knife or wand made from an ox rib, the end rounded, the blade flattened and roughly shaped', in a late prehistoric or Early Dynastic context. More enigmatically, in a very early level of the Hassuna period settlement at Yarim Tepe I, the excavators reported 'an ox shoulder blade with a system of incisions . . . possibly indicating some form of reckoning' (Merpert and Munchaev 1987: 15). Little exactitude may be brought to bear upon bone '*polishers*' and '*burnishers*', reported from time to time, in relation to pottery-making. No less obscure is the role of bone tools in textile manufacture, where they have traditionally been thought particularly appropriate. On the rare occasions when they have been published, the identity of bone *spindle-whorls* is usually clear (cf. Starr 1939: 488; 1937: pl. 127FF); but not so that of various *spatulae*.

Spatulae appear among the earliest bone tools, sometimes perforated at one end (cf. Shemshara: Mortensen 1970: fig. 49d) or elsewhere; they were usually made from rib bones. Their range of shape and size, and their survival into historic times, is intermittently evident (cf. McCown 1967: 107-8). This is one of the rare instances among bone tools where a distinctive form becomes recurrent at a later date. A group of *spatulae* with one rounded and one sharply pointed end emerged both in Syria (Doyen 1986: 47 ff.: 'lissors') and in Mesopotamia (cf. Reuther 1926: 32 ff., fig. 40: 'Knochenfedern'; Langdon 1924: pl. XXIX.1, centre; McCown 1967: pl. 154: 3) in the second quarter of the first millennium BC, and is still reported centuries later (cf. Huot *et al.* 1987: 177, pl. 43: 1). Their function has yet to be firmly established. Reuther (1926: 32-3) thought they might be 'forks' for eating; some have associated them with the appearance of linear scripts written on tablets with a point rather than a cut reed (cf. Moorey 1978: microfiche 1: C06); recently Doyen (1986: 49) associated their apparently sudden appearance and then widespread use with a role in the newly introduced manufacture of cotton, though in form they are neither closely related to the Roman *spatha* nor to a weaving comb. Beek (1990) has argued that their 'carefully smoothed and polished' form could be used to remove foreign matter from the eye.

Bone makes good *handles*, since it has a natural socket especially suitable for the tang of metal weapons and tools, or mirrors. It served this role from a very early date, long before the appearance of metal, though at present there are no bone handles from Mesopota-

mia to compare with the fine polished and carved sickle-handles of Natufian Palestine; local equivalents are less elegant (cf. Watson 1983: fig. 143: 1-3). In the Hassuna period at Tell Shemshara distinctive lancet-shaped handles in bone were split at each end on the underside to take chipped obsidian or flint blades (Mortensen 1970: 58, fig. 49a-c). Bone fittings appropriate for knife-handles or for the inlay plates of metal flange-hilted daggers and knives (cf. Moorey 1971: 74) are still rare in archaeological reports, but appear both in the second (cf. Starr 1939: 488; 1937: pl. 127EE) and the first millennium BC (cf. Koldewey 1914: 270, fig. 194). The handles of the earliest cylinder seals were at times carved in stone closely resembling in shape the distal end of a goat or sheep metapodial (cf. Boehmer and Dämmer 1985: 138, fig. 4), which would seem at times to have been used for the purpose.

Anatolian evidence suggests that bone might have been used in the manufacture of *cheekpieces for horsebits* before the general introduction of metal for the purpose in the second half of the second millennium BC; but actual examples have yet to be identified from Mesopotamian sites.

Bone *pegs* appear to have been used to secure door-locks, at least at Tepe Gawra (cf. Tobler 1950: pl. XCIXa), to judge by impressions of them recognized on the reverse of clay sealings (Matthews, R. J. 1989^a).

(ii) PERSONAL ORNAMENTS AND COSMETIC ARTICLES

The material evidence for bone *pins* is still surprisingly sporadic and unpredictable, with an unexpected revival of the fashion in the Sasanian period, possibly inspired by Roman fashion (cf. Kish: Moorey 1978: microfiche 3:G14). They appear in the earliest village settlements (cf. Watson 1983) and then intermittently in published reports through prehistoric times to the Uruk IV-III horizon, when they seem to have been in regular use (cf. Mackay 1931: 271, pl. LXXI: 8-12; Genouillac 1934: 62, pl. 34a-b, d-e). In the earlier third millennium at Telloh (*Girsu*) Genouillac (1936: 124) reported that 'l'os avait servi à faire des poinçons et d'épingles aux époques présargoniques. L'époque d'Ur III^e dyn. semble d'avoir gardé cet usage.' Here context has to be taken into account. Where pins appear in graves they are of metal; bone, if used, is not evident to any degree even in low-status graves; but in domestic contexts inadequate reporting may well conceal their true prevalence (cf. Woolley 1956: 66, pl. 15: U. 14484).

At Nuzi, a millennium later, 'bone pins are found, complete and fragmentary, in large numbers throughout all the buildings'. They included fine examples with zoomorphic terminals (Starr 1939: 486; 1937: pl. 127). Decorated bone pins may have been more evident at

this time at Assur than isolated published illustrations reveal (Haller 1954: 99, pl. 20c). At Nippur bone pins are intermittently reported from the later third millennium to the Neo-Babylonian period (McCown 1967: 100, pl. 152). It is difficult to assess the use of bone for combs (cf. Curtis 1983a, fig. 1), as 'ivory' combs attract more attention in reports (see below).

From the earliest village settlements, as is well illustrated at Jarmo (Watson 1983: 356-8), bone was used for *beads and pendants, rings and bracelets*; but is rarely reported in such roles in historic times. Again this may simply be a reflection of a concentration of excavation where high-status ornaments are more likely to have survived. Although occasionally reported as a material for *stamp seals*, bone was not appropriate for engraved cylinder seals. Bone *kohl-tubes and mirror-handles* are evident by at least the Achaemenid period (cf. Moorey 1980: 94-6).

(iii) INLAYS

Among the many mosaic inlays, characteristic of Early Dynastic II-III in Sumer, pieces of bone are the least common at most sites. A millennium later, from Rooms M78-9 of the palace at Nuzi, Starr (1939: 487) recovered 'several hundred complete and fragmentary pieces' of what he identified as bone inlay, cut in various plain geometric shapes. One piece was still in place in a wooden setting; another had a metal frame. As texts from Nuzi refer to ivory-inlaid furniture, this identification may require review (cf. from Tell Brak: Oates, D. 1987: 187-8, pl. 42d as 'ivory'). A bone plaque from Nuzi, in the 'House of Shilwi-teshub', was incised with a stylized tree (Starr 1939: 488; 1937: pl. 127R). A grave of the early Akkadian period at Nippur contained a wooden box with bone mosaics on its lid and sides, and bone tab handles (Gibson 1990: 5, figure).

(iv) RECREATIONAL OBJECTS

Bone has been used for gaming pieces since time immemorial, and 'knuckle bones', the natural bones, are recurrent in Mesopotamia (cf. Starr 1939: 488), as are imitations in other materials. Bone dice (cf. Woolley 1956: 44, fig. 7a: U.6551) may have been rarer than their baked clay counterparts.

The only *musical instruments* of bone so far identified are from the later prehistoric strata at Tepe Gawra (XVII-XII) (Tobler 1950: 215, pl. CLXXXII; Rashid 1984: 46-7). Seven bone pipes made from animal leg bones were recorded. Some are double, employing a natural bifurcation at one end of the bone. The three earliest are simply whistles, but the other four have stops bored in the upper side. It has been suggested that simpler bone tubes, usually with bell-shaped mouthpieces, may be successors to the pipes.

4. Wild Boar's Tusk

Both the upper and lower canine teeth of the wild boar develop into tusks. Male boars have the largest, ranging from 25.5 to 63.5 cm. for the upper tusks and from 16.5 to 19.0 cm. for the lower. This ivory is fairly dark tan in colour, contrasting with the mellow white of elephant ivory. Moreover, it more closely resembles bone and is more brittle and more easily chipped than ivory. The animal is represented in Mesopotamian art (Buren 1939: 79 ff.) and has always been a favourite, if dangerous, quarry for hunters (cf. Thesiger 1964: pls. 60-1). The proper separation of the various types of ivory (boar's tusk; elephant; hippopotamus) has not proceeded far enough in Mesopotamian archaeology for any accurate and detailed study of manufactured boar's tusk, particularly in the historic periods. Actual tusks are reported from the Northern Palace area of Tell Asmar (Delougaz 1967: 240, As.33.464, now in Baghdad) in the third millennium BC; from level IV at Billa (Old Babylonian; now in Philadelphia 31-54-433: Sheldon 1971: 42); and from a mid-first-millennium BC context at Babylon (Koldewey 1914: 271, fig. 194).

Only in the report of excavations at Tepe Gawra are a series of objects from late prehistoric and early historic levels described as boar's tusk, notably combs (Tobler 1950: 85-6, 93-5; pls. LIV, CV), a rosette bead (Tobler 1950: 88, 96, pl. CVI: 44), stamp seals (Tobler 1950: 86, 93, pl. CVI: 39; Speiser 1935: 123, no. 25, pl. 57, fig. 25), and pins (Tobler 1950: 86, 93, pl. CV: 29; Speiser 1935: 116, 208, pl. 82, fig. 15) and a plaque (Speiser 1935: 123, no. 29, pl. 55a). Reese (1985: 396) has argued that the comb from tomb 34 (stratum IX) 'is much too big to be from a boar', suggesting that it was made from a hippopotamus lower canine (cf. Tobler 1950: 86, pl. LIVb, CV.27).

5. Hippopotamus Ivory

It has long been assumed that the majority, if not all, of the ivory artefacts reported from sites in Mesopotamia were made from the tusks of elephants. This is by no means to be taken for granted, as has already been indicated in considering wild boar's tusk. Caubet and Poplin (1987) have now shown that a much higher percentage of Syrian Bronze Age ivory objects were manufactured from hippopotamus (*amphibius*) ivory than had previously been appreciated. In contrast, it appears that hippopotamus ivory is virtually absent from the increasing number of surviving carved ivories of the Iron Age attributed to workshops in Phoenicia and Syria, perhaps because the hippopotamus population was by then in decline. This means that much greater caution is now required with the assessment of the

corpus of 'ivory' objects, not yet subject to expert distinction between hippopotamus and elephant ivory, reported from Mesopotamian sites (cf. Krzyszkowska 1990).

Hippopotamus canines and incisors grow continually and are larger in the male animal. They are the hardest of all teeth used as ivory. The largest normal lower canine on record was 64.5 cm. long. They generally reach 50 cm., but malformed ones can reach to over a metre in length. Hippopotamus ivory is harder, whiter, and denser than that of the elephant and has always been much prized for its whiteness (Penniman 1952: 23, pls. VI, XX). As it is difficult to work on account of the surface enamel, the curvature of the tooth, and its central cavity, it is likely to have been preferred only where readily available and already well-known to local craftsmen (cf. Caubet and Poplin 1987: 299-300).

The osteological, art-historical, and textual evidence for the presence of the hippopotamus in Egypt, Syro-Palestine, and Cyprus has recently been re-examined (Caubet and Poplin 1987: 292; Reese 1985; forthcoming). The presence of the hippopotamus in Egypt until the nineteenth century AD is well established. It was at home in the coastal region of Palestine into the Iron Age. Bones from such sites as Ras Shamra (Ugarit) and Tell Soukas indicate a similar situation further north on suitable stretches of the Syrian coastal region, where again it probably survived into the Iron Age. The hippopotamus remains from Cyprus are thought to have come from either Egypt or the Syro-Palestinian coast for local manufacture or votive deposit there in the Late Bronze Age. The hippopotamus does not appear to be represented outside Egypt on any objects of Near Eastern origin that may be regarded as wholly independent of an Egyptian connection, nor has a term for it yet been confidently recognized in Akkadian or Hebrew or cognate languages (cf. Caubet and Poplin 1987: 294-5 nn. 22-3).

There is no evidence for the existence of the animal in Mesopotamia, nor does it appear to have been represented in local art. If, and when, hippopotamus ivory was used in Mesopotamia it would have been imported raw or as ready-made artefacts from the west. Apart from a comb in the late prehistoric tomb 34 at Tepe Gawra (see above), only some of the ivory artefacts from Tell Brak of types conventionally made of hippopotamus ivory in Late Bronze Age Syria may at present be tentatively cited as examples of hippopotamus ivory objects from a site in Mesopotamia (Oates, D. 1987: 187-8, pl. XLII; cf. Caubet and Poplin 1987: 279 ff.). The movement of unworked hippopotamus ivory is illustrated by pieces from the wreck at Ulu Burun off the coast of Turkey (Bass *et al.* 1989: 11, fig. 20) probably in the late fourteenth century BC.

It is increasingly clear that hippopotamus ivory was the preferred choice for utility purposes, despite the

difficulties of working it, in the Levant for over five hundred years in the second millennium BC, from the Middle Bronze Age ivories of Acemhöyük and Kültepe to the Late Bronze Age examples from Kamid el-Loz, Megiddo, and Ugarit (cf. Caubet 1991^b). If there really were herds of elephants in Syria at this time, as has long been supposed (see below), this pattern of use is perhaps surprising. Elephant ivory was certainly used at this time in palace workshops for larger and more luxurious ivory-work; but more of the ivory may still have been coming from India or Africa than has previously been supposed.

6. Elephant Ivory

True ivory comes only from elephants. The tusks are incisors, not canines, from the upper jaw. In adult animals they consist entirely of ivory; in the young there is a little enamel at the tip. Owen long ago provided the classic description of the distinctive structure of elephant ivory: 'transverse sections or fractures shew lines of different colours or *striae* proceeding in the arc of a circle, and forming by their decussations minute curvilinear lozenge-shaped spaces' (cited in Penniman 1952: 13). The pores, when fresh, contain an oily substance which not only facilitates carving, but also contributes to the familiar transparent polish of worked ivory. In some cultures, as in ancient Greece (Pausanias, v. xi. 10), ivory is oiled to maintain this quality.

Inside an elephant's tusk there is a pulp cavity, almost as wide as the tusk at its base, but diminishing to a point about half-way up. From this to the tip of the tusk runs a nerve canal appearing as a minute hole in section. The structure of the tusk is of vital importance for appreciating that often less than 60 per cent of its volume offers ivory of good quality. The material closest to the pulp cavity is relatively soft, as it is the newest growth, whilst that furthest away is the oldest and most friable (the 'husk'). It is the zone in between which yields the best-quality ivory.

The two living survivors of the richly diversified order of mammals to which the elephant belongs are the elephant of Asia, usually known as the *Indian* (*Elephas maximus*), and the elephant of *Africa* (*Loxodonta africana*). They are separately derived from a common ancestor who existed in the Quaternary (Scullard 1974; Barnett 1982). In both species the tusks are usually carried by the bull; those of the female being smaller and sometimes entirely absent. The tusks differ in shape and texture, the African being generally larger and more curved than the Asian. In ancient art the key features for establishing the difference of species are the profile of the back, slightly humped or convex and rising higher than the shoulder on the Asian, whereas the African is slightly convex ('sway-backed'); and the

ears, those of the African being huge, covering much of the shoulder, whilst those of the Asian are one-third the size, covering only the sides of the neck and being markedly triangular in shape. The form of the head, if well rendered, may also be indicative, as on the Asian it is high and domed, on the African flat and sloping. Experts are able to distinguish African from Asian ivory on the tusk, especially when fresh; but when the ivory has been manufactured and long buried, often in harsh conditions, separation is an unresolved problem (Herrmann 1986: 55). An elephant tusk from level IIA at Mehrgarh in Pakistan, c.5500 BC, grooved by artisans, is the earliest evidence for the working of an Asian elephant's tusks (Jarrige 1984: 24). A seal and a gaming piece of elephant ivory from Mundigak (III) in Afghanistan, c.3000 BC, are the earliest ivory artefacts so far discovered outside India (Jarrige and Tosi 1981: 39).

The African elephant was not present in Western Asia and by the middle of the third millennium BC no longer inhabited Egypt, though present in a number of accessible parts of North Africa. The Asian elephant was known in Western Asia in antiquity, where it became extinct some time in the second quarter of the first millennium BC. It now occurs in parts of India, in Sri Lanka, and in south-east Asia. The evidence for the existence of native elephants in Iran in antiquity is tendentious and unconvincing (cf. Barnett 1982: 7 n. 44). The so-called Syrian elephant presents special problems discussed below.

(i) SOURCES OF IVORY FOR MESOPOTAMIA

Before surveying the sources of ivory open to craftsmen in Mesopotamia at various times, it is worth recalling that in historical times the rule of easiest access has not always been the determining factor. The harder and more delicately grained African ivory has appealed so much more to craftsmen than the Asian that they have been prepared to pay more to get it.

African ivory was available to Mesopotamia through her western neighbours. In the first millennium BC, when the Phoenicians were in contact with the more distant coasts of North Africa, with the Egyptian delta, and with islands like Cyprus and Rhodes, through which ivory was transhipped, ivory from the African elephant reached deep into the Near East. At least some of the carved ivory fragments from Samaria have been identified as African elephant ivory (Crowfoot and Crowfoot 1938: 55) and 'some of the Nimrud ivories must be from African tusks on account of the size of their original diameters' (Barnett 1957: 168). African ivory was also available to Phoenicia, if only sporadically, through contacts with *Ophir* down the Red Sea (1 Kgs. 9: 26–8, 10: 11, 12 = Chron. 8: 17–18, 9: 10, 21). This region is not certainly located, but

was probably not in India, but rather in Somaliland (with possible extension to the neighbouring coast of southern Arabia), in much the same area as the *Punt* of Egyptian texts (Barnett 1982: 9 n. 4, 47). Although the exact location of *Tarshish* in the Mediterranean area is also uncertain, the ivory brought thence to Solomon in Phoenician ships would also have been from the African elephant (2 Chron. 9: 21). It is likely that the elephant hides which Hezekiah of Judah sent to Sennacherib in 701 BC had been imported from Africa (Oppenheim 1969: 288). The situation before 1000 BC is less clear. Whenever ivory is recorded as reaching Mesopotamia from the west there is always the chance it was African in origin, despite the existence of the 'Syrian' elephant until about 700 BC. There are indications, for instance, that in the Kassite period the source of Assyro-Babylonian ivory had shifted from the Indian subcontinent to Africa (Leemans 1960: 37), but this will remain difficult to document in detail (cf. Gubel 1987: 20–4 on sources of ivory).

'*Syrian*' ivory cannot be considered without some reference to the problem of the elephant so designated. As there is textual, artistic, and isolated osteological evidence for elephants in Syria well into the first millennium BC, some scholars write of the 'Syrian' elephant as a distinct indigenous subspecies of the Asian (Indian) elephant. Deraniyagala (1955) christened the beast *Elephas maximus asurus* Deraniyagala; a terminology adopted by Barnett (1957: 164–7) and Mallowan (1966: 484). In commenting on the elephant tusks found in the Middle Bronze Age Palace (level VII) at Tell Atchana, Deraniyagala reported that they show 'a flattened plane of wear at the apex which is the usual condition in *E. maximus*, whereas in *Loxodonta africana* the apex is usually conical' (Deraniyagala 1955: 116, pl. 45:1). Although the term 'Syrian' elephant may be appropriate in a geographical sense, describing a habitat between the plain of Jabbul and the Khabur basin, its physical validity is less secure, since there is no hard evidence that the elephants of Syria differed in race from those of India, even if there were minor variants (Scullard 1974: 29–30).

It has been argued that the 'Syrian' elephants had not been in Syria since the migration of the Indian elephant from Africa in the Pleistocene, but had been subsequently reintroduced as a stocked herd, artificially transplanted from somewhere to the East (Winter 1973: 266–7). Although it is recorded that Seleucus I (312–292 BC) brought elephants from India to graze in the Apamea region of Syria (Strabo, *Geography*, xvi. ii. 10; Scullard 1974: 97 ff., n. 46), there is no indication that he bred from them. Winter (1973) particularly has argued that the absence of ivory in the first quarter of the second millennium BC as a recorded commodity in trade across Syria, and down the Euphrates, when it was certainly being traded up the Gulf from the Indian

subcontinent (Ratnagar 1981: 111), may indicate the absence of the elephant from Syria at that time. If this were so, it would have been introduced some time in the middle of the millennium, since it first appears in Egyptian records of the earlier XVIIIth Dynasty (see below). Against the trade argument must be weighed evidence for an ivory industry in Anatolia in the 'Assyrian Colony Period' (c.2000–1750 BC) (Barnett 1982: 32 ff.; including a sawn tusk section at Acemhöyük); carved ivory in Middle Bronze Age 'royal' tombs at Ebla (Matthiae 1979: figs. 69 ff.); and carved ivories in Palestine and Jordan at this time (Barnett 1982), even if some of it is hippopotamus ivory.

Zoologists (personal communication) find the concept of a relict population much more plausible. They regard successful breeding of an imported herd far less probable than the survival of a relatively small community of Indian elephants in an appropriate ecological niche, remote from human contact. Elephants live on the boundary between forest and grassland, requiring a diet of grasses, bark, and tender branches (Miller: 1986). The slow deterioration of the natural environment, perhaps through increasing aridity and deforestation, and increasing pressure from human predators after 1500 BC, had eliminated this elephant community by the later Neo-Assyrian period. Collon's (1977) argument for a reintroduction of the animal soon thereafter has to face not only the same practical objections as Winter's case, but also the absence of any hard evidence in its favour. The inscription on the ninth-century Rassam Obelisk refers to 'a herd of town-bred elephants' among tribute from the west (Reade 1980: 18–19).

In the sixteenth and fifteenth centuries BC both Tuthmosis I and Tuthmosis III and one of the latter's generals recorded hunting elephants in Syria, perhaps near Apamea (Caubet and Poplin 1987: 298). Soon thereafter, in a Syrian tribute scene painted on the walls of the tomb of the vizier Rekhmire at Thebes, a very large pair of elephant tusks and a small elephant more akin to the modern Indian than to the African elephant, with tusks fully grown, are depicted (Davies 1935: pl. XII). It has been suggested that this indicates the survival of a dwarf elephant; but it seems more likely that it was as babies that elephants were given as gifts and that the tusks were a conceptual feature inserted by the Egyptian artist (Winter 1973: 264).

Tiglath-Pileser I (c.1114–1076 BC) and other Assyrian kings down to Shalmaneser III (c.858–824 BC) refer to the hunting and killing of elephants in the Khabur region of modern Syria and on the Euphrates in the area of modern Ana in Iraq, and to their trapping for royal zoos (Barnett 1957: 166; Mallowan 1966: 479; Collon 1977: 220). After this the Assyrian records refer only to elephant tusks, hides, and to ivory furniture. From Bit-Adini, east of Carchemish, across the Euphrates, Assurnasirpal II (c.883–859 BC) took 'an ivory

dish, ivory couches, ivory chests, ivory thrones' (Grayson 1976: 141). Shamshi-Adad V (c.823–811 BC) recorded a throne of ivory; Adad-nirari III (c.810–783 BC) ivory beds and stools and ivory overlaid with gold and incrustated (Mallowan 1966: 479). Mallowan (ibid.) believed that some of the ivories found in Fort Shalmaneser at Nimrud were part of Sargon's booty, taken on his Urartian campaigns; one ivory label was inscribed with the name of the city of Hamath in Syria.

Elephant hides and tusks came to Shalmaneser III from the Chaldaean tribes of Babylonia (Luckenbill 1926: 625); to Tiglath-Pileser III with tribute from city-states in south-east Turkey: Kummukh (Commagene), Que (Cilicia), Carchemish and Gurgum (Marash area), and Tyre in Phoenicia (Luckenbill 1926: 772). Tusks were part of the joint contribution of Egypt and the Arabs of the coast and steppe to Sargon II (Luckenbill 1927: 18); whilst tusks and hides came from Judah to Sennacherib and from Sidon to Esarhaddon (Luckenbill 1927: 240, 527). Some scholars have tried to use this evidence to plot a quantitative decline; but scattered allusions of this kind will hardly bear the weight of such interpretations. They do little more than indicate that various factors, including a combination of human exploitation and deforestation, had eliminated the elephant from Syria before the end of the Neo-Assyrian period (cf. Miller, R. 1986; cf. Caubet and Poplin 1987: 300–1).

Representations of the elephant in Syro-Palestine are rare. The animal is shown on a cylinder seal and on a pottery cult object from Bethshan in the Late Bronze Age (Rowe 1930: 22, pl. 36; 1940: 57, 88, pl. 44A, 1, 2). A fragmentary elephant-shaped model or vessel was found at Sinjirli in Hilani I, a building probably destroyed in the reign of Esarhaddon (c.680–669 BC) (Andrae 1943: 68, figs. 80–1, pl. 35a, b). Only part of the head with the small ear of the Indian species, trunk, and one foot survive, with the foot of its driver.

The osteological evidence is scattered and has been scantily published. Elephant remains from Late Bronze Age contexts have been tabulated by Caubet and Poplin (1987: 297 ff.). Limb and foot bones and vertebrae of elephant have been reported from Early Bronze Age silos at Ras Shamra (Ugarit); but the published references are not explicit (Schaeffer 1962: XXIX, 230, 233). A limb bone was found at el-Qitar in 1985 (McClellan 1986: 435–6), and another sawn elephant limb bone is reported at Munbaqa (Boessneck and Driesch 1986: 150), both in Middle to Late Bronze Age contexts. Lower jaws or femurs were recorded in the Late Bronze Age levels IV and II at Tell Atchana (Woolley 1955: 288; Barnett 1957: 164–5 n. 4). A tooth is reported from Sinjirli (Barnett 1982: 88 n. 73) and Chatal Hüyük in the Amuq yielded a humerus proximal end (D. Reese: personal communication). From Bronze Age Kamid el-Loz Bökönyi (1990: 71–2) reported a small

rib fragment and a sawn right proximal femur fragment of an immature animal. A right molar and four fragments of adult pelvis, cut and sawn, are reported from Arslantepe (D. Reese: personal communication).

Tusks are more common, but they may well illustrate no more than a commerce in ivory. They have been reported at Chagar Bazar, and at Tell Atchana (level VII) in the Middle Bronze Age, at Megiddo and Ras Shamra in the Late Bronze Age (Barnett 1982: 88).

The Late Bronze Age Ulu Burun shipwreck also yielded a section of elephant tusk, 20.1 cm. long (Bass 1986: 282–3, pl. 18). Collon (1977: 222) reported that 'two of the actual tusks [from Atchana] are still preserved in the Antakya Museum, however, and they measure 1 m 60 cm in length. An elephant with tusks this length must have been a sizeable beast, and indeed this is the average length for the Indian elephant'. The elephant tusks reported from Iron Age levels at al Mina are in fact the horn cores of large domesticated bovids (Francis and Vickers 1983).

A palette of 'elephant' ivory and a stamp seal, perhaps in ivory, said to represent an elephant's foot, are reported from Tell Judaiah in the Amuq Plain in the late sixth to fifth millennium BC (Braidwood, R. J., *et al.* 1960: 133, figs. 101:4, 103:5). If these are of elephant and not of boar's tusk or hippopotamus ivory, they are among the oldest artefacts made from the ivory of local elephants.

The contribution of the Asian elephants in the Indian subcontinent to Mesopotamian ivory supplies is rarely explicit. It is possible that a reference in *The Curse of Agade* to various exotic animals, including elephants, in the public squares of Agade indicates the arrival of the animals themselves in the Ur III period, perhaps from *Meluhha* (Cooper 1983: 50–1). At this time (c.2150–2000 BC) ivory from *Meluhha* is only mentioned in connection with ivory bird figurines (Oppenheim 1954: 11, 15 n. 24). Otherwise in the body of texts from Ur dating to about 2000 BC ivory is attributed to *Dilmun* (Bahrein), whither it had presumably been shipped up the Gulf from the Indus, where ivory was plentiful on sites of the Harappan period, both as tusks and as objects (Ratnagar 1981: 113). Texts of the Isin-Larsa period (c.2000–1800 BC) from Ur refer to rods, combs, inlays, boxes, spoons, and 'breastplates' of ivory donated to temples by merchants returning from *Dilmun* (Oppenheim 1954: 6–12; Ratnagar 1981: 111 ff.). It is probable that at the time when south Mesopotamia was in contact with the Indus by sea, directly or indirectly, from the middle of the third millennium BC to about 1700 BC, ivory was regularly traded. The same pattern of use is recurrent for those periods in Mesopotamia when there is material evidence for ivory: cosmetic items, sheaths for knives or razors, inlays, figurines, and personal ornaments.

After the middle of the second millennium BC very

little ivory may have been reaching Babylonia from the Indus region. The trade only opened up again in the Achaemenid period. Caution, however, is necessary since Babylon is one of the few places mentioned by Assyrian kings as supplying them not only with ivory but also with tusks in the ninth century BC (Luckenbill 1926: 625 (Shalmaneser III)). However, such ivory might have come from African sources through Babylonian contacts with Arabia. Records of Neo-Assyrian booty from *Dilmun* (Oppenheim 1954: 17) do not include ivory.

(ii) THE ELEPHANT IN MESOPOTAMIA

A single leg bone of an elephant was found in a context (C 35) of the earlier fourteenth century BC at Nuzi (Starr 1939: 493; 1937: pl. 28C) and a large right thigh bone was attributed to the time of the First Dynasty of Babylon, in the second quarter of the second millennium BC, at Babylon (Koldewey 1914: 271; Reuther 1926: 10, fig. 4). Both tusks and bones ('sawn elephant skeleton') have been reported from Haft Tepe in Khuzistan, dated to the fourteenth century BC (Collon 1977: 222 n. 25; Negahban 1991: 18, pl. 14B). The Geology Museum, University of Copenhagen, has a tusk from the Danish excavations on the island of Failaka in the Bay of Kuwait (D. Reese: personal communication). At Nimrud, in Room T.10 of Fort Shalmaneser, Mallowan reported the presence of 'the long bones of an elephant' together with burnt wood and carved ivories (Mallowan 1966: 451). Layard (1853: 195) found tusks in the North-West Palace at Nimrud, whilst Mallowan calls attention to a tablet he recovered from room ZT 4 of the same palace, of the later eighth century BC, referring to nine ivory tusks in store, presumably at Nimrud (Mallowan 1966: 483). In all cases the bones are assumed to be from elephants of the Asian species; the tusks indicate no more than commerce and may not be so simply attributed.

Representations of the elephant in Mesopotamia are very rare. Some dubious claims need first to be eliminated. There is no elephant on a late prehistoric cylinder seal in the Brett collection (as Muscarella (ed.) 1974: no. 104); the animal in question is horned and the original catalogue entry indicates that the supposed 'trunk' is a flaw or miscutting (Frankfort 1939a: pl. 6c). A tiny lapis amulet from Kish, of uncertain date, described as 'deux petits elephants . . . accostés tête à queue', is impossible to recognize in the published illustration (Genouillac 1925: 25, pl. XVII, fig. 4b). The relevance of a calcite elephant-shaped amulet in the Schimmel Collection is equivocal, since it is of unknown origin and date, though it has been attributed to the prehistoric period (Muscarella (ed.) 1974: 104; cf. Barnett 1982: 5–6, pl. 1e).

The earliest certain representations of the beast are

on objects datable to the third millennium, though they were not necessarily made in Mesopotamia. A tiny, fragmentary stone vase, said to have been bought in Mosul, is carved with three elephants in frieze, heads shown frontally (Böhl 1937: 8: 463, pl. XXXVIII, fig. 13). The style is hard to localize, as it may not be directly matched among carved stone vessels of the Early Dynastic period in Mesopotamia. A glazed steatite cylinder seal from Tell Asmar shows an elephant with a rhinoceros and a crocodile (Frankfort 1939a: pl. 61: 642). Although cylinder seals were not used in the Indus Valley civilization, the material and style of the seal suggests manufacture in an intermediary region. A related cylinder seal, once in the de Clercq Collection, also shows an elephant, but again in a hybrid style of uncertain affiliation (Clercq and Menant 1888: i, no. 86). At least one stamp seal of the distinctive 'Gulf' type is carved with an elephant (Louvre AO 26502: Barnett 1982: 5, pl. I, c, d). The earliest definitely local artefact showing an elephant is a simple baked clay plaque of the earlier second millennium BC from Ur (Woolley 1976: pl. 91, fig. 250). It is ridden by a driver. Brentjes (1961: 18: pl. on p. 21, lower) has identified elephants on seals of the Karum Kanesh (Kultepe II), c.1900 BC, in Anatolia; but the beast in question is best described as 'of uncertain identity'. Beran (1957: 163) has identified an elephant on a 'Middle Assyrian' seal, but the seal is in poor condition and the animal is difficult to see.

Virtually the only other local illustration is the elephant on the 'Black Obelisk' of Shalmaneser III (c.858–824 BC) from Nimrud (Barnett 1982: pl. 1b). This is a beast of the Asian species said in the accompanying inscription to be from *Musri*, often identified with Egypt. The alternative, a location to the north or north-east of Nineveh, seems much more likely in this instance (cf. Nashef 1982: 198–9), though it need have nothing to do with the ultimate origin of this particular animal. A terracotta elephant figurine, with traces of a rider, from the pioneer excavations at Nippur, is unlikely to be earlier than the Seleucid period (Buren 1930: no. 814, pl. 46, fig. 220).

(iii) THE REPERTORY OF IVORY OBJECTS IN MESOPOTAMIA

The earliest ivory objects reported from excavations in Mesopotamia may be of boar's tusk, hippopotamus, or elephant ivory, so may not be used, until properly identified, as the base for deductions about the latter's presence or absence. An 'ivory' bead has been reported from an aceramic Neolithic settlement at Qermes Dere, near Tel Afar, in northern Iraq c.8000 BC (= Mureybit II–III) (Watkins and Baird 1987: 12). An 'ivory' mace-head was found in levels attributed to the Ubaid period at Tell eth-Thalathat (Egami 1959: pl. LXXVII. 5). In

publishing the combs from Tepe Gawra in strata X–VIII, of the second half of the fourth millennium BC, Tobler commented that ‘at least four combs were made of ivory which, to judge by appearance and size, was obtained from boar’s tusk’. If this is correct, it is probable that the ‘ivory’ used for beads and hairpins, as also occasionally for amulets and seals at Tepe Gawra (Tobler 1950: 85 ff., 192 ff.) in the later prehistoric period, need not imply the use of hippopotamus or elephant ivory in Mesopotamia before an advanced date. As Sheldon (1971: 199) pointed out, a hair-ornament and a stamp seal published from Gawra as ivory are in fact made of bone (see Tobler 1950: 86, 93, pl. 105, fig. 30; Speiser 1935: 122, no. 14, pl. 56: 14). ‘Ivory’ is listed amongst the materials used for beads at Uruk in the late prehistoric period (Limper 1988: 111).

Sheldon (1971) and Dolce (1978) have shown that great caution is needed in using publications of the inlays favoured by Sumerian craftsmen of the Early Dynastic II/III periods (c. 2700–2350 BC). Bone, ivory, limestone, and shell were variously used and have not always been correctly distinguished in excavation reports. Details were rendered in incised lines, which could be filled with dark or coloured materials to provide contrasts. Ivory, it now seems, was used more rarely than the literature might suggest, particularly at Mari (cf. Sheldon 1971: 13 ff., 103 ff.; Dolce 1978: M. 307, 350, 393). An unknown number of inlays from Mari published as ivory are in fact of shell, including the distinctive butchering scene (cf. Barnett 1982: pl. 34a–c). Similarly at Adab (Bismaya) the inlays published as ivory have to be reduced in number to remove examples of shell and stone (cf. Sheldon 1971: 200; Banks 1912: 272–4: a shell rosette; shell and stone fish; small felines of stone; stone cow-eyes). Isolated ivory examples remain at Adab, as at Susa (Dolce 1978: A:2,5; ?E.3).

One of the royal tombs at Ur (RT 789) contained two small ivory bull’s legs, perhaps from a personal ornament of some kind (Woolley 1934: 439). Examples of ivory combs are sufficiently distributed, at sites like Tell Asmar, Kish, Tepe Gawra, and Ur, to indicate that they were one of the commoner uses for this luxury material (Delougaz 1967: 247; Speiser 1935: 116–17; Mackay 1925: 135, pl. XXXIX.8, pl. LIX.6; Moorey 1970: 127–8; Watelin 1934: 50–1; Woolley 1934: 471, 489). It is also likely that pins in richer graves were more often of ivory than excavation reports at present suggest (cf. Assur: Andrae 1922: 56 ff.; Gawra: Speiser 1935: 116–17; Ratnagar 1981: 112 n. 24). At Kish, in Cemetery A, ivory was used for a dagger-handle (Mackay 1929: 135, pl. XXXIX.8).

Ivory statuettes of nude females appear in various Early Dynastic and Akkadian contexts. At Mari two were included in the misleadingly named ‘Treasure of Ur’ in Early Dynastic III (Parrot 1968: pls. VI–VIII).

They are paralleled, in the Akkadian period, at Assur, at Tell Brak, and at Tell Wilayah, though this example has been described as ‘wood’ (Andrae 1922: 56 ff., pl. 29; Oates, D. 1982: 195, pl. XI; Madhloom 1960: pl. 7). An Early Dynastic III text lists an ivory figurine among gifts from the queen of Adab to the wife of Lugalanda, prince of Lagash; another text in the same series refers to unworked ivory (Lambert, M. 1953: 58).

An isolated example of the use of elephant ivory in furniture manufacture in Early Dynastic III was recovered from Tell al-Ubaid in the temple debris: ‘part of a rounded bar of elephant ivory cased in copper. Largest fragment 2 in (5.2 cm) high; D. 1 7/8 in. (4.8 cm.). Probably the copper-shod foot of the ivory leg of a chair’ (Hall and Woolley 1927: 39). Remains of a complex piece of ivory furniture, carved in a characteristically Sumerian style, were retrieved from a grave of the Early Akkadian period at Kish (no. 317: Moorey 1970: 102, 127, pl. XVIII; 1978: 72–3, fiche 4:5A). Watelin described it as ‘consisting of two small bearded human-headed bulls . . . mounted standing parallel on a pedestal supported by wheels . . . only one of the bulls could be preserved’ (Watelin 1934: 50). The best-preserved bull (7.5 cm. long; 5.5 cm. high as extant) has a deep rectangular socket in its neck; the upper neck is pierced with a tiny hole and the back of the head is cut back to form a small ledge. One pedestal survives with only three hoofs represented as standing on it. In addition there is the left shoulder and much of the body of another bull, much of the right shoulder of a bull which does not belong with the previous piece, part of the left shoulder and body of yet another bull (for there seems to be no connection with either of the previous animals), and a rather battered head with a bearded human face exactly as on the best-preserved animal. There seems little doubt there were originally four beasts, certainly three. Though very damaged, the fragments of platforms may be restored to make a second complete one and two very damaged ones. Where it is possible to tell, only three hoofs stood flush with the top of each platform. Certain fragments provide a clue to the destination of the fourth hoof. It seems that the front knee, probably the right in two cases, the left in two cases, was bent, as on two surviving examples, and the hoof set on foliage rising from the platform. One hoof resting on a fragment of foliage and one fragment of a platform with painted foliage and dismembered leaves suggest that at least parts of the animals’ bodies were similarly painted. The original assembly of these animals may be not reconstructed; but they illustrate the use of ivory for elaborate, if relatively small, pieces of furniture in the Akkadian period, manufactured locally.

The head of a female statuette reported from the cult room of the Ishtar Temple in level G at Assur is of stone not ivory (cf. Sheldon 1971: 201; Andrae 1922:

57, no. 65, fig. 47, pl. 29, k, 1). When found, the striking stone head of a man from Bismaya, usually attributed to the Akkadian period (Frankfort 1943: pls. LXVIII–LXIX), was originally reported to have had ‘eyeballs of ivory’ (Banks 1912: 257). A Sumerian text, of the Akkadian period, from Telloh (RTC 221: Sheldon 1971: 180) lists two pieces of ivory with their dimensions: one is 2 cubits (60 inches) long and 5 fingers (inches) wide; the other is 1 cubit (30 inches) long and 6 fingers (inches) wide. This is particularly valuable in indicating the import of raw elephant ivory (from the size) at the time.

Although sparse, the evidence for worked elephant ivory in Mesopotamia between about 2650 BC and 2100 BC is various enough to indicate that use of this material was by then established in royal and temple workshops. It is not clear whether the raw material came from Asian elephants in Syria shipped down the Euphrates to cities like Mari or whether import of elephant ivory up the Gulf from the Indian subcontinent, documented only from the Ur III period, had already begun by Early Dynastic III.

One isolated and relatively coherent group of ivory objects from Syro-Palestine is relevant to this enquiry, since some scholars have suggested they are of Mesopotamian origin. Four small ivory bulls’ heads, perhaps furniture fittings, have been found on Early Bronze Age sites in Israel. One has been dated as early as Early Bronze IIB (c. 2900–2700 BC), the others to Early Bronze III. Two are from Ay, where an ivory comb was also found, and there is one each from Jericho and Beth-Yerah (Khirbet-Kerak) (Bar-Adon 1962; Ben-Tor 1972; Callaway 1974; Cleveland 1961). The later ones to some extent resemble a small stone bull’s head, of local style, from the ‘Shara Temple’ at Tell Agrab in the Diyala Region of Mesopotamia; indeed, they are more like it than they are like any Syro-Palestinian artefact of the time (cf. Frankfort 1943: pl. 52:302). As there are local stone bulls’ heads from Early Bronze contexts in Palestine, the case for a Mesopotamian origin for these ivory examples remains unproven (cf. Ben-Tor 1972: 27–8). Ivories from the Levantine coastal region at this time, as at Byblos, are more readily linked stylistically with Egypt. As at least two of these bulls’ heads are of hippopotamus ivory, manufacture in the Levant seems most likely (Jericho/Beth-Yerah; Tally Ornan: personal communication).

Oppenheim (1954: 11), in comparing references to ivory in texts from Ur of the Ur III period written in Sumerian and of the Isin-Larsa period written in Akkadian, noted a marked difference. In the Ur III texts ivory was manufactured locally into small animal and human figurines, small round objects (‘apples’) and the feet of chair-legs (claws or hoofs). One Ur III text refers to a tusk of 38 manas in weight from *Magan* (Legrain 1947: no. 751). In the later texts ivory as a

raw material, as well as ivory artefacts, were listed as imports from *Dilmun* (Bahrein). Among the imported objects were ivory combs, ‘breast plates’, boxes, inlaid furniture, and spoons. Ratnagar (1981: 116) has shown that these combs, boxes, and inlays have counterparts on Harappan sites, though at present there are only isolated reflections of typical Harappan patterns on the ivory combs found in Mesopotamia. None may confidently be identified as an import. Nor have the listed ivory ‘bird figurines’ yet been found either in Mesopotamian or Harappan sites, whilst the ‘breast plates’ remain enigmatic. Ivory objects have been excavated on Bahrein, as have unworked fragments of ivory (Ratnagar 1981: 113; cf. Reade and Burleigh 1978). Their dating is often uncertain and not all are fully published; but they suffice to show that objects of ivory made on Bahrein, as well as others produced beyond the Gulf, might have been imported into Mesopotamia, c. 2500 and 1700 BC.

In 1954 Oppenheim summarized the documentary situation for Babylonia in the following millennium or so, both in respect of the textual and the material evidence:

no ivory objects are, to my knowledge, mentioned in the economic and administrative texts of the Old Babylonian period (later than those of *U.E.T.V*) nor, as a matter of fact, in those of the Middle- and Neo-Babylonian. Even the royal inscriptions of the Chaldaean kings, with their glowing reports of the sumptuous decorations of the palaces and sanctuaries, mention ivory only very rarely and in a way that shows it was available only in small pieces. It stands to reason that Southern Mesopotamia remained outside of that large area in which—during the second half of the 2nd and of the first half of the 1st millennium BC—the use of ivory spread from Egypt and Syria.

(Oppenheim 1954: 11–12)

At Ur in the period from about 2100 to 1750 BC the archaeological evidence for ivory is singularly meagre, embracing only an ivory rod and supposedly a box-lid, but it is certainly later in date (Woolley 1974: 101: U.16294; 50, 99, U.7903; but cf. Woolley 1962: 115). A fragment of the torso of a male statuette dedicated to Inanna was found at Nippur in the Inanna Temple (level IV; cf. Sheldon 1971: 40, no. 43; Ratnagar 1981: 112). At Mari ivory is sporadically referred to in documents (Dalley 1984: 62). Simple artefacts were found at Tell Asmar (Ratnagar 1981: 112 n. 24) as well as textual evidence for the presence of an ‘ivory throne . . . which is inlaid with gold’ for the local deity and a pair of ‘ivory *dibba*-doors’ for his temple; presumably these were ivory panels set into a wooden framework (Frankfort *et al.* 1940: 160, 190). Incrustation on a wooden door in the palace at Mari is identified as bone rather than ivory (Parrot 1958^a: 268–70, figs. 322–3). At Susa, although sometimes incorrectly identified (cf. Sheldon 1971: 202), ivory is mentioned at this time

in a text (Scheil 1932: no. 310). It is now evident that a headless statuette of a woman (Amiet 1966: 217) is shell not ivory.

Outside Mesopotamia in the earlier second millennium BC there is increasing evidence for ivory carving in a number of palace workshops in Anatolia and Syria (Barnett 1982: 32 ff.). It is not always easy to separate the Syrian from the Egyptian contribution to this industry in technique and raw materials. By the second half of the millennium the 'Amarna Letters' indicate the arrival of ivory-work from Egypt in Mesopotamia (Knudtzon 1915: ii: glossary *sinnu*). In one case Burnaburiash II requests Amenophis IV to have 'trees and field plants' made from ivory, to have them coloured, and then sent to him (Knudtzon 1915: no. 11, reverse: lines 10–12). At Nuzi there are indications not only of the use of elephant ivory, but of the animal itself (see above). Nuzi texts give ample evidence of ivory inlays in furniture (Starr 1939: 536–7). Inspection by eye suggests that a statuette from Nuzi, perhaps representing the goddess Ishtar-Shaushga in Hittite guise, is ivory rather than bone (Starr 1937: pl. 101; Mellink 1964). This object recalls not only the widely ranging contacts of the Mitannian Empire, but also the vitality of ivory carving in Hittite workshops. Various objects from Tell Brak, including a duck-head cosmetic dish, which may be of hippopotamus ivory, of the thirteenth century BC, could well be imports from workshops in Syria (Oates, D. 1987: 187–8, pl. XLII). A number of the so-called 'chariot knobs' from Kassite sites, some with royal inscriptions (cf. Brinkman 1976: E.2.6), are listed as ivory, but confusions with stone are evident (cf. Sheldon 1971: 203). Ivory finger-rings have been reported from graves of the Kassite period at Tell Zubeidi in the Hamrin (Boehmer and Dämmer 1985: 60) and two female figurines of ivory from Dur Kurigalzu (Iraq 43 (1981): 172).

The most spectacular ivory objects of the second half of the second millennium BC from Mesopotamia are from a single grave, no. 45, at Assur, entombing a male and a female skeleton, dated by Haller (1954: 135–9, pls. 29–30) to the second half of the thirteenth century BC. This dating seems more likely than Moortgat's (1969: 113–15) earlier one, in view of the most closely associated archives, of Babu-ah-iddina, a high-ranking official, whose grave it may in fact be (cf. Pedersen 1985: 106–13). The grave goods included ivory combs, one incised with a procession of ladies and musicians; ivory pins, one with a clenched fist, one with a nude girl playing a tambourine, carved on the head; and two ivory vessels. A pyxis, with lid, was incised with goats and domestic cocks among cedar and palm trees. An accompanying cosmetic dish was decorated with projecting human heads, one on either side, to which a swivel lid was probably fitted; contemporary faience dishes are similarly designed. Although in every

case a 'Syrian' origin is possible, local manufacture may be assumed without evidence to the contrary (Barnett 1982: 40, pl. 36a, b). Unfortunately, references to raw and worked ivory in Middle Assyrian texts from Assur are not explicit about places of manufacture (Sheldon 1971: 188–9). A more distinctively 'Assyrian' hand is evident in a series of contemporary inlay fragments found scattered outside the Palace of Tukulti-Ninurta I (c.1243–1207 BC) at Assur at the foot of the terrace fill. The excavators attributed it to his reign; but Moortgat (1969: 115–16) tentatively suggested the fourteenth century. Incised line on flat silhouettes is used to render a winged bull, a god 'with flowing streams', and stylized trees (Andrae 1977: 116–17, pl. 54; Preusser 1955: 30–1, pls. 25–6; Barnett 1982: pl. 35).

The existence of a Middle Elamite ivory-carving tradition in Khuzistan increases the possibility that native Mesopotamian work of this period may have been more common than is yet apparent. At Tchoga-Zanbil in the fourteenth to thirteenth century BC, in the 'Temple of Pinkir', two sets of ivory inlays representing the head of a winged goddess above a frieze of goats and trees were found (Ghirshman 1968: 53 ff., pl. XXXIV; Amiet 1966: fig. 271). Again incised line is used on flat silhouettes, save for the deity heads, which were boldly modelled with cavities for eye inlays. The case for local manufacture is strengthened by the presence at neighbouring Susa of statuettes in ivory (Amiet 1966: figs. 325, 327) in a style whose Middle Elamite character is much more evident, since it is matched stylistically by locally made terracottas.

Although it cannot yet be traced through the intervening centuries, in common with many other minor arts in Assyria, incised linear decoration on ivory plaques is again evident in the ninth century, to which most of the Assyrian ivory-work found at Nimrud has been attributed (Mallowan and Davies 1970; Herrmann 1992: 277 ff.). Although some carved ivory was produced in Assyrian court workshops in the local style in the eighth century BC (Herrmann 1992: 278), it was by then superseded in popularity by ivory-decorated furniture from workshops in Syria or Phoenicia received as booty or tribute in Assyria. Ivories decorated in the Assyrian style have also been found in the debris of the sack of buildings in level IVB at Hasanlu in north-west Iran, usually dated about 800 BC (cf. Dyson and Muscarella 1989) primarily on the basis of carbon-14 determinations. But this date has been challenged by Medvedskaya (1988; 1991), who has proposed a date almost a century later on the basis of comparative dating for certain distinctive items of horse-harness found on the site.

In contrast to the preferred techniques of western craftsmen, the Assyrians were more inclined to neglect the sculptural potential of ivory. They primarily manufactured thin panels, for application to pieces of furni-

ture, incised with scenes set within geometric and floral borders in which much use was made of compasses and dividers. They also produced distinctive figures in silhouette. The narrative scenes are generally those encountered on the monumental palace reliefs, though no precise match has yet been recognized. These scenes include court life, battles and hunts, processions of tributaries (bringing tusks of ivory among other things), sacred animals, and monsters. When low relief is used the same repertory appears (cf. Barnett 1957, pls. X–XII; Mallowan and Davies 1970: pls. XXVII ff.). Ivory was also used in the architectural decoration of Neo-Assyrian palaces and perhaps also temples. Layard (1849: ii. 263–4) suggested that ivory might have been used to inlay wooden ceilings. The South-East (or Acropolis) Palace at Nimrud, possibly restored in the third quarter of the seventh century BC, contained at least one room which had been decorated with ivory set into wooden panels (cf. Mallowan 1966: 293, pl. 269). The high status and role of the furniture on which Assyrian-style ivories appeared is indicated by their distribution through apartments in palaces designed for royal ceremonial and in temples for royal participation in cult.

Although carving in the round in the Assyrian style is less evident, it is by no means entirely absent, as with an inkwell from Nineveh supported by two human-headed winged bulls *couchant* (Barnett 1957: pl. CXXVI.T9). It is likely that a whole range of functional objects carved in ivory, often undecorated, such as combs, knife-handles, scabbards, and styluses found at Nimrud were locally made. Herrmann (1992^a) has argued that certain openwork plaques decorated with floral designs may also be Assyrian rather than Syro-Phoenician, as had earlier been suggested.

Local also are the ivory writing-boards found at Nimrud and Assur on which scribes wrote with a stylus on a wax surface usually, it is assumed, in Aramaic not Akkadian (Mallowan 1966: 152 ff., pls. 89 ff.; Wiseman 1955; Howard 1955; Klengel-Brandt 1975). The 'acrolephantine' (or 'chryselephantine') technique, for which, in statuary or inlay, the flesh portions of the bodies (face, arms, and legs) were of polished ivory, whilst the remainder were in metal or some other material, is represented by fragments of an inlaid panel from Balawat (Barnett 1957: pl. CXXVII. U. 3). The style suggests that this also was an aspect of local ivory-working.

By far the larger part of the ivory-work recovered from Nimrud came from workshops outside Assyria, to the west in Syria and the Lebanon, or was manufactured in palace workshops within Assyria by craftsmen deported from these regions working there in their native styles. The ivory-carving tradition evident in the Late Bronze Age in the palaces both of Syro-Palestine and of Anatolia (Barnett 1982: 25 ff.) was eclipsed (like so many other crafts at this time) for two or three centuries after about 1150 BC. But the necessary skills seem

never to have completely died out, for by at least the ninth century BC a number of production centres were again active in Syria. Whether Phoenicia also had an ivory industry again by this time remains obscure, though biblical references (1 Kgs. 10: 18, 22: 39) suggest that it might well have done. Among the ivories from Nimrud there are one or two which may have come from workshops in Anatolia or Iran, or even Egypt or Nubia, that have yet to be closely identified.

Poulsen (1912) and Barnett (1982: 43 ff.) demonstrated the existence of Syrian schools of ivory carving active from the later tenth to at least the eighth centuries BC, during which time local supplies of elephant ivory were steadily depleted to the point of exhaustion. Barnett (1957: 46 ff.) sought at first to derive the carved ivories of this type largely from workshops at Hama; but, later, following Winter's researches (1976; 1976^a; 1981), he broadened this to embrace other centres (Barnett 1982: 46). Winter argued that the Syrian style may be subdivided on the basis of consistent variations in style and motifs to support the view that luxury goods of this range were produced with varying degrees of mastery in a number of political centres in Syria: 'probably not just one but most of the major cultural centres in the Levant of the early first millennium BC were engaged in the production and exchange of luxury goods—of which ivory constituted one of the most important commodities' (Winter 1981: 130). These are hard to identify with certainty in the absence of direct evidence for ivory workshops in local excavations. As Barnett (1982: 46; cf. Herrmann 1986: 47 ff.) pointed out, 'there are difficulties and dangers in establishing the location of such centres of manufacture because of the mobility of the craftsmen, the portability of their products, and the uncertainty involved in drawing analogies and inferences from less movable works of art such as stone reliefs, and from one technique to another, different in character and tools'. Herrmann (1986; 1992; 1992^a) has continued to refine the definition of various distinctive groups through a combination of stylistic and technical criteria.

Carved ivories of the Syrian or northern tradition have been found in Iran at Hasanlu (in level IV: Muscarella 1980: 192 ff.), in Iraq at Nimrud (Barnett 1957: 63 ff.; Mallowan 1966: *passim*; Mallowan and Herrmann 1974; Herrmann 1986: esp. 47 ff; 1992; 1992^a; Safar and al-Iraqi 1987) and at Kish (Winter 1976: 11 n. 58), and on a number of sites in Syria and Anatolia, but not yet in Palestine (Barnett 1982: maps on p. 45). No ivories in this style were found in Sargon's palace at Khorsabad nor are they yet known from any archaeological context certainly of the seventh century BC. The ivories from Nimrud are dated by comparative criteria not by archaeological context, since there are no contexts in which they were found that may be closely

dated between the earlier ninth and later seventh century BC.

The separation of Syrian from Phoenician or Northern from Southern carved ivories turns upon the much more prevalent use of Egyptianizing features in designs on Phoenician (Southern) work; on certain stylistic traits, like a recognizably regional Syrian convention for rendering human faces; on the rarity of inlaid decoration on Syrian (Northern) work; and on 'the desire to please sensuously evident' in Phoenician work, not so in Syrian (Barnett 1957: 43, 62; cf. Winter 1976: *passim*). Winter (1976: 11) has neatly summarized the primary stylistic contrast: 'the greater sense of action, squatter more powerful proportions and more highly charged space of the Syrian carvings, as opposed to the more quiescent, elegant and slender figures harmoniously disposed in space with an attempt at balance between *plein et vide* that is characteristic of the Phoenician works'. However, the task of distinguishing one workshop from another is complex and enduringly controversial (cf. Winter 1992). The Syrian ivory carvers, as well as producing carved panels for the decoration of wooden furniture, made ivory pyxides, hand-shaped bowls, and figures in the round designed as handles or staves (Barnett 1957: 63 ff.).

Phoenician carved ivories, characterized above all by their marked debt to the craft and iconographical traditions of Egypt, albeit filtered through a Canaanite legacy, are still virtually unknown from the rare excavations conducted within Phoenicia itself. Isolated finds from Byblos and Sarepta, however, and concentrations of carved ivories on sites in Cyprus and Palestine, with which the Phoenicians are known to have had close ties, have provided the basis for defining this group. Eighth-century Phoenician ivories have been found in quantity at Nimrud (North-West Palace) and Khorsabad, occasionally at Nineveh, in Assyria, and in isolated cases at Sippar and Larsa in Babylonia (Barnett 1957: nos. U. 1 and 2). In Syria they are reported from Carchemish and Arslan Tash, from Sultantepe in Anatolia, from Megiddo, Samaria, Lachish (Tell ed-Duweir) and Bethzur in Palestine, and at Salamis in Cyprus (Winter 1976: fig. 2). None were traced in level IV at Hasanlu in Iran, suggesting to some scholars that this tradition was not active before the eighth century BC (Winter 1976: 15, 22). Barnett (1982: 46) has challenged this view on the grounds that biblical references indicate a continuing, if attenuated, tradition from the Late Bronze Age crafts of Canaan. Moreover, in his view, some of the ivories found at Arslan Tash and Samaria may be of ninth-rather than eighth-century date. Herrmann (1986: 52) has drawn attention to a concentration of finds for which a Sargonid date (c.721–705 BC) is arguable: 'Thus, contexts that can provide dates for the southern tradition, Samaria, Salamis, the North West Palace [Nimrud] and Khorsabad, all agree

with a date in the reign of Sargon', who captured possible ivory production centres at Hamath and Samaria on his campaigns c.720 BC.

There is clear evidence that when ivory carving was eclipsed in North Syrian workshops, perhaps before 700 BC, Phoenician workshops and distributors remained active through into the Achaemenid period (see below). At this time Phoenician workshops may have been supplied largely, if not exclusively, with African ivory, since the 'Syrian' elephant had been eliminated and contacts with the Indian subcontinent, until Achaemenid times, had not been revived. As the biblical references make clear, Phoenician ivory carvers were particularly renowned for working panels to be set into furniture and also elements of furniture entirely cut from ivory (cf. Gubel 1987).

Publication of the carved ivories from Nimrud is steadily reaching the point at which profitable study may be made of their varied functions. Some categories, as with equestrian ornaments (Orchard 1967), are relatively easy to isolate; but it is usually extremely difficult, if not impossible, to offer reliable reconstructions of the furniture once decorated with these ivories. Elements of what may have been a couch were found in Room NE 26 of Fort Shalmaneser (Curtis (ed.) 1982: pl. 8a); in SW 7 there was a set of ivory chair-backs stacked together (Mallowan and Herrmann 1974); in SW 37 stands for goblets (Herrmann 1986: figs. 1–2) and other sets of fittings have been provisionally reconstructed.

A discussion of the West Semitic alphabetic inscriptions on carved ivories would be inappropriate here; but some description of the information they yield is relevant. Millard (in Herrmann 1986: 45) suggested that more of them were probably in the Aramaic than in the Phoenician or Hebrew scripts. At their simplest these signs were fitters' marks, sometimes recognizable letters, sometimes other signs, sometimes phrases ('below'; 'side of the throne') on the tenons, backs, or edges of the ivories. There they served as a guide in the assembly of complex pieces of inlaid furniture. As there is no comprehensive survey of these marks, and as there is not always sufficient certainty in distinguishing one alphabet from another, they may not yet be used as a check on the stylistic attribution of individual ivories. Longer inscriptions, including personal names, some of which may be those of historical figures, seem most often to have been property marks, whilst occasional place-names indicate something about sources, though they may not automatically be assumed to indicate the place of manufacture. A few longer inscriptions are dedicatory: 'Property of X, son of Y, which he offered to deity Z' (cf. Millard 1962; in Herrmann 1986: 43–6; Röllig 1974; Lémaire 1976). Egyptian inscriptions in the hieroglyphic script are rather different, since they are used in designs and are not scratched on the reverse. They appear either as

short epigraphs with figures or as isolated short segments of text. None makes much sense and they may not be used to identify either historical figures or the place of production (cf. Kitchen 1986), save to say that they were not made in Egypt.

Very little ivory-work has yet been published from excavations at Babylon. Outstanding is a woman's head, in local style, from a statuette usually attributed to the sixth century BC, though it could be earlier (Reuther 1926: pl. 66). A nude statuette of a woman, her feet and arms damaged, was found in the fill of a Parthian temple at Nippur (Crawford, V. E. 1959: figure on p. 80). It has been dated to the Neo-Babylonian or Achaemenid period. There are other isolated pieces of carved ivory that may indicate the existence of local Babylonian workshops in the second quarter of the first millennium BC. It is hard to give a precise date to an ivory calf-head and an ivory lion-head from Sippar; but both are Mesopotamian in style and fall most easily into this period (Barnett 1957: U.7–8, pl. CXXVI). It is no more easy to place a mirror-handle in an Egyptianizing style, said to be from Birs Nimrud (Barnett 1957: U.17, pl. CXXIII); but it might be an import from the west.

Evidence from Ur best demonstrates the continuing penetration of ivory objects from Syro-Phoenicia down the Euphrates into Babylonia. In levels attributed by Woolley to the Neo-Babylonian and Persian periods, ivory was more commonly reported at Ur than at any previous time. The types of object made of carved ivory are the traditional ones: combs (Woolley 1962: 105 ff., pls. 19–20: U.314, 450, 785–6, 7902, 7913), pins, kohl-sticks and kohl-pots (ibid.: U.7907–8, 16371 (?ivory), 17139), mirror-handles (ibid.: U.7905, 16380), a spoon (ibid.: U.303), and a variety of cosmetic boxes or palettes (ibid.: U.136, 485, 2677, 7801, 7903–4, 15460). Certain objects, either by their figured decoration (U.2677) or in one case by a votive inscription (U.7801 = Barnett 1957: U.11), may be attributed to Phoenician craftsmen, as probably may the mirror-handles in an Egyptianizing style. At least one cosmetic pot, carved as a sphinx *couchant*, is, however, more Assyro-Babylonian in manner (U.7904), whilst a cosmetic dish supported by two buxom nude females (Woolley 1962: pl. 19: U.303 = Barnett 1957: U.10, pl. CXXV) might possibly be from an Arabian or Gulf workshop.

Within court circles ivory was prized in the Achaemenid Empire both as a raw material and as artefacts. On the friezes of the Apadana at Persepolis the Ethiopian delegation bring ivory (Schmidt 1953: 90). This accords with the report of Herodotus (iii. 97) that the Ethiopians delivered twenty tusks every three years as tribute. According to the well-known foundation inscription of Darius I (c.521–486 BC) from Susa, ivory came from Ethiopia, Arachosia in modern Afghani-

stan, and Sind in modern Pakistan (Vallat 1971: 58). Only a few scattered fragments of ivory inlay were recorded in the excavations at Persepolis (Schmidt, E. F. 1957: 71, pl. 40: 1–2). But from a well in one of the Achaemenid palaces at Susa Mécquenem recovered an important series of ivory fragments restudied by Amiet (1972^a), who assembled them into five stylistic groups: Syro-Phoenician; Achaemenid; Egyptian; Greek; miscellaneous. All appear to be of the Achaemenid period. The pieces in a 'Syro-Phoenician' style indicate the survival of long-established local workshops (cf. Descamps de Mertzfeld 1954: pl. LXIV. 687). Designs in the international Achaemenid court style were used on combs (Amiet 1972^a: 180 ff., pl. V. 2, figs. 14–15), on inlay plaques carved in low relief (ibid.: 188 ff., figs. 19–23), and on pieces of mosaic inlays (ibid.: fig. 24). Some fragmentary plaques carved with scenes in low relief, and the head of a male statuette, look more 'Egyptian' than 'Egyptianizing' (Amiet 1972^a: 319 ff., pl. VI). A few ivories carved in a Greek style are particularly distinctive (ibid.: 324 ff., pl. VI). Ivory was used at this time both for complete scabbards (Litvinsky and Pichikiyan 1981: pl. I) and also just for scabbard chapes, some carved with a 'curled animal' of Scythian ancestry (Bernard 1976).

(iv) METHODS OF MANUFACTURE

The tools and workshop conditions of ivory carvers in ancient Mesopotamia, as in Syro-Phoenicia (Gubel 1987: 25–8), are unknown. Mallowan (1966: 483–4) attempted to remedy this deficiency by recounting the practice of ivory carvers in modern India:

I was told that the tusk was only considered mature at 50 years—that is the half-life of the male elephant. The craftsmen, incidentally, were all of humble origin; they were poorly paid and their workshop was equipped only with a bare minimum of furniture; a single patron employed about twenty of them . . . the patron averred . . . that African were better than Indian tusks . . . in Jaipur . . . the craftsman was only using chisel, file, fine saw and a nail with a sharp point, and a small tool with a flat paddle-shaped blade at each end . . . His practice was to saw a section longitudinally, cutting the tusk in two halves and then to make two similar figures after having sketched the object intended on the convex side. The technique explains the fact that many of the Nimrud ivories were carved in pairs . . . At Jaipur the craftsmen said that the most delicate and tricky part of the operation was cutting out the open and *ajouré* parts of the figures . . . if an accident happened, then the free standing parts were altogether cut away, and only the solid figure was produced . . .

The oldest surviving textual source for ivory-working appears to be an eleventh-century AD illuminated manuscript which illustrates the working of ivory at that time, though only the first process and the final product.

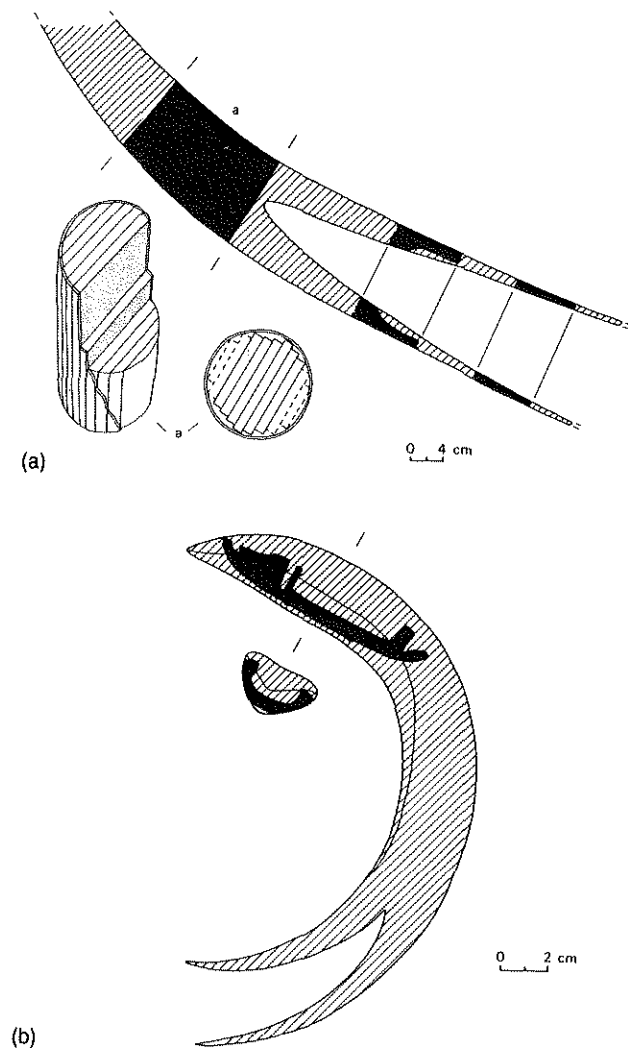


Fig. 7. (a) Diagram to illustrate the sectioning of an elephant's tusk to provide ivory panels and circular boxes of ivory (after Caubet and Poplin 1987: fig. 16). (b) Diagram to illustrate cutting of a duck-shaped cosmetic dish from a hippopotamus tooth; c. 1400–1300 BC (after Caubet and Poplin 1987: fig. 9).

Initially, the husk, which may have been damaged by the elephant in feeding, fighting, or working, was stripped off with an adze-like tool; the Byzantine illustration indicates that all processes were undertaken at one place and that antler was worked by the same craftsmen.

The newer denture round the pulp cavity was usually discarded, save when a very thick plaque was required. Ivory-work through the ages demonstrates that the carvers knew and chose to work the best material available, determining which side of a slab offered the best opportunities and which direction was the best in which to cut it, working with the grain. The 'Nimrud ivories'

demonstrate that ivory was economically used; by clever joining waste was avoided. Flaws were plugged or concealed by overlays. Any tusk was divided up in the most careful way: the hollow lower end for pyxides; the central section for larger figures or panels; the point for smaller statuary. Fragments were recycled (cf. Barnett 1957: nos. S.118, 142a–b, 406); bone was also skilfully used on occasion to serve as a cheap substitute.

Available studies of technique (Barnett 1982: 9 ff.; 1957: 155 ff.; Herrmann 1986: 55 ff.) are based largely on deductions from surviving artefacts, a few unfinished and thus more revealing. Herrmann (1986: 55–6) has made preliminary studies of the significance of tool-marks. At Ur, in texts dating to about 2000 BC, ivory carvers are associated with joiners; a connection likely to have been enduring. Ivory-work was very often part of furniture decoration, and carved wood and carved ivory occasionally appeared together in the same object (cf. Safar and Al-Iraqi 1987: plate on p. 53). The techniques required to carve ivory, a tough material, are close to those used for hard woods. Nor should a close relationship with stonecarving be overlooked, since among the equestrian face-pieces at Nimrud are examples in gypsum as well as those in ivory (Orchard 1967: 43–5, nos. 201–16, pls. XLIV–XLVI). Mesopotamian texts (cf. Barnett 1982: 86 n. 12) illustrate how single consignments of tusks were cut up and issued in the form of small contracts to ivory carvers; but they give no real indication of how the craftsmen were organized. In the Near East workshops of ivory carvers have been identified, with varying degrees of confidence, at Tell Keisan and Megiddo in Israel, at Ras Shamra in Syria, and at Paphos in Cyprus (cf. Barnett 1982: 11; Briend *et al.* 1980: 328–9). In many ways the most instructive is the earliest, at Safadi, a site of the Beersheba Culture of the mid-fourth millennium BC in Israel. Here the excavator reported a tool-kit including simple copper awls, one still in its bone handle, and a bow-drill (Barnett 1982: 23). As Mallowan's observations (cited above) indicate, the ivory-worker's tool-kit includes a few basic items: awls, chisels, drills, gouges, knives, and saws; abrasives and polishers for finishing; compasses to set out designs; a pointed metal tool for engraving.

In a study of Mesopotamian crafts, attention is properly concentrated on the distinctive technical features of the 'Neo-Assyrian' carved ivories, usually thin plaques with incised, or, more rarely, low relief designs attributed to local craftsmen on the strength of their style and iconography. In almost every respect they have more in common with 'Middle Assyrian' ivories than with their contemporary western counterparts. The Assyrian craftsmen appear generally to have been more economical in their use of ivory than were western arti-

sans, whilst their technical range is less and their level of skill not so great.

The predominant thin ivory panels or plaques, for overlay (veneering) more often than for inlay, were fixed in place with animal (?) glues and then secured with copper alloy or ivory pins or pegs, which were often carelessly placed, though the head is set into a hollow. This detail, possibly adopted from fine carpentry, is not evident on Syro-Phoenician ivory-work. It is unfortunate that so little is known of Assyrian carpentry, since it is also noticeable that parts of ivory statuettes in Assyrian style were also secured with metal or ivory pegs rather than with the tenons or key-hole slots used by western ivory-workers. Compasses are evident in the incised designs from at least the ninth century, as is the use of colour to pick out designs, though there is no evidence for inlays set into *cloisons*. It is not clear to what extent guidelines were used for carving in the round as they were in the west (Barnett 1957, pl. XCVII S. 404), perhaps following Egyptian practice, or lathes for similar work (Barnett 1957: 158).

Surface decoration of ivory was much more prevalent than the present condition of carved ivories in museum displays might suggest. Only vestiges have normally survived long deposit in the earth and over-enthusiastic conservation. Indeed, it is possible that in antiquity very little of the ivory surface remained plain, perhaps only some of the background and areas of flesh. Surfaces were overlaid with gold and silver leaf, perhaps on occasion to conceal flaws (Herrmann 1986: 58); sometimes the surface below the gold is stained purple (Barnett 1957: 155). The surfaces were also stained or painted. Pigment, applied as a solution or fine slurry, penetrated into the porous surface of freshly cut ivory. It is generally too fugitive for conclusions to be drawn about the colour schemes most widely employed, though they seem likely to embrace the same range as is found in inlays (see below). There are isolated cases where ivories have been deliberately blackened, rather than fortuitously caught in the fires that ravaged the palace rooms in which they had been stored (Herrmann 1986: 60). It is possible that this is a deliberate attempt to imitate ebony, the shiny black wood with which Egyptian craftsmen loved to combine ivory. It is likely to have been rare in Mesopotamia. The effect could have been achieved by placing the carved ivories in a reducing oven and heating them until they changed colour.

In the Egyptianizing (or Southern) Groups particularly, ivories were inlaid. Either certain areas of the raised design were cut out to be highlighted with inserted colour (*cloisonné*) or the background was left high and the design itself cut out to be filled in with colour (*champlevé*; silhouette). Inlays were regularly set on bedding material: red (iron oxide) and blue (Egyptian blue) were commonest at Nimrud, but green

and yellow (yellow ochre) also appear (Herrmann 1986: 59). The inlays were predominantly of glass; semi-precious stones are relatively rare. Those in glass were opaque, frequently in shades of blue. Their rough shape was formed in moulds and finished by cutting and polishing before insertion (Saldern 1966: 632–3).

(v) CHEMICAL STUDIES

Scientific studies of ancient Near Eastern ivories have so far concentrated on gross compositional analyses in order to assess deterioration and possibly to establish age in relation to environmental history (cf. Baer *et al.* 1978). The application of carbon-14 dating to ivory has not yet been systematically applied to pre-Islamic examples from the Near East (Herrmann 1986: 55). Research continues into ways of distinguishing African from Indian ivory in ancient specimens, so far without useful results.

7. Ostrich Eggshells

The ostrich inhabited most of the deserts of the Near East until recent times, though its occurrence is now much more limited (cf. Reese 1985a: 378). In antiquity it was well known in Mesopotamia from its presence on the left bank of the Euphrates (Xenophon: *Anabasis*, I. v. 3) and perhaps elsewhere in the Syrian steppe. Laufer (1926: 6) concluded that, since the pores in surviving ostrich eggs from ancient Mesopotamia were 'exceedingly fine . . . it may be concluded that the species represented by them is identical with, or allied to the present Syrian and North African ostriches'. This, the largest living bird, is renowned for its speed, whilst its equally proverbial stupidity is most evident when, cornered in hunting, it fails to take the evasive action that might save it. By contrast, in open country, it is wary and capable of speeds of up to 26 miles an hour. Finet (1982) has reviewed some of the available textual and archaeological evidence from Mesopotamia.

The ostrich is most often represented in art after about 1300 BC, when Assyrian royal annals refer to the death and capture of ostriches, some of which were held in zoological parks (Finet 1982: 69–70). It is rare on seals before the later second millennium BC when it appears on Middle Assyrian seals (Buren 1939: 87–8; Ward, W. H. 1910: 203–4); an Old Babylonian clay plaque from Kish shows a man riding an ostrich (Moorey 1975: 90, pl. XXIVa). Among a number of representations on seals in the Neo-Assyrian and related styles is the famous seal of Urzana, King of Muṣaṣir, north-east of Assyria, in the late eighth century BC, now in The Hague, showing a mythical hero

grasping the necks of the ostriches set on either side of him (Collon 1987: no. 405). Representations of the bird on seals do not reveal what stratagems were used to hunt it on foot (cf. Laufer 1926: 22 for ethnographical evidence), though the bow is commonly used to kill it. A bowman, firing at what is probably meant to be an ostrich, also appears on one of a series of decorated bronze goblets attributed to a tenth-century BC West Iranian workshop working in the Babylonian style (Calmeier 1973: 50–1, F6). A bronze bowl in the Louvre, probably of the Achaemenid period, is decorated with an ostrich hunt, involving bowmen riding camels and horses (Parrot 1953: 1 ff., pls. I–III). A horseman also appears in a scene of ostrich hunting on a fragmentary glazed vessel of the seventh century BC from the North-West Palace at Nimrud (Mallowan 1966: i. 119–20, fig. 61). Traditionally the Arabs relied on the speed of their horses to run ostriches down: 'the horsemen hunt in relays and are apt to overtake the birds by pursuing in a straight line' (Laufer 1926: 14).

Although the flesh is edible and the fat useful (cf. *CAD*, *lurmā*), the ostrich has been primarily valued for its plumage, notably the tail feathers, and for its large eggs (Laufer 1926). It is not clear whether the figures shown in Near Eastern art with 'feather crowns' were using those of the ostrich. The egg, however, was widely appreciated both as a food fit for gods and kings and as a container when emptied. Ostrich eggs are laid in the sand and incubated primarily by the cock bird, particularly at night. They are usually only unattended in the heat of the day. Unhatched eggs are placed close to incubated ones to serve as food for young chicks.

Archaeological evidence for the use of ostrich eggs as containers is sporadically distributed in time and space in Mesopotamia; richest in those periods when the evidence is largely derived from excavated graves. As they are commonly smashed to pieces, ostrich eggs have often gone unrecorded by excavators. Within Mesopotamia there never seems to have been a tradition of decorating ostrich eggs with incised, engraved, or painted designs as in other cultures. A rare example of a painted egg was reported from Susa in a grave of the mid- to later third millennium BC (Mecquenem 1943: 82, fig. 68.3).

Evidence for the use of ostrich eggshells as drinking goblets or liquid containers is not yet evident in Mesopotamia before the third millennium, though there is every likelihood they were used much earlier. At Tell Kannas on the Middle Euphrates, a site of distinctive Uruk IV type, fragments of ostrich eggs were found in rooms adjacent to the South Temple (Finet 1982: 72). The use of ostrich eggshell cups among the élite in Early Dynastic III is well illustrated in the Royal Cemetery at Ur, where they occurred mounted, and finished at the neck, with shell mosaic decoration set in bitumen (U.9255: Woolley 1934: 283, 543, pl. 156) and imitated

in both gold and silver, also elaborated with mosaic rims and bases, in the royal tomb PG 779 (U.11154: Woolley 1934: 283, 567, pl. 170). Elsewhere in the cemetery, according to Woolley, fragments of ostrich shell were 'fairly common' (Woolley 1934: 423, 439, 443, 449, 459, 467, 491; 1956: 141 (painted red)). Among the less high-ranking people buried in Cemetery A at Kish, in the third quarter of the third millennium BC, at least eight of the 154 recorded graves had contained ostrich eggs, some mounted as cups as at Ur, some perhaps simply food for the dead (Mackay 1925: 19; 1929: 136, pl. XXXVIII.1 (stands); graves 2, 43, 75, 88, 90, 104, 120, 128; Moorey 1978: fiche 1; Laufer 1926: pls. I–III). Three per cent of male graves, 2 per cent of female, and 1 per cent of children/adolescents' graves held them. An ostrich eggshell cup was found in the contemporary 'Planoconvex Building' at Kish (Mackay 1925: 19) and they occur in graves at Abu Salabikh (cf. Postgate 1980: 73). In view of the natural habitat of the bird it is not surprising that similar use of its eggs is evident in the third millennium on the Euphrates at Tell Asherah (Terqa) (Caubet 1983: 194) and Mari, where shell fragments were attributed to the Temple of Ishtar (Parrot 1953: 2). Beck (H. C. 1931: 434) refers to 'several pieces of ostrich shell' at Nineveh.

In the earlier second-millennium palace at Mari, where textual references to ostrich eggs are recurrent (Caubet 1983: 194), Parrot found shell fragments in what he believed were foundation deposits, but this is debatable (Parrot 1958^a: 79; cf. Ellis 1968: 142–3). The ostrich was said to be 'represented throughout Nuzi by numerous fragments of eggshell' (Starr 1939: 492, cf. 488); they were undecorated. The date of ostrich eggshell fragments in the *Edublatmah* at Ur are uncertain (Woolley 1965: 30). Ostrich eggshells were found in graves of the 'Assyrian' cemetery at Mari dating to the thirteenth century BC (Parrot 1937: 83, fig. 16). Of much the same date are the 'several fragments of ostrich eggshell cups' from the Kassite royal palace at Aqar Quf (Baqir 1945: 14).

After the second millennium BC the archaeological record is less explicit; but intermittent evidence suggests that the ostrich eggs continued to be widely exploited from the Zagros (Finet 1982: 74) through the Levant to the west Mediterranean (Caubet 1983; Reese 1986).

Little may be said at this stage about the use of ostrich shell in the manufacture of beads, though Beck (H. C. 1931: 432–4) alludes to their rarity at Nineveh.

8. Tortoiseshell

Commercial tortoiseshell today comes from one major source, the epidermic plates of the hawksbill turtle (*Eretmochelys imbricata*), but in antiquity more than

one kind of sea turtle and the land tortoise were probably used (cf. Lucas 1962: 39; Owen 1981 with bibliography). Both were available in Mesopotamia, though their use as materials there is still obscure. If the ancient terminology is correctly understood, tortoiseshell is listed among foreign materials reaching Ur up the Gulf in the early second millennium BC and was used in manufacture of a throne (Leemans 1960: 25 n. 4; Mieroop 1987: 37). The tortoise/turtle is recurrently, if not commonly, represented in the art of Mesopotamia from the prehistoric period until Neo-Assyrian times (Buren 1939: 103–4); but tortoiseshell is remarkably rare in the archaeological literature. Woolley is reported as stating that 'no specimen of tortoiseshell was ever found at Ur' (cited in Leemans 1960: 25 n. 4). At Abu Salabikh, in an Early Dynastic III domestic context, a complete 'tortoise' shell was found lying upside-down next to a conical bowl on the floor of Room 1 in Area A (Postgate and Moorey 1976: 167; Postgate 1977: 275, fig. 2). In the Old Babylonian levels at Nippur 'turtle' shells were found (Owen 1981: 41; quoting Gibson); but there is virtually no other evidence after that, although the writer of the *Periplus* mentions tortoiseshell more than any other object of trade in the first century AD (Casson 1989: 101–2). Its absence from Mesopotamia may have something to do with the ebb and flow of the Gulf Trade. The absence of tortoiseshell has been noted in the varied repertory of materials at Ras Shamra in the second millennium BC, when it might have been expected (Caubet and Poplin 1987: 289).

9. Marine and Freshwater Shells

Shell, one of the most durable natural materials, has so far received no systematic attention in Mesopotamian archaeology. Until recently it was casually retrieved and rarely reported in any detail. In ancient Mesopotamia molluscs were a source of food and their shells a valued raw material, variously employed to manufacture inlays, personal ornaments, seals, and utensils. Shells also played a role in religious life, more evident in texts than in the material record (cf. Oppenheim 1963; Aynard 1966). Although the number and range of shells found in excavations is considerable, only a few of the larger marine gastropods and bivalves are well suited to manufacture. They will inevitably receive most consideration here, but the regular use of natural shells (little modified) as personal ornaments requires a wider perspective throughout.

As recurrently in the study of manufacture in Mesopotamia, it is only recently that serious attention has been paid to the proper identification of materials. Even now only small samples of shells are studied in this way, so it is impossible to make any quantitative

statements about the use of specific species through time and space. The matter is further complicated when dealing with manufactured shell, particularly when fragmentary, since even first-hand examination by an expert may not yield a firm identification. One Early Dynastic I grave of an adolescent (16–18 years) and an adult woman at Kish (no. 686: Algaze 1983–4: 175), for which Reese has provided shell identifications, may be cited as an illustration of how varied the range of shells available and exploited for food, decoration, and vessels in Mesopotamia might at times be. Even with only a proportion of the recorded shell available for expert identification this grave had included: 2 *Lambis* vessels (one with spines); 6 beads of *Fasciolaria columellas*; *Spondylus gaederopus*; 2 *Rapana bulbosa*; *Arca* sp.; *Dolium macolatum*, and a bitumen stopper containing a freshwater shell.

The manufacture of shell did not offer significant problems; it was one of those rare natural materials whose varied forms lent themselves very often to practical and ornamental purposes with minimal modification. As has been seen in discussing the manufacture of beads, shell was worked with simple chipped stone tools so long as they were current and then with copper alloy equipment. The working of mosaic panels in Early Dynastic III, in which bone, stone, shell, and mother-of-pearl were used interchangeably, best indicates that all these materials shared a common workshop tradition. In the case of larger shells some parts might be used for personal ornaments, whilst others were used for inlays or other purposes.

It is obvious that the kind of survey offered here will be steadily improved as quantified expert reports steadily become available; but it is unlikely that the spread of evidence for manufactured, as distinct from natural, shells will be radically modified. Although shells, virtually unmodified, were used as personal ornaments to a greater or lesser extent throughout the prehistoric and later periods in Mesopotamia, a widely ranging repertory of shell objects is only evident at present in the third millennium, pre-eminently in Early Dynastic II–III. At this time mercantile enterprise down the Gulf and across the sea to the Indian subcontinent put Sumer into contact with regions where a great variety of gastropods, particularly, were locally available and often vigorously exploited by local craftsmen (cf. Kenoyer 1984). However, this trade is also documented half a millennium later, at a time when the evidence of Mesopotamian burial furniture is unfortunately meagre, so shell is rare in the surviving material record at that time. This may reflect reality, as there appear to be no textual references to shell imports from overseas c.2100–1800 BC save for mention of *ajartu* as imports from *Dilmun*. Oppenheim (1963) rendered this as 'a cowrie of a special kind' rather than as the 'white coral' preferred by others.

(i) SOURCES

(a) Freshwater

Except for use as personal ornaments, local freshwater shells do not appear to have played much part in the craft tradition of ancient Mesopotamia. *Unio* shells, a commonly reported bivalve, may represent food, personal ornaments, or containers when listed for sites as dispersed through time as Umm Dabaghiyah, Abu Salabikh, Nippur, Nuzi and Nimrud. Of Early Dynastic Abu Salabikh Postgate (1980: 74) noted: 'another zoological remnant which is absent from graves, although very common otherwise, is the shell of a simple bivalve (*Unio* sp.)'. This bivalve would have been common in local canals and streams. According to Mackay (1929: 136, pl. 38.1), the bitumen stands for ostrich-egg cups at Kish were inlaid with pieces of freshwater mussel (*Anodonta*?) in Early Dynastic III.

(b) Marine

Theoretically, three major source zones are relevant to the supply of shells for Mesopotamia: the eastern Mediterranean; the Red Sea; and the waters of the Gulf and the Indian Ocean. For most practical purposes the division is a cruder one, between 'Mediterranean' and 'Gulf' species; but as so much of the material evidence is manufactured from parts of shells, they tend to lack diagnostic features necessary for proper identification. Even when identification is possible, significant errors have arisen and uncertainties inevitably occur in attempts to locate potential ancient source zones, since the necessary research has rarely been done. Thus all statements about sources have to be treated with due caution. They rest for the most part on information about modern source areas combined with erratic and irregularly studied evidence from archaeological sites in the primary source zones, notably through the Gulf and across the Indian Ocean to the north-west coasts of the Indian subcontinent. There is also an imbalance in modern literature, which has concentrated heavily on the role of shells and shell artefacts in commerce and cultural interaction between the Indus Valley, Iran, Mesopotamia, and the Gulf in the later prehistoric and early historic periods (cf. Ratnagar 1981; Gensheimer 1984; Kenoyer 1984), for which the material evidence is particularly instructive and unusually well published.

The Gulf and beyond

As the most important, and best studied, of the potential source zones, this may best be considered first. 'It can be assumed that many of the smaller gastropods and bivalves that are now common in the silty-salty Gulf, were also available in this region in ancient times, e.g. Conidae, Neritidae, Olividae, Arcidae, Spondulidae, Cardiidae, etc. Other shell artifacts can be identified as having been made from species that have more

limited distributions in the eastern Gulf, in the Gulf of Oman or even further east along the coasts of the Indian subcontinent' (Gensheimer: 1984: 65). Among the more regularly reported species are:

1. *Engina mendicaria* (L.). This small (up to 2.5 cm.) attractively banded shell was commonly perforated for use as a personal ornament in Mesopotamia from pre-historic times. Reese has noted occurrences at Abu Salabikh, al-Hiba, Tell ed-Der, Gawra, Khafajah, Kish, Nimrud, Nineveh, Nippur, and Telloh. It was a Gulf species, perhaps most prevalent in the Gulf of Oman and along the Makran coast; but is also found in the Red Sea.

2. *Fasciolaria trapezium* (L.). This relatively large shell (15–20 cm.) is widespread in the Indian Ocean, especially prevalent in the Gulfs of Oman and Kutch (India), but rarer along the Makran Coast. Occurrences in the Gulf are said to be rare. This shell can be badly damaged by its natural interlacing burrows and its walls are relatively thin.

3. *Lambis truncata sebae* (Kiener). This is a large, massive shell (up to 30 cm.), not common in the Gulf, but reported from the Omani coast, with occasional appearances on the coasts of the Indian subcontinent, and from the Red Sea.

4. *Chicoreus ramosus* (L.). This is another large shell quite common in the Gulf of Oman, near Muscat, now rare in the Gulf, and present in the Gulf of Kutch and along the coast of Pakistan. It was commonly used in the Indus Valley settlements.

5. *Turbinella pyrum* (L.). Large, solid, and heavy shell (up to 25 cm. high; 800 g. weight), not naturally ornamented so its smooth shell is attractive for working; also a remarkably thick shell. This shell is about the same size as *Fasciolaria trapezium*, with a distribution limited to the waters of the Indian subcontinent. It was the shell most commonly used as a raw material at Mohenjo-Daro (Kenoyer 1984: 51), but is apparently rare on sites in Mesopotamia, reinforcing the view that in antiquity it could only have been acquired from sources in the vicinity of the Indus Valley. Care is needed in using the literature relevant to this species in Mesopotamia. Hornell (1941) drew special attention to the presence of *Turbinella pyrum* (*Xancus pyrum*: 'Shanka': 'Indian Chank') at such sites as Kish, Telloh (*Girsu*), and Ur; but his identifications have not been sustained by more recent research (Gensheimer 1984: 71; D. Reese: personal communication). Shell utensils, notably the so-called 'lamps', from Telloh originally identified as *T. pyrum* are in fact *Lambis truncata sebae*, as indeed seems also to be case with the same old identifications at Kish and Ur. Thus these particular artefacts need not necessarily imply contacts with the Indus Valley cities (contra: Ratnagar 1981: 148). In the Indus region the massive columella of *T. pyrum* was used to

manufacture a wide range of artefacts (Kenoyer 1984: 57).

6. *Strombus decorus persicus* Swainson. This Indian Ocean species was probably the shell used most often in certain periods, as at Tell ed-Der (Gautier 1978: 191 ff.) and at al-Hiba (Carter, E. 1990: 95) for shell rings and disks.

7. *Scaphopoda* (tusk shells). These are regularly referred to in Near Eastern archaeological literature as 'Dentalium'/'Dentalis', which experts regard as seriously misleading and a potential source of false inferences. This class contains a number of genera, including *Dentalium*, with distinct geographical distributions. Thomas identified those recovered in the sixth-millennium settlement of Umm Dabaghiyah as *Paradentalium hexagonum* (Gould 1859) (? = *P. octangulatum* (Donovan) with an Indo-Pacific distribution, not a Mediterranean one, as was implied in the excavation report (Kirkbride 1972: 8). This species was also recorded at Nineveh (Beck, H. C. 1931: 432).

8. *Cypraea* spp. Cowries of various species are common on Near Eastern sites from the time of the earliest settled communities and were obviously traded over long distances (cf. Reese 1986: 328, map 8). It is important that Indo-Pacific/Red Sea species (*annulus*; *moneta*) are clearly distinguished from Mediterranean cowries (*luria*; *lurdia*; *spurca*) in assessing the archaeological evidence for commercial contacts. At Umm Dabaghiyah, for instance, it is the former not the latter that are recorded; at Arpachiyah in the later Neolithic, cowrie shells strung as beads held red ochre, probably also from sources in the Gulf (Reade 1991: 13, fig. 12).

9. *Conus* spp. As beads recovered from Mesopotamia are generally larger than the only Mediterranean cone (*Conus mediterraneus*), they probably derived from one of a number of species native to the Gulf and Indian Ocean.

Some of the major species appear to be rare in, or absent from, the Gulf itself and most probably reached Mesopotamia from the Gulf of Oman or further afield. How early this contact began, and whether it was direct or indirect, perhaps through *Dilmun*, is an open question. It may have been an aspect, in the first instance, of the trade network which took Ubaid and Jamdat Nasr types of pottery to the extremities of the Gulf. Contact further afield with the Indian subcontinent is most evident in the shell record (*T. pyrum*; *Chicoreus ramosus*) from the second quarter of the third millennium BC, and then for some centuries into the second millennium BC.

The Red Sea

In reporting on a sample of shells from eighth- or seventh-century levels at Nimrud, Wilkins (1966) noted that 'the species in the collection are fairly common to the Indian Ocean, several occurring in both the Red Sea

and the Persian Gulf, notably those marked with an asterisk in the following list (i.e.: *Nerita albicilla*; *Cypraea annulus*; *Cypraea erosa*; *Cypraea felina*; *Thais undatum*; *Strombus floridus*; *Engina mendicaria*; *Turbo intercostalis*) . . . The samples of shells are not large enough to warrant any important conclusions, but they incline rather to the Red Sea than the Persian Gulf'. This dichotomy may have been more relevant to the supply of shells in Assyria rather than in Sumer (and later Babylonia), where the Gulf was more directly accessible.

The Mediterranean

In 1931 Beck, citing the identifications of shells from Nineveh made by Tomlin, listed the following Mediterranean species, though noting that in this sample shells from the Gulf or Indian Ocean 'represent the greater number of specimens': *Columbella rustica*; *Cypraea lurida*; *Cypraea spurca*; *Nassarius gibbosulus*; *Conus mediterraneus*; *Cardita antiquata*; *Glycymeris violacescens*; *Osilinus tubiformis* (*Monodonta turbinata*).

Clench, reporting on the shells from fourteenth-century BC deposits in Temple A at Nuzi (Starr 1939: 489), isolated as Mediterranean species: *Murex brandaris*; *Murex trunculus*; *Cypraea lurida*. He commented that 'those that could have come only from the Mediterranean are of extreme interest, not only as definite proof of a considerable trade with that coast, but because, being restricted exclusively to the temple, they are another example of cult practices and objects originating in the west'. Reese (1986: 330) has reported on *Murex* and *Cypraea* on contemporary sites.

At Tell Rimah, again most probably used as personal ornaments, the following Mediterranean species were recognized in contexts contemporary with, or soon after, the Nuzi sample: *Nassarius gibbosulus*; *Columbella* sp.; *Glycymeris cor.*; *Neverita josephina*; *Cerastoderma tuberculata* (*Acanthocardia tuberculata*) (Carter, T. H. 1965).

Reese (1986: 320 ff.) has commented on the use and distribution of *Arcularia* (= *Nassarius* = *Nassa*) *gibbosulus* in the period c. 1550–1200 BC. This shell has an extremely long history as a personal ornament extending back to the Upper Palaeolithic in the East Mediterranean. They penetrated deep into the Near East from an early date and Reese lists them on such sites as Mari and Terqa on the line of the Euphrates, at Hasanlu and Susa in Iran, and at Tell al-Hafriyat, Gawra, Tell ed-Der, Kish, Nimrud, Nineveh, Nuzi, and Tell Rimah in Iraq.

Mediterranean shells were represented in the sample from Nimrud (Wilkins 1966), and Reese (1989) has discussed those found in level IV (c. 1000–800/714 BC) at Hasanlu in north-west Iran: *Arcularia* (67); *Murex trunculus* (8); *Murex brandaris* (2); *Cerithium vulgatum* (1); *Donax trunculus* (1). They constitute only 1 per cent of the sample.

(ii) THE REPERTORY OF USES

(a) Amulets, beads, and pendants

This is not only the largest category of shell artefacts, but also the most varied and recurrent from the earliest settled communities in Mesopotamia through into modern times. Crudely classified they fall into three main categories: *natural shells*, pierced but otherwise little modified for stringing as beads; *beads* made from shells whose identity may be established from a recurrent pattern of use, if not always from individual examples; *anthropomorphic and zoomorphic amulets or pendants* cut from shell fragments whose identity is often obscure. Jewellers' hoards sometimes contain shells (cf. Larsa: Huot *et al.* 1978: 195–6, cf. Arnaud *et al.* 1979; Ur: Woolley 1976: U. 16927 A–B; Babylon: Reuther 1926: 16).

The following gastropods, of Gulf or Indian Ocean origin, were suitable with minor modification for use as beads; asterisks denote shells particularly popular for necklaces in Mesopotamia from the third to the first millennium BC:

Nerita sp. (cf. Tosi *et al.* 1981: no. 82).

Cypraea sp. (Tigris) (cf. Tosi *et al.* 1981: no. 17).

Polynices mamilla (L) (cf. Tosi *et al.* 1981: nos. 42, 51, 80).

Widely diffused through the Gulf and across the Indian Ocean.

**Engina mendicaria* (L) (Tosi *et al.* 1981: nos. 54, 83). Arabian Sea and Indian Ocean; does not live in the Gulf.

**Oliva bulbosa* Röding (cf. Tosi *et al.* 1981: nos. 81, 91).

Gulf and Indian Ocean.

Columbella sp.

**Conus ebraeus* (cf. Tosi *et al.* 1981: nos. 15, 38).

Indian Ocean.

Dentalium sp. (cf. Tosi *et al.* 1981: no. 14).

For use these shells might be modified in a number of simple ways:

1. Perforation by piercing.
2. Perforation by grinding.
3. Perforation by drilling; *Oliva/Conus*: the top is ground so that the canal of the columella could be perforated.
4. The last coil of shell is prepared by grinding and then pierced or widened with an awl.

This category is inevitably a heterogeneous one, since most shells have sufficiently decorative forms to be attractive ornaments. They were most commonly strung as beads, but there are isolated instances of shells set in metal earrings, as at Assur (Haller 1954: 56 (tomb 685)), or as the bezels of metal finger-rings, as at Susa (Mecquenem 1905: 90, fig. 315). In the seventh century BC tablets written in Aramaic were being sealed with

cowrie shells mounted for the purpose, presumably in finger-rings (Homès-Fredericq 1986: pl. 25). The smaller gastropods (e.g. *Arcularia*; *Columbella*; *Conus*; *Engina mendicaria*) might have their body whorl pierced, bored, or cut with a pointed tool or blade, for threading, or else the apex purposely removed for stringing (cf. Tosi *et al.* 1981: 15–16, 20). Scaphopoda (dentalia), holed at both ends, were natural beads, as had been realized since the earliest settlements in Iraq.

Conus (or *Strombus*) whorl beads are one of the most familiar types of shell ornament throughout the Near East, not least in Mesopotamia, made by sawing off the apex of the shell. Indeed, survival of the debris from this operation (columella; lip; distal end of the shell) would be one of the best indicators of a manufacturing centre. Lateral holes were usually 'hour-glass' borings; surface decoration was incised; and the surface polished with abrasives. Although no working tools for shell have yet been certainly identified in Iraq, Payne (in Moorey 1978: microfiche 2:D12) suggested that flint microborers from the late prehistoric and early historic levels at Kish might have been used for this purpose. The same was probably the case at al-Hiba, where microlithic tools and shells were associated (Carter, E. 1990: 95).

It is noticeable that imperfect shells were also traded, as examples occur of water- or beach-worn specimens. Some shells have already been holed by a carnivorous gastropod.

One of the most distinctive aspects of shell jewellery is the use of the solid spiralling columella of *Fasciolaria trapezium*. They were ground down and perforated to make large cylindrical beads with the distinctive columellar ridges clearly visible in finished examples. On present evidence their chronological range extended from the later prehistoric period, when they were already imitated in baked clay (Mackay 1931: 275–6, pl. 71:14, 16–18, 74:4), into the middle of the third millennium. They occur from Jamdat Nasr and Kish in the north through Tello, Uruk, and Ur (cf. Genouillac 1934: pl. 34, fig. 3c; Heinrich 1936: pl. 31; Woolley 1955: 112, U.19247, pl. 27). They appear in about 8 per cent of the graves reported from the 'Y' Cemetery at Kish, where they were said at times to have been part of 'girdles' (Langdon 1924: 104, pl. 50:2, as 'wood'; Watelin 1934: 28, pl. 19:4).

Gensheimer (1984: 70) has identified two small shell face amulets from the Early Dynastic III Ishtar Temple at Mari as carved from the thick digitations of the *Lambis* shell.

The extent to which shell beads were used in Early Dynastic Mesopotamia, when they appear to have been particularly popular, is impossible to estimate from existing reports. In Cemetery A at Kish, towards the end of the period, shell beads may have been placed more often with female than with male skeletons, but

the available evidence, though better than elsewhere, is not statistically significant. Thereafter it is almost non-existent. Already by the Isin-Larsa period shell is rarely reported by Woolley (1976: 195 ff.) from graves at Ur. Of 198 graves listed, only four are reported to have shell ring beads; 'conches' or large shells are reported in five others, of which that in grave 38 is the most significant. According to Woolley (1976: 243), U.16700 (Grave LG/38) was 'cut as a lamp, with rough spout. Early Dynastic type.' It held 'an unfinished cylinder seal and a set of miniature tools (U.16699), pl. 99'. A cowrie shell was reported in one other grave (LG/28).

The wide appeal of shells as personal ornaments, and perhaps their amuletic role, is illustrated by imitations of them in stone and other materials from prehistoric times (cf. Matarrah: Braidwood, R. J., *et al.* 1952: pl. XII.18), through the early historic period (cf. Kish: Mackay 1929: 293, pl. LX.3–4; Jamdat Nasr: Mackay 1931: 273, pl. LXXII), to the late period when faience was widely used in the production of beads and amulets.

(b) Bangles and rings

The bangles of *Turbinella pyrum* so characteristic of the Indus Valley shell industry (Kenoyer 1984: 54–5, fig. 6) have yet to be identified in Mesopotamia, though at least one is published from Susa (Tosi *et al.* 1981: no. 13, with correction in Gensheimer 1984: 71 n. 56). *Pugilina bucephala* and *Chicoreus ramosus* were also used in the Indus for bangles, but specific identification is difficult from fragments.

Rings made from *Conus* (or *Strombus*) (cf. Gensheimer 1984: 69 n. 18) are recurrent from prehistoric through historic times. Some are of a size suitable for use as finger-rings, but many are too small and were threaded as beads (cf. Tosi *et al.* 1981: nos. 12, 46–8). A distinctive group of shell (*Conus* or *Strombus*) finger-rings decorated with incised figured and geometric designs is only evident at present in the thirteenth to twelfth centuries BC (Beyer 1982; Boehmer 1988). They are found from Mari and Meskéné-Emar on the Euphrates, through sites in the Hamrin region and into Luristan. There is also a closely related series of lobed metal finger-rings. Related rings are reported at Ur (Woolley 1965: 88, 106, pl. 36, U.16187).

(c) Containers and utensils

The best-known examples of shells and containers in Mesopotamia are the so-called 'lamps' of the third millennium BC made from suitably trimmed shells of *Lambis truncata sebae*, sometimes incised or decorated with inlays and overlays. They were also carefully copied in metal, faience, and light-coloured soft stones ('alabaster'), to the extent sometimes of imitating the distinctive digitations usually removed from the natural

shells (cf. Woolley 1934: 283: not 'tridacna'; Watelin 1934: pl. 38: 3). It is now generally agreed (cf. Gensheimer 1984: 69) that they are unlikely to have served as lamps. What have been described as traces of burning may be remnants of a black cosmetic (cf. Mackay 1929: 135, pl. 38.3). Since they have spouts, it is best to follow Woolley in regarding them as utensils for liquids, though their precise function remains an open question (Woolley 1934: 283; cf. Mackay, in Marshall 1931: 569).

Lambis shells were noted in at least 18 per cent of the Early Dynastic I graves recorded in the 'Y' Cemetery at Kish; but only one is recorded a few centuries later in Cemetery A, and then as a cosmetic container. In the Royal Cemetery at Ur 'in many graves there were conch-shells with the natural orifice enlarged and usually with the whorls and column cut away. Sometimes, at the top of the hole or on a bar left across the mouth was carved the head of a bird of prey conventionally rendered and with the eye inlaid with lapis lazuli' (Woolley 1934: 283, pl. 101, U.8191, 8198). They were copied in gold, silver, and copper (Ibid.: pl. 240: type 115).

The shell examples were subject to zoomorphic transformations as in a remarkable bird from grave PG 183 at Ur (Woolley 1934: 283, pl. 102: U.8313): 'the body is made of a large conch shell cut open above; the head is of pink limestone and was fixed on by a peg driven through a hole in the top end of the shell; below the attached head there is encrustation work imitating the bird's breast-feathers in lapis lazuli and shell, small diamond and triangular pieces set in bitumen'. Some were modified for mounting on a foot, as at Khafajah: 'a round hole .05 in diameter in the bottom of the lamp is filled by a piece of lead with projections which may have fixed it to a foot of clay or bitumen' (Frankfort *et al.* 1932: 91).

This use of large gastropods is evident at all sites of the Early Dynastic period where there have been extensive excavations including graves: at Bismaya, in the Diyala, at Fara, at Kish, at Tello, Ubaid, and Ur (cf. Aynard 1966); but there is virtually no evidence for such vessels later nor of their shapes copied in sheet-metal vessels. They appear specifically to be an aspect of trade with the Gulf of Oman in the third millennium. In this case the raw shells were traded into Mesopotamia and manufactured locally with decoration in Sumerian style.

There are, however, isolated cases of shell utensils that were certainly imported ready-made at this time. A large ladle made from *Chicoreus ramosus*, an uncommon shell on Mesopotamian sites, was reported from the pioneer excavations at Telloh (Aynard 1966: 31). Such artefacts have only been documented in the Indus Valley civilization (Kenoyer 1984: 56, fig. 7), whence it almost certainly came in the mid- or later

third millennium BC. In the Indus they were highly prized objects, involving a considerable amount of skilled labour to produce, first apparent in the Mature Indus period and not found after the decline of the major urban centres.

The confusion of *Lambis* and *Turbinella* has already been mentioned; but there are cases of *Turbinella* or *Xancus* used for vessels in Mesopotamia. Grave 513, for a man, in the Early Dynastic 'Y' Cemetery at Kish, contained a *Turbinella* or *Xancus* shell worked into a vessel. In the same cemetery were examples of *Charonia* sp. in about 1 per cent of the reported graves, presumably also there as containers (identifications by D. Reese).

Natural shells, particularly small bivalves, make excellent containers and were exploited, predominantly in the third millennium BC, to hold cosmetic pigments. Cockle shells (Arcidae; Cardiidae) were especially favoured then. They were basically unmodified for this purpose. In grave 91 of Cemetery A at Kish, *Paphia malabarica* (a Venus shell), not *Ostrea edulis* (an oyster) (Mackay 1929: 132, corrected by Reese), appeared instead of the more usual *Laevicardium*. Kish in Early Dynastic III is also one of the few places where *Lambis* is clearly recorded in a grave with 'traces of a black pigment resembling kohl' (Mackay 1929: 136, pl. 38: 3); these are the containers so often called 'lamps' (see above).

It is particularly unfortunate that the sex of skeletons was not identified for correlation with the occurrence of cosmetic shells in the Royal Cemetery at Ur and elsewhere, save in the Early Dynastic III B to early Akkadian A cemetery at Kish, where cosmetic shells are reported in 57 per cent (17:30) of male graves, 22 per cent (2:9) of female graves, and 25 per cent (4:16) of the graves of youths or children. The single occurrence of copper imitations was in a male grave, whilst all metal toilet or cosmetic sets were also in male graves (contra Mackay 1929: 130, 168; Susan Pollock: personal communication).

The chronological range of these pairs of cosmetic shells remains an open question. At Khafajah they, and their imitations in copper, do not appear in the grave sequence before levels attributed to Early Dynastic II; previously, cosmetic pigments were placed in stone jars (Delougaz 1967: 134 ff.). Of the graves recorded before Early Dynastic II, 15 per cent (13:85) held stone cosmetic jars, in about 50 per cent of cases in pairs; of the graves recorded for Early Dynastic II-IIIa, 21 per cent (18:83) had shell cosmetic containers, 6 per cent (5:83) their imitations in copper. At Kish there was minimal record of cosmetic shells in graves of the 'Y' Cemetery (Early Dynastic I: 4 per cent), but they were represented in 42 per cent of the graves in the 'A' Cemetery (Early Dynastic IIb-Early Akkadian) (Moorey 1978: microfiche 1 D07-F14).

The sparse record of 'cosmetic shells' in graves of the Late Prehistoric to Early Dynastic II sequence at Ur (Woolley 1955: 104 ff.) is comparable to the Diyala sites and to Kish, as is the very marked rise in frequency in Early Dynastic III (Woolley 1934: 412 ff.). 'Every woman's grave of the old cemetery seems originally to have contained cosmetics . . . The ordinary receptacle is a cockle shell, or rather a pair of cockle shells of which one is the receptacle proper and the other the lid; in many graves the shells were numerous, in that of Queen (Pu-abi) they were of abnormal size; imitation shells in copper, silver and gold were found in richer graves (Pl. 165)' (Woolley 1934: 245). As already noted, the Kish evidence questions Woolley's assumption about a female monopoly. In the same period at Abu Salabikh 'cosmetic shells (*Cardium* sp.) were frequent' (Martin *et al.* 1985: 4).

At some point in the last quarter of the third millennium BC the packaging of cosmetic pigments becomes archaeologically elusive since they are no longer regularly placed in shells, or in any other medium, in graves. As such containers are not reported in other contexts, it has to be assumed that for a period of time shells no longer served this specific purpose. In writing of a cache of Neo-Assyrian objects found at Nimrud in a wall cavity in the North-West Palace, Mallowan (1966: 114, pl. 57) referred to 'an assortment of coloured shells . . . in addition cockle shells intended to hold kohl for the eyebrows; one of them, ND 1714, was decorated with a spirited engraving of a scorpion'; this is a dog-cockle shell. However, he does not make clear whether or not traces of cosmetic were still evident to support this identification, or whether this was an assumption, as may well be the case.

After the wide variety of shells used for artefacts in the third millennium BC there are very few distinctive groups later in the historic period. The most conspicuous in the archaeological record is best known from fragments, since undamaged examples are exceedingly rare. These decorated *Tridacna* (giant clam) shells all date to a brief period of time, probably within the second half of the seventh century BC. Their exact origin and function remain debatable (cf. Stucky 1974; Reese 1988). The decorated shells are all of *Tridacna squamosa*, found both in the Red Sea and in the Gulf. This shell has a hardness of 3 on the Mohs scale and the density of calcite ('alabaster'), with which fragments of it are sometimes confused. The projecting scales were removed with a hammer or forceps and the outer surface smoothed down with abrasives and polished to prepare it for decoration. Linear designs were then engraved with a burin of semicircular or square section, not always to a high level of skill.

Unworked or partly worked fragments of *Tridacna* have been reported in some quantity from Syro-Palestine (Reese 1988: 40); but are rare on sites in

Mesopotamia, where they are listed for Babylon (Reese 1988: 37), Nimrud (Reese 1988: 40), and Uruk (Boehmer 1987: 103-5, pls. 5-6). Fragmentary decorated pieces steadily accumulate from a widely distributed range of sites extending from the western Mediterranean to Iran (Brandl 1984: fig. 20a). Within Mesopotamia they are currently listed at Assur, Babylon, Kish, Nimrud, Nineveh, Sippar, Uruk, and Ur, as well as from Susa in Iran (Reese 1988: 38). These find-spots offer no grounds for supposing that they were decorated in any of these places. The iconography is narrow in range and certain features are very distinctive, though difficult to pin down to a precise geographical source. The iconography is heavily dependent on the 'Phoenician' tradition, but the workshop(s) producing these decorated shells need not necessarily have been in Phoenicia itself (cf. Culican 1970^a: 67; Stucky 1974: 86 ff.); somewhere in southern Syria or modern Jordan cannot yet be ruled out.

These decorated *Tridacna* shells have commonly been identified as toilet articles, but their precise role remains an open question. They seem unlikely to have been used simply as containers for packaging cosmetic pigments, like the more practical plain third-millennium cockle shells. In a number of examples traces 'of a green colour are visible in the crevices and spaces of the engraved decoration or over the entire surface' (Stucky 1974: 97), as if they had once held cosmetic. If so, it seems most practical to suggest they were palettes in which powdered cosmetics were mixed with oils or unguents for immediate application. In the west there are also stone dishes and plaques, some with similar decoration, which might have served either for grinding or mixing cosmetics, but these are not yet reported from Mesopotamia at the appropriate time (Culican 1970^a).

Also confined at present to Egypt and Syro-Palestine are a series of oval, concave shell disks, with a central hole and floral decoration akin to that used on the complete shells, which have also been identified as *Tridacna* (Brandl 1984), though some are made of other shells. Their function is unknown. They should be distinguished from a distinct class of Iron Age shell disk, which is made from other types of shell, and has a rather different history and distribution as the following section seeks to explain. It is likely that 'a large *Tridacna* shell . . . ornamented with bands of inlay very similar to those of the inlaid stone vessels from Warka and Khafajah' reported by Perkins (1949: 154) from late prehistoric Khafajah is some other type of shell more akin to the 'lamps'. It has not yet been fully published.

Another group of Iron Age disks, this time cut from *Xancus gravis* (Barnett 1963: 82), has a rather different history and distribution. They have a central hole, sometimes with a bronze nail still surviving in it, and on

occasion more holes similarly equipped (Barnett 1963: pl. XVI). In addition to incised geometric decoration on the outer surface, commonly incised concentric circles, these shells sometimes bear inscriptions on their inner faces. They also have small holes drilled in a small ledge on an inner edge, representing the first whorl of the complete shell from which they were cut. According to Barnett the 'nails' did not secure the shells to anything, but served to increase the noise they made when fitted together in pairs as castanets or clappers (cf. Rashid 1984: 110-11). He believed they were secured together by thongs through the holes in the pierced ledges. Herzfeld had originally identified them as shield bosses, whilst Mallowan (1966: 125, 452, pl. 66) preferred a role in the decoration of horses or chariots.

Examples without known archaeological context have been reported from nineteenth-century excavations at Nimrud, Nineveh, and Sippar (Barnett 1963); but in more recent excavations at Nimrud they were found in a well in the North-West Palace (Mallowan 1966: 125, pl. 66) and in Fort Shalmaneser (*ibid.*: 452). In the first context they were associated with other, smaller ornaments made of shell cut in various shapes, some with metal studs still in position. Mallowan (1966: 125) compared them to figure-of-eight horse-trappings shown on the reliefs of Sargon and Sennacherib and dated them accordingly. In Room T10 in the south wing of Fort Shalmaneser amid debris from the sack of Nimrud about 614 BC were more fragments of the disks, some of which bore on the inside the name, in Hittite hieroglyphs, of Irhuleni, King of Hamath, at the time of Shalmaneser III in the ninth century (Barnett 1963: 82-4; Mallowan 1966: 452). Whatever the precise purpose of these objects, they are significantly earlier than the *Tridacna* group previously mentioned (see above). A stray example is reported from the Anglo-American excavations at Kish 1923-33 (D. Reese: personal communication).

Oval and circular bosses or disks cut from large gastropods and drilled with a central hole are reported from Hasanlu (Reese 1989: 85) and Susa (Tosi *et al.* 1981: no. 18). The former are Iron Age and the latter undated; but Gensheimer (1984: 71) has called attention to their similarity to shell disks made from *Turbinella pyrum* at Indus sites in the third millennium. These examples lack the central metal stud. It is likely that such objects served a variety of functions and that the decorated group associated at present particularly with Neo-Assyrian sites stand at the end of an extended history.

(d) Seals

By the later prehistoric period in Sumer occasional stamp seals were made from shell, sometimes in animal shapes (cf. Buchanan and Moorey 1984: no. 224; Kish).

Shell was also employed early for cylinder seals; some 13 per cent of those registered for the late prehistoric period in the Diyala were of shell (cf. Frankfort 1955). Shell was used through Early Dynastic times, reaching a peak of popularity in Early Dynastic III, before declining to a low point by the end of the millennium. In the British Museum Collection 21 per cent (21: 99) of Early Dynastic III cylinder seals are in shell ('aragonite'); 8.6 per cent (21: 243) in the Akkadian period; 4 per cent (8: 165) in the Ur III period (Collon 1982a: 14); but by the early second millennium less than 1 per cent were made of shell (Collon 1986: 6). Edens (cited by Kohl 1989: 230) has calculated that more than 50 per cent of cylinder seals found at Ur in the Early Dynastic period were made of shell from the Gulf; roughly 36 per cent of Akkadian cylinder seals from Ur, the Diyala sites, Kish, and Susa were of shell.

Most of the long shell cylinder seals of Early Dynastic times were probably cut from the columella of *Fasciolaria trapezium* (cf. Woolley 1934: pl. 221: U.71). As the diameter of this columella is relatively small, such seals are characteristically long and thin with a diameter of less than 25 mm. The large shell cylinder seals especially distinctive of certain Early Dynastic III male graves at Ur (Woolley 1934: pls. 196-7, figs. 54, 57-60) may have been cut from the more massive columella of *Turbinella pyrum* (Gensheimer 1984: 71), such also may be the case with shell seals reported from Gawra and Susa about the same time. Some large shell cylinder seals were ingeniously made by joining sections of shell together (Woolley 1934: pl. 99a: U.9907).

(e) Spindle-whorls

Shell is a perfectly appropriate material for spindle-whorls and is reported in this role from time to time (cf. Mackay 1929: 135), sometimes made from the apex of *Strombus* shells.

(f) Inlays

One of the outstanding features of the applied arts in Sumer before the Akkadian period was the use of light-coloured stones, shells, mother-of-pearl, and much more rarely ivory, for inlays set in dark stone and in wood (Dolce 1978). Since inlays of shell were originally cut from small pieces and are now often fragmentary, their proper identification is difficult. The outer portions of *Fasciolaria trapezium* were probably used for the purpose, though no systematic attempt at identification has yet been made. *Lambis truncata sebae* was similarly employed. Gensheimer (1984: 70) detects the distinctive wavy growth lines of *Lambis* on an engraved Early Dynastic III shell plaque from Tell al-Ubaid (Hall and Woolley 1927: pl. XXXV.3). At Harappa and Mohenjo-Daro *Fasciolaria trapezium* 'was used almost exclusively for the manufacture of inlay . . . *Lambis*

truncata sebae was used primarily for making exceptionally large, solid plaques' (Kenoyer 1984: 56-7).

Although precursors to this technique of inlay decoration may be found at Uruk in the late prehistoric period, in terracotta (Dolce 1978: pls. I-III), the use of shell is not evident yet before the phase in the Diyala defined as Early Dynastic II. Two fragmentary schist plaques from Temple Oval II-III at Khafajah have cavities cut in them to take silhouettes of shell and limestone (Frankfort 1939: 47, nos. 197-8). In one case the design is entirely of goats and sheep in frieze; the other is too fragmentary for identification.

The most important examples of architectural plaques and friezes made like this, though much more damaged, were found in Palace A at Kish (Mackay 1929; Dolce 1978: i. 73 ff.; ii. 20 ff.), contemporary with the inlays from Khafajah, the Pre-Sargonic Palace at Mari (Dolce 1978: i. 148 ff., pls. xxxvi-IX), and the temple at Tell al-Ubaid (Hall and Woolley 1927; Dolce 1978: ii. 156 ff., pls. XLIII-XLVII). With the possible exception of the last group, they were interior fittings applied to mudbrick walls in dark stone settings. The palaces have scenes of military triumph, with processions of booty, and banqueting; the temple frieze has pastoral scenes appropriate to the goddess Nin-Khursag. In Room 61 of Palace A at Kish the main inlaid frieze of stone and mother-of-pearl, with a military theme, makes minimum use of shell. But with it were parts of a pastoral scene, with figures on a much smaller scale, in which shell had played a much greater part. The animals are cut from the rounder contours of the shell, which gives these inlays a modelled character entirely lacking in those of stone and of mother-of-pearl. It is possible that these inlays come from wooden fittings as do the most famous Sumerian shell inlays, those from the Royal Cemetery at Ur. Indeed, it is likely, to judge from Dolce's rough statistical tables, that shell inlays found scattered without indication of context came more often from wooden furniture, or possibly inlaid wooden panels on walls, than from formal architectural friezes with stone settings.

The skill with which Woolley recovered the examples of these inlays from the graves at Ur accounts for our exceptional knowledge of this necessarily perishable craft: 'And the same technique that was applied to the decoration of great buildings and wide surfaces was turned as freely to the adornment of small domestic things with that extra refinement of detail which the scale demanded; the mother-of-pearl-encrusted furniture with which the bazaars of Damascus are stocked today is the degenerate but direct descendant of an applied art brought to its highest pitch by the Sumerians . . .' (Woolley 1934: 262).

As Woolley (1934: 263) described, shell was usually treated in one or other of three ways by craftsmen in

Early Dynastic III using it for inlays or overlays (cf. Dolce 1978: 58 ff.):

1. A square or rectangle of polished shell was engraved with a design, then the lines were filled in with red or black pigment; at Ur 'the beast will generally be outlined in black and the conventional trees and landscape in red' (Woolley 1934: 263, pls. 96b, 98a, 99b; cf. Dolce 1978: pl. XIII.W series). Such pieces might also be inlaid with lapis lazuli and other coloured stones.

2. The design would be engraved on a piece of shell and the background then cut back to the depth of 1 mm. or so leaving the figure in raised relief. The background might then be blackened with bitumen to set the figure off (cf. Woolley 1934: pl. 100).

3. Figures or devices were cut entirely in silhouette with the inner details engraved on the surface, again often picked out in black and red. These were either set in bitumen alone or formed part of a design in which pieces of lapis lazuli formed the background, the whole set on a bitumen base (cf. Woolley 1934: pls. 91-3).

The outstanding examples of this technique at Ur are decorated gaming sets, boards and boxes, musical instruments, toilet boxes and chests, as well as vehicles (Woolley 1934: 263 ff.). The repertory of finds in the Royal Cemetery is wide enough to suggest that virtually all luxury wooden furniture was decorated in this way. This inlay technique is not yet evident outside Sumer and Akkad, save for isolated examples at Susa that might be imports (cf. Dolce 1978: 57, 163), nor, more remarkably, does it appear to have survived into the Akkadian period. Half a century after Woolley's remarkable finds it remains one of the most distinctive hallmarks of Sumerian craftsmanship. Although the iconography is overwhelmingly local in origin, it remains possible that the ultimate source of the fashion in Early Dynastic II/III was the Indus Valley, where shell inlay was 'quite common at Mohenjo Daro and other large urban sites' (Kenoyer 1984: 56 ff.), though apparently not so various as it became in Sumer.

Bow-drills fitted with chipped stone bits were probably used in the manufacture both of shell and of stone inlays. In the absence of pattern saws they were used into recent times in the Near East to cut out the outline of linear patterns by workers in metal, plaster, and wood (cf. Wulff 1966: 73, 98). Indeed, the spindle-tipped borers found at Tell al-Ubaid (Hall and Woolley 1927: pl. 13.5, centre row) may well have been used in the production of the shapes for mosaics found in the temple there. Shell is brittle; breaking might well have been minimized by first drilling a line of holes following the outline of the desired shape and then finishing it with abrasives. Bone and shell silhouettes reported from Mari have a pattern of drill holes of uniform diameter like those produced by a bow-drill fitted with

spindle-tipped stone borers (Parrot 1960: 142, fig. 171; 1967: pl. LXIX.2690).

The history of shell inlays in wood is not again evident until the Neo-Assyrian period, when remains of furniture found in Fort Shalmaneser at Nimrud reveal its continuing popularity. In the room NE26 were scattered pieces of floral friezes executed in shell inlays, arched lotus buds and rosettes, perhaps from the back of a couch (Mallowan 1966: 396, pl. 323). Also scattered in this apartment, presumably from the decoration of wooden furniture made in the ninth or eighth centuries BC, were sphinxes, trees, and winged genii carrying buckets, all cut from shell with details incised on the surface (Mallowan 1966: 396, pls. 326-30). They are very reminiscent of a series of plaques made in copper or bronze for furniture decoration, some found by Layard and others by Mallowan at Nimrud. Their iconography, as with those in shell, indicates manufacture within Mesopotamia (Mallowan 1966: pls. 324-5). In another part of Fort Shalmaneser (SW34) Mallowan reported 'bronze rosettes and a small shell plaque fragment depicting a male figure carrying a bucket' (ibid.: 407); and 'one more curious discovery occurred in the bathroom [as SW3 was thought to be] namely a large quantity of shell tesserae, mostly cut and perforated as polygons. They would seem to be rejected portions of conches thrown out by shell-cutters who presumably had a workshop within the arsenal. The discovery of a number of carved shell objects already noted is consistent with this hypothesis.'

(g) Ritual and votive use of shells

The evidence of material culture illustrates the textual evidence for the deposit of shells in foundation deposits throughout historic times (cf. Ellis 1968: 132-3, 135-6; Aynard 1966: 32-3). No systematic identification of shells in such contexts has yet been undertaken to see if there is a recurrent pattern of species. At present only two shells with royal votive inscriptions have been published, both from the collections of the Louvre. One is a *Chicoreus ramosus*, dedicated by Rimush (2278-2270 BC), from Tello (*Girsu*) (Aynard 1966: 21-2; Tosi *et al.* 1981: no. 6); the other a *Mitra episcalia* Lamarck, again from Tello, dedicated by Ur-Ningirsu in the Neo-Sumerian period (Tosi *et al.* 1981: no. 7).

(h) Miscellaneous industrial uses

Evidence for the use of shell beyond the manufacture of artefacts is rare and may too easily be assumed in specific cases. Wilkins (in Mallowan 1966: 635), in identifying shells from Nimrud, listed among them *Murex trunculus* with the comment, 'shell broken for extracting purple dye'. However, there is no evidence elsewhere to suggest that *Phyllonotus* (*Murex*) *trunculus*, also listed at Nuzi (in Starr 1939: 489), was present at Nimrud in quantities in the Neo-Assyrian period

sufficient to indicate the manufacture there of purple dye. It has been calculated that 12,000 *Bolinus (Murex) brandaris* produce 1.5 g. of pure dye, enough to colour the trim of a single garment (cf. Reese 1979–80: 83; in general, Jensen 1963; on technique, Michel and McGovern 1987; on chemistry, Ziderman 1990, with bibliography). As had long been the case (cf. Dalley 1984: 54), blue- and red-purple dyed fabrics reached Mesopotamia as finished goods from workshops in Syro-Phoenicia.

In the first millennium BC the Phoenicians produced two distinct purple products, a blue-purple (hyacinth) and a red-purple ('Tyrian purple'). As long ago as 1864 a mound of banded dye-murex (*Phyllonotus (Murex) trunculus*), all broken above the chromogenic gland, revealed the species from which the blue-purple had been made. Nearby, but quite separate, was a second mound of spiny dye-murex (*Bolinus (Murex) brandaris*) and the rock shell or oyster drill (*Thais haemastoma*) for manufacture of red-purple. The latter does not yield a fast dye alone so was mixed with murex species. The ancient shell deposits at Tyre appear to be exclusively the spiny dye-murex for making 'Tyrian purple'. As all three are both ornamental and edible, it is always necessary to seek supplementary evidence for their use in any particular context. Reese (1979–80) has pointed out that beach- and water-wear allow for determination of whether the shell was collected alive, as for food or dyeing, or dead, as for ornamental or secondary use.

According to the excavator's report on Room 24 in the early second-millennium BC palace at Mari, many of a series of over twenty baked clay oval containers found there contained 'petits coquillages blancs' (Parrot 1958: 190). On account of the regular rows of mudbrick 'benches' found in this room Parrot identified it as a scribal school, suggesting that the shells might have been used in teaching the pupils to count. As no school exercises, or any other decisive evidence, was found here, philologists have doubted the identification as a schoolroom. It is, moreover, difficult to imagine the reading and writing of tablets in a room as poorly lighted as this probably was. The same objection would apply to Dalley's proposal that tailors may have squatted on the 'benches' (Dalley 1984: 29 n. 21). It is, for the moment, an enigma.

The use of ground shell in the production of glass is evident in texts (cf. Oppenheim *et al.* 1970), as are other industrial uses. Ghirshman's (1966: 18, pl. XX.5) suggestion that a group of shells in a chamber of the ziggurat at Tchoga-Zanbil were to be ground up for mixing with pigment is conjectural.

(i) Select check-list of specialist shell identification

I am much indebted to the advice of Dr David Reese over many years. Through him I was able to see K. D. Thomas's report on the shells from Umm Dabighiyah

and his own reports on the shells from Uch Tepe and from the Oxford-Field Museum (Chicago) Excavations at Kish.

1. Tell Abaqa: Amberger 1987.
2. Tell ed-Der: Gautier 1978, 1989.
3. Tell Gubba: Ii 1989: 216–21.
4. Tell al-Hiba: Mudar 1982.
5. Kish: Moorey 1978: *passim* (identifications by D. F. W. Baden Powell; corrections by D. Reese).
6. Nimrud: Wilkins in Malloyan 1966: 635.
7. Nineveh: Tomlin's identification cited in Beck, H. C. 1931: 432.
8. Nuzi: Starr 1939: 489.
9. Tell Rimah: Carter, T. H. 1965: 57–8 (T. Abbott and R. Robertson).
10. Tell Sabra: Gautier 1988.
11. Uch Tepe: D. Reese: manuscript.
12. Uruk: Boehmer *et al.* 1987: 74 ff., pl. 102.

(j) Notes on the pigments found in cosmetic shells

The only scientific identifications of cosmetic pigments at present available for Mesopotamia were made on samples of third-millennium date. The pigments used in wall-painting changed little once the repertory had been established (see p. 327), so there is no reason to think otherwise for cosmetics. Inspection by eye supports this view. Bimson (1980) re-investigated the cosmetics from graves in the Royal Cemetery at Ur, first scientifically studied by Graham (1928; cf. Woolley 1934: 245, 248), providing the best available range of scientific determinations. She observed that study of the cosmetic shells from this context now in the British Museum supported Woolley's opinion that green and black pigments predominate, with blue, purple, red, white, and yellow among the other colours less commonly represented. Such also was the case in Egypt (Lucas 1962: 80 ff.). Records of frequency have only been provided for the Early Dynastic IIB to Early Akkadian Cemetery A at Kish, where 'the colours found, arranged in order of frequency, are black 17 times, red 5, green 5, white 3, blue 1. In none of the burials was a complete set of pigments found; there were never more than two in the same grave' (Mackay 1925: 14–15). In the excavation season to which Mackay refers 38 graves were recorded; 4 cosmetic shells were recorded in one grave (no. 24, female), 2 in fifteen graves, and 1 in two graves.

Black/dark brown. These pigments have been found to be particularly variable. X-ray fluorescence showed that the major elements were either manganese and iron; manganese alone; calcium, manganese, iron and copper, or manganese and calcium; minor elements such as lead, sulphur, titanium, and zinc were also present. The colour was provided by the oxides of

manganese (pyrolusite). It is not certain whether these were artificial or natural mixtures, which they might be. Tosi (personal communication) has identified a workshop in Oman, where he believes pyrolusite was processed into kohl and packaged in shells for export.

Two samples tested by Brill (1970: 117 n. 14) from stone vessels, excavated at Khafajah and dated c. 2700 BC, 'were found to contain manganese as their only major metallic component . . . probably in the form of the mineral pyrolusite'. A sample of dark cosmetic pigment from a pair of cosmetic shells found in the Early Dynastic III 'Plano-Convex Building' at Kish, tested in Oxford, was reported to be lead sulphide (galena) (cf. Brill 1970: 118 n. 14; Moorey 1978: microfiche 1: BO8), which appears to have been particularly favoured in Egypt (Lucas 1962: 80–3), followed by manganese oxide. A Sumerian literary text (Stol 1989: 165–6) indicates that lead for kohl came to Sumer from Elam. As in ancient Egypt, there is no firm evidence that antimony or an antimony compound was a major constituent of eye-paint (*kohl*) in Mesopotamia (cf. Lucas 1962: 81–2; Brill 1970: 117).

Blue. This is usually a pale shade of blue, commonly azurite, sometimes with a white dilutant identified by Bimson (1980: 77) 'as hydroxy-apatite but cerussite may have been present in others'.

Green: This again is a copper mineral (azurite/apatite/malachite) modified with a white dilutant in the form of cerussite or hydroxy-apatite (Bimson 1980: 75–6; cf. Brill 1970: 117–8 n. 14).

Purple: Only one sample of this colour, from Ur, has been analysed; Bimson (1980: 77) identified it as 'almost certainly a naturally occurring ferruginous earth' (haematite and quartz).

Red: This is haematite, the commonest natural red pigment (Bimson 1980: 76–7).

White. Bimson (1980: 75) did not rule out a mineralogical source, but thought it most likely to be calcined bone, the commonest source of hydroxy-apatite.

Yellow. This is an ochre, in one case identified as goethite (iron oxide hydroxide). Bimson (1980: 77) also examined 'a brilliant yellow cosmetic . . . intermingled with green; this yellow was found to contain wulfenite which is a relatively uncommon mineral and so far as is known has not been identified before in a similar context'.

(k) Mother-of-pearl

Mother of pearl is the nacreous material lining the shell of the black-lip pearl oyster (*Pinctada margaritifera* (L.)), which has the same composition as pearl, essentially calcium carbonate. As it can be obtained from the Gulf and waters east, this was the most probable source exploited in ancient Mesopotamia, though it may also be obtained from the Red Sea (cf. Lucas 1962: 38). It is most evident in the Early Dynastic period

when, like shell, it was employed for personal ornaments and inlays. Its restricted appearance and the artefacts on which it was used indicate a luxury, most fashionable for a relatively brief period of time, when shell was also exploited to an unusual degree for manufacture during Early Dynastic III.

Mother-of-pearl pendants are regularly reported in Early Dynastic graves, notably in the Royal Cemetery at Ur (cf. Woolley 1934: U. 8073 in PG 95), but in other roles it is rarer. In Pu-abī's grave it was used to decorate what may have been a knife-handle (Woolley 1934: pl. 101: U. 10437); a little toilet box had sides which were 'plates of nacreous shell and panels of mosaic encrusted on a wooden box of which the substance had perished' (Woolley 1934: pl. 101: U. 14483A). Although isolated decorative fittings are reported, as with a rosette in PG 169 at Ur (Woolley 1934: pl. 221: U. 8301), mother-of-pearl was most often used for inlays in wooden settings. As Dolce's (1978: 12 ff.) survey has shown, mother-of-pearl inlays appear already in the Uruk IV–III horizon, though as a low percentage of the materials used for this purpose (12 per cent). In the Early Dynastic II/III time-range Dolce lists no mother-of-pearl inlays cut as humans or animals at Tell Chuera, Khafajah, Nippur, or al-Ubaid, but mother-of-pearl was combined with red and black stone in the decorative sheathing of wooden columns at Ubaid. By comparison with other inlay materials in her lists, mother-of-pearl constitutes 83.4 per cent at Tell Asmar, 46.8 per cent at Telloh (*Girsu*), 33.3 per cent at Bismaya, 26.5 per cent at Kish, and 15.4 per cent at Ur, with only 0.5 per cent attributed to the Royal Cemetery. The extensive range of inlays published from Mari allow for some breakdown by building, all, save the Pre-Sargonic Palace (56.25 per cent), religious structures: Temple of Ishtar (57.2 per cent), Temple of Dagan (23.8 per cent), Temple of Ishtar (45.5 per cent), and Temple of Ninnizaza (89.8 per cent). No mother-of-pearl inlays are listed for the Temple of Ninkhursag, the Temple of Shamash, or the *Massif Rouge*. Mother-of-pearl is very occasionally listed as the material of cylinder seals (cf. Frankfort 1955: nos. 5, 208, late prehistoric).

With the exception of elephant ivory the materials discussed in this chapter had been exploited in Mesopotamia from the earliest phase of settlement in the plain. Techniques for their manufacture, primarily cutting and drilling, abrading and polishing, had been developed long before the earliest farming communities were established and were changed little in the following millennia, save for the introduction of new abrasives and of copper alloys and iron for tools. Locally available bone, antler, horn, boar's tusk, and ostrich shell were recurrently used for the subsistence crafts, more rarely in the making of luxury equipment. The

imported materials, ivory and most shells, were primarily employed by craftsmen in palace and temple workshops, who particularly exploited the varieties available through the Gulf Trade, c.2600 to about 1750 BC, and again in the Neo-Babylonian and Achaemenid periods, and from the west at the time of the Middle and Neo-Assyrian empires in the later second and earlier first millennium BC. Foreign workmen had often travelled from the same regions as the raw materials, bringing their skills and working tools with them on occasion (cf. Oded 1979). Artefacts made locally from these materials serviced local needs and were not exported through commercial networks, though fine goods may have travelled as gift-exchanges, or as tribute or booty when invaders entered the plain. If and when they did,

they did not apparently influence craftsmen in adjacent regions as comparable Egyptian goods did. The materials and the few basic techniques needed to exploit them were widely available in the Near East. Mesopotamia had no monopoly, and her styles and iconography do not appear to have had the appeal that those of Egyptian or Egyptianizing products so clearly did particularly from the mid-second to the mid-first millennium BC.

The crafts considered in this and the two preceding chapters depended upon mechanical modification of raw materials; those to be considered in the next three chapters involve the chemical manipulation of materials, a mastery of pyrotechnology, and more sophisticated skills and equipment.

4

THE CERAMIC AND GLASSWORKING CRAFTS

1. The Craft of the Potter

THE POTTERY OF MESOPOTAMIA IN ANTIQUITY, like that of Egypt, is remarkable for the prehistoric painted wares rather than for the almost invariably undecorated and standardized forms mass-produced in the historic periods. Although archaeologists have traditionally studied the morphology and typology of pottery as if it was particularly indicative of change, anthropologists have observed that potters are natural conservatives. Times of major political or social change rarely have complementary effects upon potting traditions. The relatively low socio-economic position of potters in many societies, as in historic Mesopotamia, has often been quoted as a significant reason for their conservatism. However, there are a number of technological and social sanctions against unnecessary or rapid change in the potter's craft. Once an acceptable range of materials has been secured, suitable for the type of pottery most commonly required, and the routine of production established, then workshop procedures will soon become fixed and hard to change, particularly if all resources are locally available. Moreover, once a repertory of utilitarian shapes for specific local requirements is established it is likely to be retained for very long periods; decoration is the element most subject to change. It is then no surprise to find that the Neolithic pottery of northern Iraq, as elsewhere in the region, already shows many of the elements of the local potter's craft which were to characterize its production for millennia thereafter.

(i) TEXTS AND PICTURES

Pottery is a craft poorly represented in the Mesopotamian textual record, where it is either taken for granted or not regarded as appropriate for specific record in those palace or temple archives most commonly recovered in excavations. Barrelet (1968: 7 ff.) and Salonen (E. 1970: 316–24) have assembled the meagre literary evidence for potters and their procedures. The term 'potter' is used for the craftsman who makes pottery and other objects of clay; deities are described as modelling clay to form anthropomorphic figures, vessels,

and bricks, sometimes designated as 'potters'. Salonen (A. 1966) gathered information on the terminology of vessels; an exercise compromised by the acute difficulty of marrying up the evidence of words and the available artefacts, whilst Waetzoldt (1971) has published in detail one of the rare texts, of the Ur III period, devoted to pot-making. What evidence there is in texts for the location of pottery manufacture points to the fact that it is one of those crafts better pursued away from towns, on account of the social nuisance of kiln firing and the need for readily available raw materials and water. Texts refer to 'villages' or 'towns' of potters and sometimes, as at Nuzi, to potters' 'quarters'. Although pigments and colourants might be traded from elsewhere, clays and tempering materials, silica, alkalis, and water, would be preferred close to hand.

Although potting is identified as a specialist craft from its earliest appearance in texts, some at least of its practitioners also worked as labourers on canals and in fields (cf. Waetzoldt 1971: 9–10). Many may only have worked full-time for part of the year, since the wet season would have imposed restraints on dry storage of fuel and the drying and firing of pots. The word for potter is rare in third-millennium texts and is absent then from lists of 'civilized' skills (Kramer, S. N. 1956: 91–3). By at least the Ur III period in the major organizations of palace and temple, the work practices of potters were carefully organized and controlled, with potters in some cases serving, under a supervisor, in groups varying from two to ten in size (Waetzoldt 1971). However, even some large temple households at this time appear to have had only one potter on their permanent staff. There is little hard evidence, at least at this stage, to suggest that it was a centralized industry in any real sense; but, since it became specialized early, there is a general conformity of type and technique over wide areas by the third millennium. The absence of pottery from textual sources emphasizes the importance of archaeology in providing the information necessary for establishing its place in the local economy.

Mesopotamia entirely lacks the representations of pottery manufacture found in ancient Egyptian tombs, mainly of Old and Middle Kingdom date, but with a

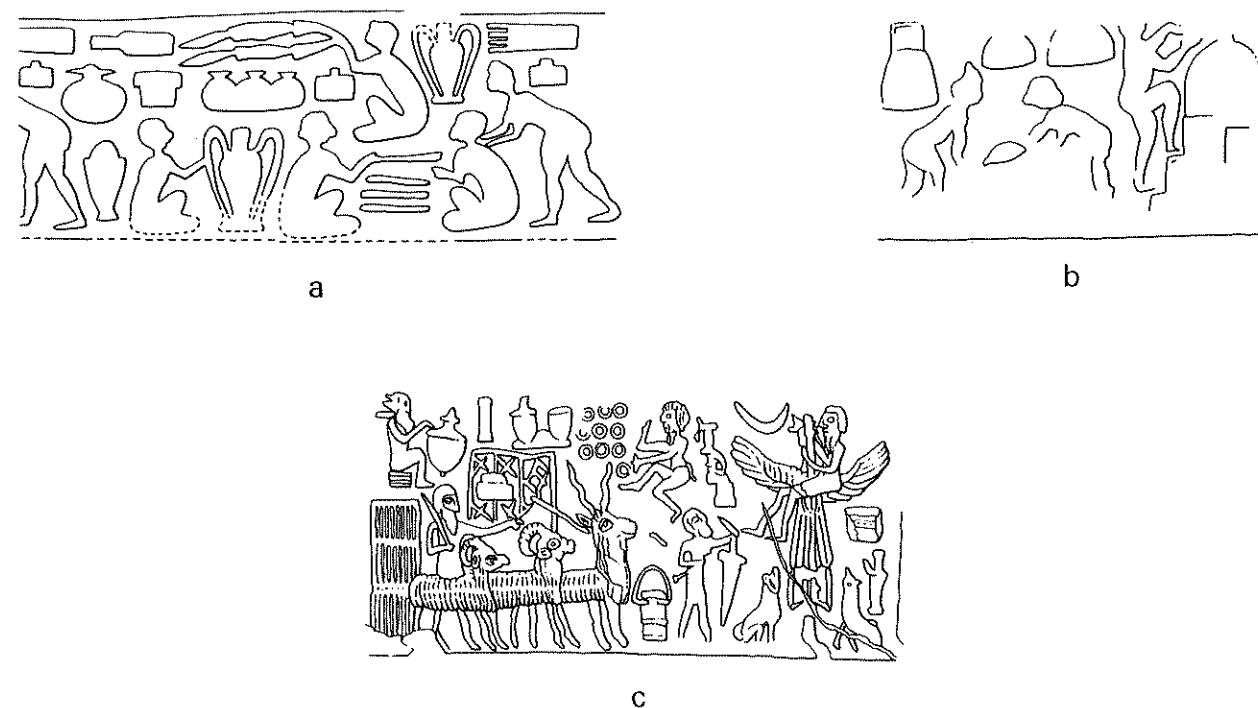


Fig. 8. (a) Ancient seal impression from Susa, Iran, c.3500–3200 BC, perhaps showing pottery-making (after Amiet 1980: fig. 205). (b) Ancient seal impression from Susa, Iran, c.3500–3000 BC, interpreted either as filling a kiln or a granary (after Amiet 1980: fig. 269). (c) Modern impression from an Akkadian cylinder seal (c.2350–2100 BC) variously interpreted as illustrating potting or cheese-making (after Boehmer 1965: no. 693).

few examples as late as the New Kingdom. Nor are there any models of potters at work to match the fairly numerous examples from tombs of the late Old Kingdom and First Intermediate Period (cf. Holthoer 1977: 5–26). The only illustrations from Mesopotamia possibly relevant to the production of pottery are on seals and sealings, of the later fourth millennium BC, which show pots in a variety of contexts. There have long been doubts about precisely what is depicted, since the miniature scale inevitably lacks detail (cf. Frankfort 1939a: 36–7; Amiet 1980: 103 n. 13; Baudot 1979). Barrelet (1968: 19–12, figs. 3–4) accepts them as scenes of pot-making and identifies the potters as female. The range of vessels represented in these scenes embraces bowls and dishes, jars (with looped appendages, as if for transport), drinking-vessels, stands, and stemmed dishes. Scenes of rural activity, of banquets and drinking sessions, and of offerings blend cult activities and daily life in a way that makes it difficult to distinguish them. It is not at all clear that the rows of pigtailed women shown squatting before triple-mouthed jars, or lines of seated figures with arms outstretched towards a jar set between them, are meant to be seen as making them; if so, some form of mass-production is implied. A group of seal impressions from Susa has been inter-

preted as showing the preparation and loading of a domed pottery kiln (cf. Amiet 1980: pl. 16, nos. 267–9); but interpretation as bread ovens or even as granaries is equally plausible. Transport of large jars in carrying devices is more easily recognized, but for what purpose is not clear (Amiet 1980: pl. 16, no. 264; Baudot 1979: 57, no. 18). Crawford (H. E. W. 1991: 129) suggests that some of these scenes may show pots in simple single-storey kilns or clamps (cf. Amiet 1980: figs. 324, 1605).

Porada (1984) has argued that a distinctive group of cylinder seals of the Akkadian period, possibly illustrating an episode in the story of Etana, includes a vignette showing potting (also Alden 1988). Frankfort (1939: 139) originally interpreted this scene as cheese-making. Porada suggested that the ring-shaped objects might be clay coils. In two cases this is plausible, with one man making them, another immediately using them; but in a third case, where they are laid out, they would rapidly have become too dry for a potter to use. An unusually detailed scene of this type on a cylinder seal (formerly Schuster Collection: *Sotheby's Catalogue* 10.7.1989, no. 5) shows a kneeling woman working with both hands in a trough, whilst a man seated in front of her lays out ring-shaped objects on a flat surface. Here either bread

production (cf. Moorey 1975: 95, pl. XXIIb) or cheese-making seems more probable.

Isolated inscriptions on vessels sometimes give its name, from which it may be possible to define the function. A rim-sherd found at Failaka, for instance, has a cuneiform inscription referring to '1 kakkullum vat', known from other sources to be used for fermenting in beer production (cf. Eidem, in Højlund 1987: 179). Otherwise no serious attention has yet been paid to this problem, save in unusual cases, as with the bevelled-rim bowl (see below) or the possible use of Early Dynastic solid-footed goblets in the salt trade (Potts, D. 1984).

(ii) ARCHAEOLOGICAL EVIDENCE

(a) *The contribution of science*

If modern knowledge of an ancient craft was in direct relation to the quantity and range of its products retrieved through excavation and survey, pottery manufacture would be the best understood of Mesopotamian industries. This is not the case. In Mesopotamia, as elsewhere, archaeologists until very recently were only interested in the finished product, preferably fine decorated wares in complete examples, for study by eye typologically for one or other of four purposes: as the basis for the division of the archaeological record into 'cultures' or 'traditions'; as a means of dating; as an indicator of cultural diffusion; and, more rarely, as a sign of ethnic identity. Questions of function, of manufacture and distribution, were rarely, if ever, raised. This has changed significantly in recent years. The range of enquiries, under the impact of the natural and social sciences on archaeology, has expanded to balance the art-historical bias of these long-standing lines of investigation.

The most coherent new research programme is that created in 1985 under the auspices of the Belgian Archaeological Expedition to Iraq, who have been excavating at Tell ed-Der since 1970. This 'Working Group on Mesopotamian Pottery' is integrating research on archaeological, cultural-historical and technological aspects of local pottery production to study in particular the Old and Middle Babylonian pottery from Tell ed-Der. Shaping techniques are investigated through 'pot-reading' (the reconstruction of forming processes from the observation of traces left by potters on their pots) and through analysis of fabrics combined with replication of manufacturing and firing techniques. Ochsenschlager (1974^a) has explored comparisons between ancient and modern potting methods in southern Iraq.

Natural scientists involved in the study of ancient Mesopotamian ceramics have focused attention on the clay and filler in pottery fabrics through petrological examination and chemical analysis, using an ever-increasing range of analytical and statistical techniques

in order to locate places of manufacture and to map distribution systems. Interpretation of such results is complex and controversial. Thuesen (1987: 130) has argued that it is better to try to understand the sampled pottery as aspects of technological traditions associated with particular 'workshops' rather than to try and locate the physical origins of the vessels sampled:

Traditionally it is assumed that the concentration (of trace elements) are characteristic for the clay sources, which might well be true. But there might be other explanations of a cultural and/or of a non-cultural nature . . . clay mixing, tempering techniques and firing conditions . . . or, the elemental composition of the sample might have been influenced by soaking of deposit through several thousand years . . . Recognition and identification of workshop traditions instead of actual clay sources is in fact a more promising level to operate on in a region where natural clay and silt is abundantly present and perhaps difficult to distinguish from site to site.

(Thuesen 1987^a: 462)

Thuesen's final point is central to any study of the potter's craft in Mesopotamia. Raw materials were generally to hand in alluvial silt from rivers or canals and clay may have been taken particularly from the banks of waterways where it was levigated by natural processes. The study of tempers and tempering methods has barely begun, but it is already apparent that there were variations of every kind across time, space, and types of pottery. As Mynors (1987: 37–8) pointed out, 'fragments of this limestone, sandstone and siltstone are to be found in almost every thin-section of pottery examined from southern Iraq. These inclusions were presumably derived from the erosion of geological outcrops, washed down by the Euphrates river and subsequently deposited in the alluvium. Larger rounded fragments of these sedimentary rocks may represent selection by potters of coarser deposits for mixing with finer alluvial clays.' A number of analysts have noted (cf. Thuesen 1987: 125–6; Noll 1976) that it is virtually impossible to categorize Mesopotamian pottery by the mineralogical composition of the paste. The tempering materials are more discriminatory (for analyses of Mesopotamian clays see Chapter 6).

(b) *The potter's workshop: equipment and the problem of identification*

It has long been customary to identify potters' workplaces in Mesopotamia almost entirely on the evidence of fire installations identified as pottery kilns, often on inadequate evidence. The most reliable evidence of pottery production is sherds or vessels showing clear evidence of damage in firing ('wasters'). They may be discarded in dumps or put to other uses, so the production place need not have been in the immediate vicinity, though it is usually not likely to have been far away. Potmakers' clinker or slag is also indicative. It is siliceous with high potassium and possibly sodium

content, whereas metal slags (equally rarely reported in accurate detail) have a significant metallic content. The more specialized the firing of pottery, the more likely its remnants are to be recognizable when damaged or eroded; but often the critical evidence may only be recovered by sieving all debris found in the vicinity of a fire-installation likely to be a kiln, and this has only recently become standard practice. Pottery kilns, particularly when damaged, may still easily be confused with ovens or with metalworking installations, or with facilities for lime-burning or brick-firing if appropriate debris is not looked for, since the individual characteristics of such features have yet to be systematically worked out (cf. Crawford, H. E. W. 1981; 1983). Open-firing of pottery may, moreover, leave traces indistinguishable from the effects of routine cooking.

Pottery kiln study in the Near East continues to be bedevilled by the assumption, implicitly if not explicitly, that typologies are necessarily diachronic, with the technologically most primitive structures representing the earliest phase of production (cf. Delcroix and Huot 1972). Yet in Mesopotamia there is remarkable sophistication at an early stage, as with the kilns at Yarim Tepe and many primitive types thereafter. Kiln form and construction, like that of furnaces, related as much to special needs in given circumstances as it did to passing time. Pottery kilns were always adapted to the peculiar characteristics of the situation, the resources available, and the type of pottery to be produced. It is now clear that attempts to describe evolutionary schemes for the history of pottery kilns in the Near East were misconceived. There is little or no evidence for any unilateral progression in prehistory as they assume. Throughout, into modern times, 'open' and 'kiln' pottery firing, in single- or double-chamber structures, might be found side by side in the same workshop or settlement for the production of different types of vessel or various ceramic fabrics.

In Mesopotamia there has been a particular confusion of late prehistoric and early historic two-storey, oval courtyard ovens with pottery kilns (cf. Delougaz 1940: 131 ff.; Delougaz 1942: figs. 18, 21, 104, 120; Delougaz 1967: 9-13; Delcroix and Huot 1972; Majidzadeh 1977: 213). Crawford (1981) has undertaken research to elucidate the role of various 'fire installations', which embraces hearths, ovens and kilns, each case to be tested in the light of associated evidence. Unless there is clear associated evidence for pottery firing (cf. Alizadeh 1985), extreme caution needs to be exercised before accepting the identification of any particular fire installation as a pottery kiln.

Little attention has so far been paid to the remains of open-firing. Bowl kilns of the Uruk period were found on the West Mound at Abu Salabikh (Postgate and Moon 1982: 105), filled with ash, clinker, vitrified bricks, and many wasters of bevel-rimmed bowls. As the struc-

ture is relatively flimsy, it was assumed that the bricks had been fired deliberately as part of a load. The firing had been done in a hollowed-out basin in the ground; stray sherds in the debris suggested that they may have been used as packing in loading the pottery for firing. Each 'bowl' possessed a flue and may have been used primarily for one specific type of vessel. An Early Dynastic I kiln at Abu Salabikh (Postgate and Moon 1982: 127), though lined with bricks, had also been used for open-firing. It was distinguished by its bone ash, perhaps used as a flux to stabilize firing conditions, when the primary fuel was straw or dung cakes. In recent times the principal sources of fuel for potters in the Near East have been agricultural and industrial (sawdust) waste, supplemented by the bones of animals, birds, and fishes. Such fuels minimize the consumption of wood for one of the most widespread of all crafts.

A potter's workshop where vessels were made simply for a household is likely to leave little or no archaeological trace; even the workplaces of full- or part-time potters may prove elusive in a region where archaeology has concentrated in towns on public buildings and high-status town houses, with a marked neglect of ordinary residential areas and suburbs and of rural settlements as a whole. To some extent an increasing emphasis on surface surveys is counteracting this bias. For example, at Al-Hiba (Lagash) in the Early Dynastic period, 'seven distinct areas of ceramic production were noted' (Iraq, 47 (1985), 222). Survey revealed evidence of potting within the walled area at Uruk (Müller, A. 1963). Pottery production was evidently a significant activity at Tell Abada in the Hamrin in the Ubaid period to judge by the 'kilns' and gypsum tournettes (?) reported from the excavation; but decisive detail is all too often lacking in the report (Jasim 1985: 53-4) as in so many others.

The remarkable site of Umm al-Hafriyat (Adams 1981: no. 1188), near Nippur, has the remains of at least 500 kilns of the Akkadian to Old Babylonian periods. The kilns were identified by residual firebox and chimney structures, overfired wasters, and yellow and black ceramic slag. The kilns were dated using serial dating of the overfired pottery (Vandiver: personal communication 1989). Here the potters appear to have established themselves on both sides of the watercourses, with different sorts of products made in different areas. The alignment of kilns next to canal beds, the presence and shape of levigation pits and the waster piles could be discerned. Excavation has yet to be undertaken to reveal the relationship between this area of manufacture and settlements.

In the absence of detail at Tell Abada and of convincing evidence for the excavation of 'pottery workshops' at Arpachiyah (cf. Barrelet 1968: 49; Delcroix and Huot 1972: 67) and Uruk (Lenzen 1960: 9, pl. 39), where brickmaking may be more likely, Woolley's

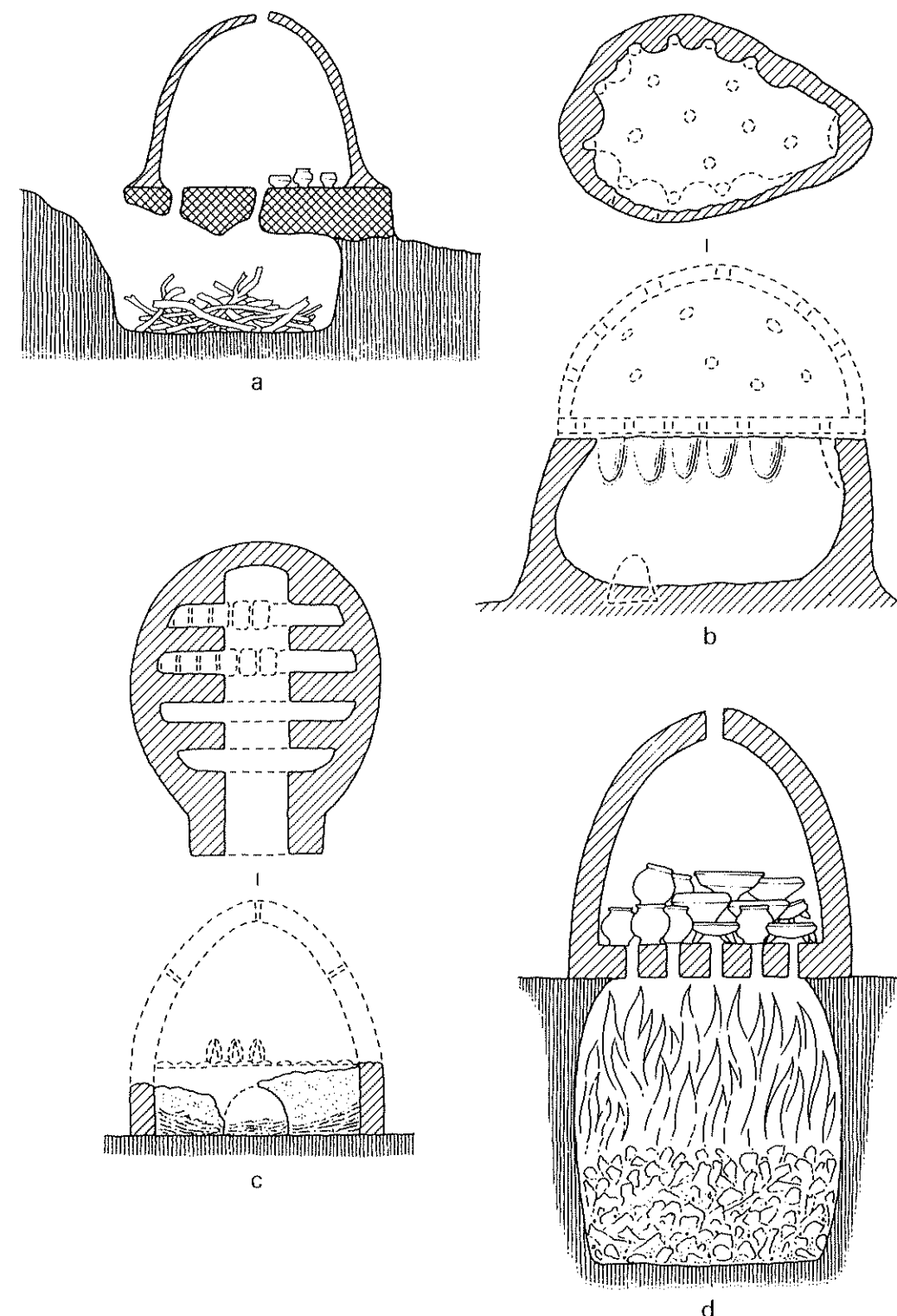


Fig. 9. (a) Restored kiln at Habuba Kabira, Syria (Uruk IV, c.3500-3200 BC) (after Strommenger 1980: fig. 75). (b) Kiln at Choga Mish in Khuzistan, Iran, c.3500-3200 BC (after Alizadeh 1985: fig. 1A). (c) Fire installation at Tell Asmar (restored), perhaps an oven rather than a kiln (after Frankfort *et al.* 1932: fig. 31). (d) Kiln (restored) at Khirbet Qasrij; Neo-Assyrian period (after Curtis *et al.* 1989, fig. 20).

account of a concentration of kilns in Pit F at Ur remains the best description of such a complex in a prehistoric context. Unfortunately, it is not clear from this sounding whether this was inside or outside the settlement in the fourth millennium BC:

At varying levels there were found, buried in the mass of wasters, the actual kilns in which they had been fired. The kilns had been used each many times and constantly repaired . . . The kilns . . . were circular and though differing in size were all approximately the same pattern . . . Below [the kiln] was a circular pit 0.90 m. in diameter and 0.35 m. deep, lined with fire-clay and originally roofed with bricks (the bricks were fused by the heat into shapeless clinkers); holes 0.10 m. in diameter and 0.45 m. apart (with a larger one in the centre) led the heat from the furnace to the kiln above; channels cut in the soil sloped down to holes in the sides of the furnace and supplied draught. The kiln proper was 1.30 m. in diameter, the ledge 0.20 m. wide round the rim of the furnace-pit serving as a support for the roof of the latter; the walls were of bricks . . . these were set in clay mortar and were liberally plastered with fire-clay which had been burnt by the heat to a greenish-white, while the soil round was deep red, shewing that the kiln was in part buried so as to preserve longer the heat of the furnace; the roof of the kiln was rebuilt for each firing and destroyed so as to remove the pots when the firing was complete. In one case the last batch of pots to be fired was found still in the kiln . . . By the kiln . . . there was a clay lead-trough . . . which seemed to be connected with the draught system . . . we unearthed . . . part of a circular basin which probably served for puddling the clay used by the potters; it was built with three courses, stepped outwards, of cement (i.e. gypsum plaster) bricks.

(Woolley 1956: 65–6)

In Early Dynastic III at Abu Salabikh (Postgate 1990: 103–4) the area at the northern end of the main mound had been used for pottery production creating a mound of debris, clinker (*salbukh*), and fragments of unfired pottery about ten metres across and one deep. At least two kilns were located there. In one room of a large house fragments of terracotta disks were found set in the floor, possibly parts of potters' wheels. The fill of this room consisted of 'clean, thin clay layers alternating with thicker deposits of clinker and ash'. Other fittings—basins and drains—suggest facilities for preparing clay.

There are no certain illustrations of potters' wheels from Mesopotamia and the material evidence is so meagre, or unrecognized, as to leave deductions from 'pot-reading' a more common source of information than surviving parts of the wheels themselves. No certain example of a tournette—a slowly turning wheel—has yet been published from a prehistoric context, though their use has been assumed from the evidence of the vessels produced on them. Nissen (1988: 46–7) has postulated the emergence of a 'pivoted working surface (tournette)' towards the end of the Halaf period, largely on the basis of changes in the type and layout of painted

patterns on pottery at this time. By the end of the Ubaid period, he argued, a more sophisticated device had appeared to be fully exploited for the first time in the Uruk period: 'setting the wheel's axle in bearings and hence the creation of an actual potter's wheel'. It is possible that plano-convex disks of gypsum from Tell Abada in the Hamrin, where there is other evidence for on-site pottery manufacture, may have been pivoted for pot-building on the upper flat surface (cf. Jasim 1985: 87, fig. 91; 10–40 cm. in diameter).

It is likely that the non-organic part of many potters' wheels in Mesopotamia was made of baked clay. Such disks, or fragments of them, will only be readily recognized in a potter's workplace with other remains of his craft equipment. In the late prehistoric levels of Pit F at Ur Woolley (1956: 28) reported that: 'by one of the kilns found bedded in the sherds, were the fragments of an actual potter's wheel; it was a disk of baked clay 0.075 m. thick and 0.75 m. in diameter, heavy enough to spin freely of its own momentum; the central pivot-hole was smoothed with bitumen (or perhaps the bitumen was for attaching a peg which itself revolved in a socket in the lower board) and at one point near the edge on the upper surface there were small holes into which could be put the stick-handles that served to turn the wheel'.

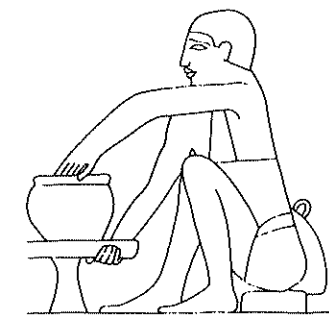
Comparable objects are likely to be much more common than is indicated by the few published examples of late prehistoric or Early Dynastic date at sites like Abu Salabikh (Postgate 1990: 103–4, pl. XVIIb, also citing examples from Adab, Tell Gubba and Tell Yahudiyah (Iraq), Khafajah (Delougaz 1942: 101, fig. 95), and Uruk (Heinrich 1935: 25, pl. 15A). The method of mounting is not self-evident. They might have been mounted on low or high pivots, using bitumen as an adhesive. Thus, from at least the late prehistoric period in Mesopotamia the potter's wheel is best reconstructed as a heavy, strong disk of baked clay or wood, up to about a metre in diameter, balanced on a relatively low fixed pivot of wood or stone. These wheels were constructed to run as true as possible without vibrating or wobbling (cf. Evelyn 1988). The substantial size and weight of the wheel-head provided ample momentum once it had been put into motion by the potter or his assistant.

A different type of apparatus, of stone, is reported from potters' workplaces in Syro-Palestine from the Chalcolithic period (at Hama) to the end of the Iron Age and intermittently from Mesopotamia (PLATE VI B). These consist of two parts of hard stone, roughly hemispherical in shape; one has a conoid projection, the other a matching hollow; when they are placed together they may be rotated. It is not always clear which is the upper, which the lower stone. This device is not really suited to act as a turntable on its own. It was probably placed on the ground or on a bench with

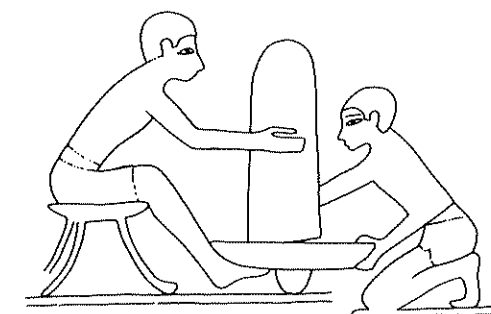
a wooden disk or 'bat' attached to the upper half with a lump of clay or bitumen. Sufficient momentum was generated by the potter or his assistant, if necessary lubricating the pivot with oil or flour. In Mesopotamia it is likely that many such pivots, or parts of them, have gone unrecognized, though they may have been used more often in the centre and north of the country, where the necessary stone was more readily available. An example of uncertain date has been published from Tell Kannas (Trokay 1989). One from Tell Yelkhi in the Hamrin is attributed to the Isin-Larsa period (Quarantelli 1985: 161 (colour plate)); part of another, undated, from the pioneer excavations at Nippur, is now in Philadelphia (University Museum, no. 8738A).

Experiments by Edwards and Jacobs (1987) have indicated that it is impractical to throw pottery on these pivoted and socketed pairs of stone bearings. Friction at the bearing surface prevents continuous rapid rotation of sufficient speed to match the 150 r.p.m. of the modern wheel for 'shaping' and 100 r.p.m. for 'opening'. If the wooden wheel-head or 'bat' was of sufficient size to give momentum when hand-rotated by the potter or his assistant (as shown in Egyptian depictions) to 15 or 20 r.p.m., it would have facilitated the forming of small bowls and the shaping and smoothing of necks and rims on hand-built pottery. Amiran and Shenhav (1984) showed that a potter's assistant might rotate such a wheel-head of 60 cm. diameter up to about 60 r.p.m.

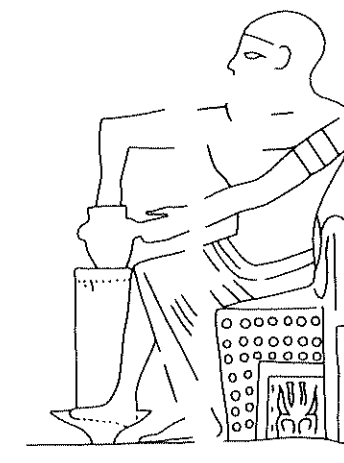
The so-called 'fast' or 'true' wheel remains elusive in the Mesopotamian record, perhaps because it was largely, if not exclusively, made of organic materials. Representations from Egypt at present offer the only chronological guidelines to its appearance; but, since it may have reached there from Western Asia, they may be deceptive. In Egypt the earliest known representation of a potter's wheel with an axis capable of rotation belongs to the Vth Dynasty in the third quarter of the third millennium BC. This low-pivoted wheel is shown hand-rotated by the potter himself, leaving only one hand free for potting. Some time in the second quarter of the second millennium BC changes are evident from the pottery itself. Illustrations early in the New Kingdom show an assistant turning the low-pivoted wheel with two hands, leaving the potter free to concentrate on forming the clay. The 'fast' or kick-wheel does not appear in Egyptian art until the reign of Darius I (c.518–485 BC) (cf. Bourriau 1981: figs. 2–4). If experts on Syro-Palestinian ceramic technology are correct in suggesting that local pottery industries were revolutionized during the seventh century BC by Assyrian introduction of throwing on a fast wheel (cf. Franken 1974: 30), then this would provide a *terminus ante quem* for its use in Mesopotamia, where conclusive evidence has yet to be found for the earliest



a



b



c

Fig. 10. Potters at work with various types of wheel as depicted in Egyptian art (after Bourriau 1981: figs. 2–4): (a) Pivoted wheel turned by the potter; Vth Dynasty, c.2400 BC. (b) Wheel turned by assistant, XVIIIth Dynasty; c.1400 BC. (c) Kick-wheel; reign of Darius I (c.518–485 BC)

use of the kick-wheel (cf. Johnston 1974: 99–100; Jeremias 18: 3–4).

For the development of mechanical assistance in pottery manufacture in Mesopotamia the scheme proposed by Edwards and Jacobs (1987: 53–5) for Syro-Palestine provides the basis for simple chronological horizons, allowing that no one method was ever exclusively used and that it is easy to exaggerate the importance of the potter's wheel in Mesopotamia even in historic times:

Early Neolithic to the Halaf Period:

- PROTO-TOURNETTE: (1) pots built on mats.
(2) pots built on a small, bowl-shaped mould allowing for slow and intermittent rotation whilst supporting the low part of a pot at the junction of the wall and base.

From the later Halaf Period:

- TOURNETTE TURNED BY THE POTTER: Pots made with use of a wheel-head, rotated by potter; pots made off the wheel by sequential slab construction then had necks formed or finished on slowly but steadily rotated tournette. Also used for smoothing, finishing, trimming, and shaving. Both the paired stone axle bearings (see p. 147) and 'fired clay disk of approximately 20 cms. in diameter which was rotated on a peg located on a flat smooth surface' fall into this category.

From the early Uruk Period:

- LOW FLY-WHEEL TURNED BY POTTER'S ASSISTANT: THE SIMPLE 'FAST' WHEEL: Pots formed on a pivoted clay disk at slow continuous rotation (15–20 r.p.m.) by potter's assistant. 'Pots formed in this manner usually show the strong clear marks of heavy finger pressure (rilling) on the interior of the base and walls and tend to show a spiral torsion twist in the walls.' Potter uses basic throwing techniques of the later 'fast wheel' on a slowly turning mass of clay.

From the earlier second millennium BC?

- COMBINED 'FAST' WHEEL: POTTER'S WHEEL DRIVEN BY Use of centrifugal force in pot-shaping; consists of a shaft with a throwing head on top

POTTER'S FEET:
KICK-WHEEL:

and a heavy wheel which the potter turns with his feet until the proper momentum is achieved. Double wheels designed to be spun by an assistant are known, but provision of a kick-wheel is more usual. The heavier the fly-wheel the longer the wheel would keep turning once kicked into motion.

Relatively little is known of the potter's ancillary equipment, much of which may have been of wood or bone or shell or simply made *ad hoc* from sherds or flint. From time to time attempts have been made to identify enigmatic objects as part of a potter's tool-kit. Alden (1988) suggested that certain distinctive ceramic rings, evident throughout the region using pottery of Uruk type, were for shaving surplus clay off pots during manufacture, perhaps deliberately to reduce weight for transport. Ii (1991), using evidence from excavations at Tell Gubba, has offered a systematic review of potters' tools from the fifth to the third millennium BC, primarily 'scrapers'. Unless such artefacts are recovered from a working area clearly occupied by potters such proposals are necessarily speculative (cf. Forest 1991, critical of Alden 1988).

In the absence of a coherently published potter's workplace in Mesopotamia, a particularly instructive framework for structuring the scattered information available there is to be found in the potters' quarter excavated at Sarepta in the Lebanon. This was in use from the Late Bronze to the Iron Age (Anderson 1987). In the Iron Age the primary installations in a series of adjacent rooms were:

1. The kilns.
2. An area where pots may have been set to dry.
3. The main working area with 'remnants of piles of levigated clay; two ceramic basins or vats of inverted conical shape; an outlined pit area for the potter, with wheel emplacement, sand, ash, and clay, and a nearby mortar. The basins may have contained slurry or slip . . . the mortar could have been used to prepare either pigments or temper' (Anderson 1987: 46, fig. 6). Although nothing of the wheels had survived, 'a stone lined pit or otherwise demarcated area with a hardened or cemented depression in the center' (Anderson 1987: 48) was taken to mark their siting. Sometimes there were indications that a roof or awning, perhaps temporary, had been set up to protect the potter at work.

Interpretation of the socio-economic implications of the material evidence for potting in Mesopotamia has been refined by the careful use of relevant ethnographical information since Matson's (1974, with bibliography) pioneering studies. Kramer's (c.1985) more

recent observations on potting in Iran provide particularly relevant guidelines for the assessment of the likely context of prehistoric potting in Mesopotamia in general and rural production in the historic periods in particular. Potting, Kramer observes, is often a very domestic activity conducted at household level within residential areas and involving men, women, and children in a variety and combination of tasks. Rural potters usually create and fire pots close to home, whilst urban potters even if they work at home (sometimes on the flat roof) fire at a distance, though not necessarily outside the town. Potting is a seasonal craft, with agricultural labour and pottery manufacture complementary in a community's annual life-cycle. Consequently, distinctions between 'full-time' and 'part-time' may have very little significance, even if they can be securely recognized by archaeologists, which many doubt. Distinctions between 'hand-made' and 'wheel-made' pottery, upon which archaeologists have customarily placed great emphasis, are rarely so absolute as is commonly assumed before the introduction of the 'fast' or 'true' potter's wheel, which may not have been in common use until the first millennium BC (compare, in general, Wood 1990).

(iii) A HISTORICAL SKETCH OF THE POTTER'S CRAFT IN MESOPOTAMIA

The available studies of ancient Mesopotamian pottery are predominantly typological and chronological in structure and emphasis, often widely scattered in the literature and almost always devoted to a single site or region for a restricted period of time. Pioneering studies by Perkins (1949) on the prehistoric pottery and by Delougaz (1952) on the pottery of the Protoliterate to Old Babylonian periods in the Diyala area (with much comparanda) have had few systematic successors in the last forty years, save for Ayoub (1982) on second-millennium BC pottery and Moon (1987) on the Early Dynastic pottery from Abu Salabikh. A 'Corpus of Mesopotamian Pottery' (As 1987) has been proposed; but no attempt has yet been made to integrate the evidence for manufacture and distribution from period to period in any region.

(a) *The first stages: to about 5500 BC*

Among the precursors of pottery is the so-called 'white ware', particularly characteristic of the pre-pottery Neolithic B period in Syro-Palestine (second half of the seventh to first half of the sixth millennium BC), which disappears after a short period of coexistence with the earliest wares of baked clay. This range of vessels and containers is made from more varied materials than was first supposed, to some degree controlled by local conditions (cf. Frierman 1971; Kafafi 1986). Natural rocks, chalky limestone, and various types of plaster

were used, consequently some were carved, whilst others were formed free-hand or with the use of moulds. They are decorated with incision and occasionally with paint. As laboratory examination is usually necessary to make a secure distinction between natural and artificial materials in this series, it is best to refer to them as 'white vessels', since some belong to the history of stone vessel manufacture, others to the pre-history of pottery. Objects of this type have been reported from Umm Dabaghiyah (cf. Kirkbride 1972: 8, pl. VI), Yarim Tepe (Merpert and Munchaev 1973), and sites in Khuzistan (Hole 1977: 223), indicating their presence in Mesopotamia, though they appear to have originated in Syria and to have been most popular in the west (Kafafi 1986: 54).

Vandiver (1987) has shown that the earliest vessels of clay in the Near East were made of montmorillonite clays with fibre temper. Their fabric was a composite material of ground clay mixed with short lengths of grass, straw, or chaff, occasionally some sand or gritty materials and water. As this mixture was not allowed to age, so that the fine particles would be wetted, it was very 'short' or friable. Consequently, vessels were built up by sequential slab construction not coil-formed as had previously been suggested. Nor could this mixture have been successfully thrown. Moulds, for which only indirect evidence is presently available, appear early in pottery manufacture for forming or supporting bases, and increase in number and function with time. Some time in the middle of the sixth millennium BC the working properties of this clay were changed by using grit rather than fibre as a temper and by allowing the mixture to age in a protected, sheltered place for about two weeks. This allowed the fine particles to wet through and maximized plasticity; but sequential slab construction endured. It was some considerable time before more rapid forming methods—moulding in sections, coiling, or throwing—were introduced. It is not until the fourth millennium BC that coil-building in spirals, building with perforated sections for foot, rim, body, and neck, and forming on a turntable are regularly evident.

The earliest potting was transformed exploitation of an already familiar raw material and in turn generated technological achievements in a wider spectrum of materials. Clay had been widely used in the Near East for building before it was used for pottery and had served a variety of roles for figurines and tokens, bins and basket linings. This clay appears to have been used without any special preparation and, when fired, to have been baked in open hearths within a temperature range of 500–800°C. But, as Vandiver (1987: 27) pointed out, these early clay artefacts do not have the same fibre-tempered clay composition or the working properties of early pottery materials, nor the same sequence of forming methods as she has identified in

potting. Consequently, she postulates a background in which mudbrick and wall construction with lumps of mixed straw and clay (*chineh*), and plaster bowl manufacture, were most influential in the emergence of sequential slab construction for vessels. She emphasizes the conservatism of early pottery technology over a very wide area in Egypt and the Near East through the persistence of ubiquitous sequential slab construction techniques. This was an optimized technology which lasted through the development and eclipse of various fine wares as well as regional variations in decoration, function, and form.

'Potmaking was not invented once somebody succeeded in making and firing a pot. Potmaking was only invented when somebody succeeded in turning the losses from firing from 80 per cent to 90 per cent into 10 to 5 per cent' (Franken 1984: 9). Kiln technology

was vital to the full emergence of pottery. At an early stage potters were evidently able to control firing to the point of sustaining an oxidizing atmosphere through the full cycle, reaching 800 °C for long enough. Kilns were a significant innovation, since the enclosed space concentrated available heat, facilitated higher temperatures and better control of the firing process, as well as more efficient use of fuel. It has been commonly assumed that the earliest kilns were open-topped, built above ground or in pits, and therefore minimally efficient in this respect; but enclosed chambers may have appeared early in Mesopotamia. The pottery experts with the Belgian excavation team at Tell ed-Der fired a small up-draught experimental kiln using stones daubed with clay in its construction and local fuel (shrubs and palm leaves), to see how suitable it was. A temperature of ± 900 °C was measured after about

three hours' firing (As and Jacobs 1985: 20). However, as only wall stubs normally survive of kiln chambers, whether or not they were permanently domed is an open question.

The earliest kilns yet recorded in Mesopotamia, in the sixth millennium BC at Yarim Tepe I in what appears to be a clearly defined manufacturing area of the settlement, already indicate a well-developed firing technique (Oates and Oates 1976: 101, colour plate on p. 42). The excavator described one of the kilns as having a combustion chamber, sunk into the ground, covered with a massive plate of clay up to 10 cm. thick, pierced by some 50 apertures, 15 cm. across, which conducted hot air into the domed upper stage. Yarim Tepe yielded a kiln of the Halaf period (Merpert and Munchaev 1973); pottery kilns of the Halaf period are reported at Tell Hassan in the Hamrin, but there, as at Yarim Tepe, there is no proper publication in detail (cf. Quarantelli 1985: 31–2, fig. on p. 33). The technology required to manufacture extensively vitrified pottery using calcareous clays was developed at an early stage and remained unchanged for 6,000 years. Tite and Maniatis (1975) estimated firing temperatures from the degree or extent of vitrification observed in the fresh fracture surfaces in pottery when examined using a scanning electron microscope. Their work offers the selection of pottery firing temperatures shown in the table on page 150.

There was a period of time after the establishment of the earliest settled communities in northern Mesopotamia when people did not choose, or did not know how, to make clay vessels. Then they were formed and sun-baked, not consolidated by firing, as is evident in the earlier seventh millennium BC at sites like Abu Hureyra (Moore, A. 1975). The earliest fire-hardened fragments, from large basins and storage jars to small vessels, so far recovered are those from the village of Ganj Dareh (level D) in the Zagros (Smith and Crepeau 1983). Potting emerged generally in the second half of the seventh millennium in a limited range of fibre-tempered wares in simple monotonous shapes; surfaces were burnished or polished and occasionally decorated with red paint (Mière 1989). Then, and for long thereafter, vessels were made by sequential slab construction: a process of building up vessels by stacking slabs of clay one on the other (Vandiver 1987). At sites like Kül Tepe, Tell Sotto, Telul eth-Thalathat II (levels XV–XVI), Umm Dabaghiyah, and Yarim Tepe I (levels XII–IX) (Mière 1989: 54) 'Proto-Hassuna' pottery was already abundant in the earlier sixth millennium BC, varying from coarse to fine wares, with and without vegetable temper, some white or cream slipped. Decorative techniques embraced burnishing, painting, incised and applied designs as in the later 'Hassuna' repertory (Mellaart 1975: 135 ff.). Scientific investigation of contemporary pottery indicates kiln

temperatures up to 1100 °C. In the Hassuna repertory, grit-tempered rather than chaff-tempered wares had slipped or burnished surfaces with linear patterns painted in black, sometimes combined with incision (Perkins 1949: 1 ff.; Mellaart 1975: 141 ff.).

Scientific analyses (Mière and Picon 1987) have shown that the circulation of pottery was already current in northern Mesopotamia in the earlier sixth millennium BC and was not an innovation of the Halaf period. Often, as at Umm Dabaghiyah, the foreign pottery is the finest; it may also form a significant percentage of the repertory (above 10 per cent at Bouqras) and come from multiple sources. This is evidence for incipient specialization—production of more than is required for local purposes—supported by the high quality of the travelling pottery. Sherds of 'Archaic Hassuna' type at Bouqras may have come from the Jezirah away to the east, whilst other foreign sherds found there may be from some 400 km. to the west in Anatolia. The implications for production methods are clear; it may no longer be assumed that the Halaf wares mark the first significant move from household 'production' to household 'industry'. But it is still difficult to define what this means in real terms: 'If, in the case of the earliest pottery, we are dealing with products definitely produced in each individual household, we must, at the latest, reckon that the very delicate, finely painted pottery of the so-called Halaf period was produced by specialists . . . However, the individually painted vessels . . . which all took a long time to make, are definitely the work of individuals, who probably carried out each stage of the production process themselves' (Nissen 1988: 45).

(b) *Developing prehistoric traditions: c. 5500–3000 BC*

The period named after the pottery found at Tell Halaf (see below) also saw the production of other painted wares of which the 'Samarra' style is the best known. It tended to be made in simpler shapes and had circular patterns applied in matt colours in contrast to the glossy paints of the Halaf wares. The increasing evidence of potters' marks on Samarra pottery has been taken as an indication of specialized craftsmanship; but their interpretation is not straightforward: 'Some potters mark their wares to distinguish their work from vessels made by others with whom they fire jointly; others use customers' marks to identify their targets. Some potters' marks identify kin groups rather than single individuals, and some are made in circumstances involving multiple authorship' (Kramer, C. 1985: 117).

Although convention allows the use of terms like *paint* and *painting* with reference to ceramics, it is in fact a matter of slips, ochres, oxides, and other mineral mixtures, which combine on the pot's surface to form relatively permanent layers of colour when heated. Although not technically paints they were applied for

Sample	Provenance/Period ^a	Approximate date BC	Firing atmosphere ^b	Vitrification stage ^c	Firing temperature (°C) ^d
IR 1a	Choga Mami (Jarmo)	c. 6000	O	V	850–1050 (C) ^e
IR 2a	Samarra	c. 5500	O	V	850–1050
IR 2b	Samarra	c. 5500	O	V	850–1050
IR 2c	Samarra	c. 5500	O-R	V+	1050–1150
IR 3a	Arpachiyah (Halaf)	c. 5000	O	V	850–1050 (C)
IR 3b	Arpachiyah (Halaf)	c. 5000	O	V	850–1050
IR 3c	Arpachiyah (Halaf)	c. 5000	O	V	850–1050
IR 3d	Arpachiyah (Halaf)	c. 5000	O	V	850–1050 (C)
IR 4e	Ur (Ubaid)	c. 4500	O	V	850–1050
IR 4f	Ur (Ubaid)	c. 4500	O	V+	1050–1150
AH 6	Ur (Ubaid)	c. 4500	O	V+	1050–1150
IR 4a	Eridu (Ubaid)	c. 4500	O-R	CV	>1150
IR 4b	Ubaid	c. 4500	O-R	CV	>1150
IR 4c	Ubaid	c. 4500	R(W)	CV	>1150
IR 4d	Ur (Ubaid)	c. 4500	O-R	CV	>1150
IR 5e	Nineveh IV	c. 3500	O	V	850–1050 (C)
IR 5d	Nineveh IV	c. 3500	R-O	V	850–1050
IR 5a	Nineveh V	c. 3000	O	V	850–1050
IR 5b	Nineveh V	c. 3000	R(W)	CV	>1150
IR 5c	Nineveh V	c. 3000	O	V+	1050–1150
IR 6a	Jamdat Nasr	c. 3000	O	V+	1050–1150
IR 6b	Jamdat Nasr	c. 3000	O	V	850–1050
IR 7a	Kish: ED I	c. 2900	O	V	850–1050
IR 7b	Kish: ED I	c. 2900	O	V	850–1050
IR 8a	Kish: ED III	c. 2500	O	V	850–1050
IR 9a	Kish: Old Babylonian	c. 1800	O	V	850–1050
IR 10a	Nineveh: Neo-Assyrian	c. 700	O	V	850–1050 (C)
IR 10b	Nineveh: Neo-Assyrian	c. 700	O	V	850–1050 (C)

(a) Type-site given in parentheses where this differs from provenance.

(b) Firing atmosphere inferred from colour of pottery body (O = Oxidizing; R = Reducing). W indicates that sherd appears to be a kiln waster.

(c) Vitrification stages: NV No vitrification; V Extensive vitrification; V+ Intermediate between V and CV; CV Continuous vitrification; All clays are calcareous; (gl) indicates glazed sherd.

(d) Firing temperatures estimated assuming: (i) heating rate 200 °C/h with soaking time of 1 h at peak temperature; if significantly faster heating rates (800 °C/h) and shorter soaking times (5 min.) were employed, then firing temperatures higher by between 20 and 50 °C would have been required in order to produce an equivalent vitrification; (ii) firing carried out in a predominantly oxidizing atmosphere (except for sherds IR 4c and IR 5b); if fired in a reducing atmosphere, firing temperatures lower by between 20 and 50 °C would have produced an equivalent vitrification.

(e) (C) indicates that mineral (calcite) is present in the sherd. For the sherds fired in 850–1050 °C range, the calcite present in the original clay would have been dissociated during the firing. If the observed calcite results from recarbonation of dissociated calcite, then its presence suggests a firing temperature at the lower end of the 850–1050 °C range. However, it is possible that the observed calcite was deposited in the sherd during burial in calcareous soil.

Source: Tite and Maniatis (1975), see. p. 151.

the same purpose and usually in the same manner. Amongst the earliest pottery produced in the Near East, carefully made examples were already coated with a specially prepared clay suspension ('slip') to form a surface of finer consistency; burnishing when damp not only gave an attractive sheen, but also rendered the fabric less porous. The pigments used on pottery from the outset, ochrous red-oxide and manganese oxide, had already long been used for body decoration, for painting cave walls, and for deposit in burials. It was also recognized at an early stage that ochre pigments fired in a smoky atmosphere deficient in oxygen turned black.

In prehistoric Mesopotamia the earliest painted pottery, of the sixth millennium BC, was monochrome; by the Halaf period paints may be monochrome, bichrome, or trichrome, with colours including black/brown and white, red, and orange. One of the most common mineral mixtures used as paint in prehistory (and later) is a combination of iron oxide, clay minerals, and micas that can produce a colour range embracing black, brown, green, orange, and red. This colour variation can depend either on the type of iron oxide and its amount relative to the silicates or on whether the iron is oxidized or reduced, or whether it has melted to combine with the silicates to form green iron silicates (Kamilli and Steinberg 1985: 321).

Courtois and Velde (1984: 89–90) have analysed the paint on sherds in the Hassuna style to reveal that it is iron oxide, some of which was found on the type site (Lloyd and Safar 1945: 284–6). These are matt paints that have to be burnished to achieve a lustrous surface. Of Samarra Ware they remarked: 'peintures pauvres en alumine dont les deux éléments chimiques principaux sont la silice et les oxydes de fer . . . Techniquement différent, le pigment "Samarra", pauvre en alumine est très riche en fer. Celui-ci est peut-être le produit d'un mélange artificiel d'hématite et de quartz fin (loessiques?) lié par de l'argile montmorillonitique et additionné de cendres végétales. Une seconde hypothèse, reposant sur le choix précis d'une argile de composition particulière: la glauconie, paraît plus plausible lorsqu'on voit la finesse des décors, tels que ceux du type "Samarra classique"' (Courtois and Velde 1984: 90). Already in the later stages at Hassuna (III–IV) there was some variety in the paints used, with more sophisticated mixtures appearing alongside coarser ones: 'une ocre rouge mêlée à de la boue marneuse' (Courtois and Velde 1984: 91). Such variations persist through the Halaf repertory.

Halaf pottery, of the later fifth to fourth millennium BC, is renowned for the technical excellence of its ware and polychrome painted decoration (Frankel 1979). The fine wares were cream-coloured, with a slip, and are generally burnished. These vessels have elaborate patterns in red and black with added

white in fine gloss paint. Davidson (cited in Vandiver 1987: 27) has used Landsat image-processing of polished cross-sections to confirm the use of sequential slab construction in the manufacture of Halaf pottery from several sites in Syria. Thin section and microprobe analysis of sherds from Choga Mami in eastern Iraq indicated that clay preparation for the painted pottery, with the notable exception of the Halaf wares, remained unchanged from Samarra to the mature Ubaid styles. The same technological continuity was evident in unpainted, incised, and coarse wares (Kamilli's research, cited J. Oates 1987: 201).

Extensive research on the paints used by Halaf potters has employed a variety of techniques, including the scanning electron microscope (SEM), X-ray diffraction (XRD), and petrographic analysis (Noll 1976; Noll *et al.*, 1975; Matson 1983; Steinberg and Kamilli 1985). With rare exceptions these pots were subjected to a single firing; a fugitive kaolinite-rich white pigment on a sherd from Choga Mami was barely fused and may never have been fired (Steinberg and Kamilli 1985: 191). As Steinberg and Kamilli (1985) have shown, the makers controlled their iron oxide-based paints by careful mixing and by management of firing (cf. Courtois and Velde 1984: 89). Some ash may have been added to prevent the fine particles from settling out and to improve sintering.

In his study of Halaf-style pottery sherds from Banahilk Matson (1983: 621) reported thus on the painting process:

The paint used to decorate the ware is undoubtedly an iron-rich red mountain clay that has been washed to remove the sand grains and other impurities. Judging from similar clay paints that I have seen in use in Lebanese villages today, it would have been sticky, would have adhered well to the surface of the unfired vessel, and would probably have had a high shrinkage during drying which would result in cracks if too thick a layer of paint were applied . . . In general, when vessels are fired, the painted decoration retains a red color at temperatures up to about 800 °C if the atmosphere is oxidizing during the final stages of firing. Higher temperatures, however, cause a brown color to develop, and slightly higher ones produce a black color. This is largely due to vitrification of the paint, for a glassy coating on the surface of the pigment particles prevents air from reaching the iron in the clay paint (which is black at the higher temperatures) and oxidizing it to red as the ware cools.

The colouring agents may be briefly reviewed:

Brown or red matt: seems to have been produced at this time by two distinct methods: 'One way was to use an iron-rich paint, consisting mostly of coarse hematite and less clay minerals, which was fired at a relatively low temperature and possibly only in oxidizing conditions (found at Choga Mami). Another way was to use a very clay mineral-rich paint with some hematite dust and stain in it but no alkali flux (found at Tepe

Gawra). Both kinds are used in monochrome and bichrome applications' (Steinberg and Kamilli 1985: 194).

Black matt: Noll *et al.* (1975: 604) argued that the more haematite there was in a paint, as distinct from magnetite or maghemite, the browner it became. In samples tested by Steinberg and Kamilli (1985: 196) it was thought that the black colour was entirely related to the spectacular crystalline state of the haematite.

Orange, light brown, and red glossy: Steinberg and Kamilli (1984: 196) are critical of the regularly expressed view that these colours were produced by using a thinner mix of paint or brush-stroke. In their samples these paints were 'sintered and contain less than 30 per cent free metallic iron oxide. Clay materials dominate. Alumina content is high and may have acted as a refractory. Potassium in all but one is low and did not act as a flux. The iron oxide is in the form of extremely fine-grained hematite (translucent red) dust and stain, and the percent of this dust causes the different color tones.'

Black or brown glossy: Steinberg and Kamilli (1984: 197) report that 'chemically, these paints are the same as the orange burnished, clay mineral-rich paints except that they contain abundant potassium, which clearly acted as a strong flux and glass former. This flux appears to have overridden any refractory properties of the high amounts of alumina.' They noted that the black of these paints, magnetite dust and glass-bearing, were stronger than those with coarse iron oxide grains.

These studies demonstrate the remarkably sophisticated control of materials and kiln procedures achieved by potters of the Halaf period. They were able to manipulate both fabric and pigments either by varying the ratio of iron oxides to clay mineral slip, or the texture (coarse/fine) of the iron oxide, or the method of application by brush, and subsequent burnishing. Mineral paint mixtures were already being caused to melt at lower temperatures by use of fluxes in a carefully controlled way: 'addition of potassium enabled glass to form in some paints during reduction firing; this allowed them to retain their black color even when the final kiln atmosphere was an oxidizing one. Lack of potassium but abundant aluminium (in the clay minerals) in other paints tended to retard the effects of reduction firing and sintering' (Steinberg and Kamilli 1985: 200).

Le Blanc and Watson (1973) have used the painted decoration of Halaf pottery to calculate a formal measure of the degree of similarity between pottery of this type at seven sites in northern Mesopotamia. They found that similarity in the painted motifs appeared to vary with the nature of communication routes between sites. Design repertoires were more similar between distant sites with no natural barriers between them than

between closer settlements separated by mountains or rivers. They argued that the fine painted pottery of the Halaf culture was one of the most homogeneous ceramic groups known in prehistory, consistent with much trade in fine wares and extensive copying.

Scientific techniques have been used to elucidate the pottery distribution network of the Halaf period. Davidson and McKerrell (1976) employed neutron activation to analyse pottery of this period from sites in the vicinity of the Khabur headwaters in Syria. They demonstrated both extensive trade in Halaf painted pottery and local manufacture in this region. Further work, following an excavation at Tell Agab, confirmed local production of some wares and trade in others (Davidson 1981). This research programme also showed, by sampling and testing clay sources in the locality, that depositional factors may produce a similar clay composition (chemical) along a wadi or river course for some distance, but differences arise as one moves away from it. This project was one of the first in the area to sustain the view that the sources of clay used there for pottery manufacture were often the immediately available sedimentary deposits, whilst encouraging the idea that such pottery analysis might sufficiently resolve foreign/local questions as well as helping to pinpoint the source of foreign wares. Later Davidson and McKerrell (1980) analysed sherds from Arpachiyah and Tepe Gawra, of both the Halaf and Ubaid periods. The result of this programme pointed to the export of Halaf painted wares from Arpachiyah to Gawra and a trade between the sites in Ubaid pottery. Campbell (1987) has published the results of tests on Halaf pottery from Karabeh Shattani, in the Eski Mosul region, isolating a local group and a group which may be non-local or produced from clay prepared by different methods.

Nissen (1988: 45) has argued that the change from static Halaf patterns, laid out in sections, to simpler flowing patterns in the pottery of the Ubaid period in the fifth millennium BC, created by pressing a pigment-soaked brush steadily against a rotated vessel or by moving it up and down, indicates the introduction of 'a pivoted working surface'. This speeded up the process of production, possibly increasing the percentage of painted pottery generally available. Ubaid pottery is generally fired to a greenish hue with dark painted geometrical designs on an unburnished surface. Tite and Maniatis (1975) showed consistently higher firing temperatures were employed at this time: 1050 °C and 1150 °C. In this period evidence for kiln construction is plentiful, but very few examples have been published with proper critical assessment of their function, particularly some important new finds in the Hamrin (see Tell Hassan: Quarantelli 1985: 32–3, figure). At Tell Abada, Jasim (1985: 53 ff., figs. 31–46) reported a wide range of 'kilns' from the settlement area. Some had

both chambers above the ground, some had a sunken combustion chamber, and some had a single chamber only in which it was assumed pottery had been fired as if in a shallow pit. One 'kiln' (Jasim 1985: 54, figs. 16, 40) had a unique system of ventilation best paralleled at Sialk (III) in Iran (Ghirshman 1938: 36, fig. 5), where there was no combustion chamber in the conventional sense. If Ghirshman's reconstruction is correct, this type of structure is more likely to be an oven than a kiln (cf. Scott 1954: 395). The fact that potters were using different kinds of kiln at Tell Abada, the double-chambered ones isolated behind a wall, may indicate that household and workshop production coexisted there; some potters were satisfying local needs, some sending their wares further afield.

A considerable number of 'kilns' were found in levels of the Ubaid period at Telul eth-Thalathat, though here again there is no proper review of the evidence for identity in the published reports (Fukai *et al.* 1970: 23 ff., pls. XVI–XX; 1981: 30–1, pls. 5–9). The structures seem primarily to have been double-chamber up-draught kilns with a grate and domed mudbrick upper chamber. The combustion chamber was underground save in one case. Comparable structures were found at Tell Songor B in the Hamrin (Fujii 1981: 182, 3, pl. 20i). Too little is published about 'kilns' in stratum XVI at Tepe Gawra to assess them. In the south there is a Late Ubaid example at Oueili (Huot *et al.* 1978: 206–7, fig. 21).

A particularly well preserved pottery kiln was found in the transitional Halaf–Ubaid period levels at Tell Ziyada on the Khabur. 'The kiln was filled to the dome with vessels . . . a great majority were overfired and very friable, others were incompletely baked as if the kiln had been abandoned in mid-firing . . . the kiln itself, whilst resembling the classic Halaf tholos construction, is a solid, large mudbrick structure . . . approximately 6 × 4 metres' (Buccellati, G. *et al.* 1991: 44–5, figs. 5–6).

The colour of the paint on Ubaid pottery may be black, brown, or red. This pottery is often found in the south of Mesopotamia fired to such a high temperature, under reducing conditions, that paste and paint are fused and the paint body warped. On a sherd from Ur, examined by Kamilli and Steinberg (1985: 322), 'the paint has a mineral assemblage that includes hedenbergite, fayalite, pseudo-brookite, and chromite. There are no common iron-oxide phases in the sample. This assemblage is similar to the paint assemblages on sherds from certain other sites (e.g. Al Ubaid, Telloh, Warka site 198), but it appears to be restricted to pots made in southern Mesopotamia.' The source of this unusual paint has not yet been certainly identified; it is also found on sherds of late Ubaid pottery from sites in the Gulf (Oates, J., *et al.* 1977: 229) and at Tepe Yahya in south central Iran (Kamilli and Lamberg-Karlovsky

1979: 54; cf. Courtois and Velde 1984: 86 ff.). At Ras Shamra, by contrast, the pottery, in a style akin to that of Ubaid, has dark paint rich in manganese (Courtois and Velde 1984: 91). Courtois and Velde (1984: 91; 1987: 159–62; 1991^a) have shown that for an initial, in some ways experimental, phase, as at Tell el-Oueili, the potters of the south used for pigment oxides of manganese and iron as had the potters working in the Samarra style. Then in the phases defined as Ubaid 3–4 at Tell el-Oueili potters used the paints typical of the Late Ubaid period throughout southern Mesopotamia. This choice of new paint, probably from freshly exploited local sources, corresponds to a time when high firing temperatures (1050–1150 °C) became standard for a time (Tite *et al.* 1982: 113). The paints are iron oxides, iron-titanium minerals and chromiferous minerals (sandy pigments) (Courtois and Velde 1991: 273–4).

The wide distribution of Ubaid pottery and the similarity of ware and decoration give scope for tests to identify local production centres. Samplings of sherds from Tepe Gawra and Tell Ubaid indicated small, but probably significant, chemical differences between the clay sources of each site. Neutron activation analysis has been used in a programme designed to establish the origin of Ubaid painted pottery found on the eastern side of Saudi Arabia (Oates, J., *et al.* 1977). Complementary petrographic studies and electron microprobe analyses of paint were also undertaken. Tests showed that most, if not all, of the plain and painted Ubaid pottery analysed from Saudi Arabia, Qatar, and Bahrain had been manufactured in Mesopotamia. At least 50 per cent of it could be shown to have come from sites in Sumer geographically closest to Arabia and the Gulf. A distinctive red pottery was shown to be locally made. It was argued that human agency had carried the Ubaid pottery down into the Gulf region, since 'analyses . . . on Ubaid and contemporary Mesopotamian wares fail to provide evidence for extensive trade in pottery at this time in that a significant proportion of the pottery recovered from sites in Mesopotamia proves to have been made locally, even such specialized "luxury" wares as Halaf polychrome. There is some evidence to suggest itinerant potters, and at most sites some vessels can be shown to have been manufactured elsewhere, but certainly there was no "commercial" trade in ceramic products at this time' (Oates, J., *et al.* 1977: 233; on increased standardization from Halaf to Ubaid, cf. Henrickson and Thuesen (eds.) 1989: 336–8).

Before passing to the pottery traditions that mark the general eclipse of painted designs in locally manufactured pottery in Mesopotamia it is appropriate to take note of the role of pattern analysis in the study of prehistoric ceramics in the region. It has a long history noticeably conditioned by the primary intellectual pre-

occupations of art-historians and archaeologists at the time of writing. Frankfort (1924: 15) summarized and refined pioneer studies 'using the ornamentation of pottery as a clue to problems of influence and relationship', the most enduring line of approach. A generation later Beatrice Goff investigated ceramic patterns as part of the complex of material symbols used by early communities in Mesopotamia in a study 'intended primarily for the use of historians of religion'. She pursued five main aims: to isolate the dominant forms in any period; to look for their interrelationships; to study particularly those designs which became most popular; to seek out distortions in representational patterns as the distortion indicates something that was significant to the artist; and to beware of drawing inferences about early periods from knowledge of later beliefs (cf. Goff 1963: XXXIV–XXXVI). She used her results to challenge views about the nature of early Mesopotamian ideology then current among philologists who were using later myths as a primary source for the ideology of prehistoric cultures. For her (Goff 1963: 169) 'the artifacts of prehistoric Mesopotamia give no evidence that the specific myths now known to us were circulating in this period'. She conceived the patterns, among other symbols, as a means of reassurance, whilst at the same time giving expression to feelings of aggression. That the decoration of pottery partakes of ritual is widely acknowledged; what collective messages it transmits are far harder to establish, even in living communities.

In the 1980s, after a break in concern with such analysis, syntactic study of pottery design took a new turn. Hole (1984) and Pollock (1983) sought ways to interpret the ceramic decoration used by prehistoric communities in Khuzistan as bearers of social messages; but their methods were challenged by Wright (H. T. 1989: 450): 'we need a more linguistic approach to pottery designs. I do not think there is much utility in saying this is a goat, this means rain or water . . . But it is in the overall organization of design, which is related to the complexity in the message people wish to give, and in the organization of design which may be related to other symbolic dimensions that people use in dealing with their universe.' Vertesalji (1989) has begun the complex task of systematically distinguishing and quantifying various types of change in the designs painted on prehistoric pottery in Mesopotamia.

The Uruk horizon (XIV–IV) is defined by the appearance of unpainted red-slipped and grey pottery in a new range of shapes with wheel-made vessels amongst the earliest. Painted wares, the Jamdat Nasr style (Uruk III), reappear at the end of the prehistoric period, particularly in the form of shouldered jars. The surface of the vessel was either covered with a plum-red slip, with the exception of reserved panels outlined and filled with designs in black paint, or the panels were outlined and filled with designs in dark paint applied

directly on the greenish-coloured clay body. In the Early Dynastic I–II periods this tradition persisted in the last local painted style of central and southern Mesopotamian pottery, the so-called 'Scarlet Ware', with decoration in red and black paint on a light ground, either a slip or clay body. It was Frankfort's view that 'the improvement of techniques enabled stone and metal vessels to take the place formerly occupied by fine decorated pottery, and that from the Protoliterate Period onward plain pots of baked clay were used as kitchenware only' (Frankfort 1954: 2).

The red and black pigments used by potters in the late prehistoric and early historic periods have been examined by Al-Kaissi and Mynors (1987) on sherds of Jamdat Nasr or Scarlet Ware pottery. Jamdat Nasr painted wares are concentrated primarily in central and southern Iraq; Scarlet Ware in the Diyala and Hamrin regions. The red is predominantly haematite; but on at least one example of Scarlet Ware, in Early Dynastic I, from Khafajah cinnabar (mercuric sulphide) had been used instead. The various shades among the reds may have been produced by mixing pigments from different sources; for example, a brown pigment may have been prepared from a slip using a manganese-based ochre mixed with haematite from a ferruginous clay. The black derived from one of three possible sources: predominantly iron or manganese, with evidence of carbon-based pigments on some third-millennium pottery.

Thuesen's (1987: 126) analysis of Scarlet Ware pigment at Tell Razuk in the Hamrin revealed that 'the earlier paint is generally of a higher quality and more homogeneous than the late Scarlet red color. The former is prepared from haematite, while the latter is made by a procedure which cannot be reconstructed yet, but which probably involved iron-producing bacteria in water . . . The scarlet red . . . is applied to the surface of the vessel after firing and thus is poorly fixed. The analysis has further shown that the red paint was applied in at least two shades, produced by mixing the paint with different quantities of calcite.'

These painted wares are, however, an exception in the transformation which ceramics in Mesopotamia underwent in the Uruk or Protoliterate period during which shapes were increasingly standardized, decoration was simplified, and large-scale production commenced. Despite the high skills of Mesopotamian potters from an early date, there is no clear evidence for centralized ceramic manufacture before about the middle of the fourth millennium BC. Both in Khuzistan and adjacent regions 'mass-produced' pottery has first been identified in the Middle Uruk period (Alden 1988: 146). To the west Braidwood noted that much of the pottery in Amuq Phase G had 'an almost "factory-made" look' (Braidwood, R. J., *et al.* 1960: 259). Now for the first time extensive production of a restricted

repertory of standard pottery shapes became a feature of the Mesopotamian ceramic repertory, in response to growing concentrations of population and centralization of craft activities in palace and temple workshops.

This change has been traditionally associated with the introduction of the 'potter's wheel', though, as has already been noted, precisely what this means in real terms remains unclear. There is no reason to suppose that it was the kick-wheel. It is more likely to have been a wheel made to rotate either on a fixed spindle or on an axis that was fixed to the wheel and pivoted on the ground. A low fly-wheel of this kind could have been turned by an apprentice. As the potential of the potter's wheel can only be fully exploited if the clay is pliable and does not break off during working, it is likely that more attention was now paid to clay preparation and the range of additives may have become more various. Identical manufacturing techniques and comparable organization of potters was evident in Sumer and its 'colonies' in Syria (Sørensen 1974-5).

'Numerous kilns', Childe (1954: 129) remarked of the Uruk period, 'are mentioned in excavation reports, but never adequately described.' A generation later the situation remains generally the same. It is now that the first of an impressive series of oval, two-storey fire-installations, with distinctive grids of radiating bars or ribs separating the storeys, are recurrently evident. All were formerly assumed to be pottery kilns; but it is now clear that they served a number of functions, perhaps primarily as ovens (Crawford, H. E. W. 1983). At Abu Salabikh in the Early Dynastic period, for example, there was a clear distinction between those structures of this form with industrial debris indicative of pottery production and those with no such evidence (cf. Postgate and Moon 1982: 127); both functions, kiln and oven, were identified within the built-up house area, as on late prehistoric sites. Appropriate debris also bears witness to their role in pottery production at Choga Mish in Khuzistan (Alizadeh 1985), at Ahmad al Hattu in the Hamrin (Sørensen 1979: 48, fig. 9), at Habuba Kabira (Strommenger 1980: 77, figs. 74-5) in the Uruk period, and at Jamdat Nasr (Matthews, R. J. 1989: 230, pl. XXXIIIb).

Disproportionate attention has been paid in the studies of the Uruk ceramic repertory to the bevelled-rim bowl, the one mass-produced type common to so many Uruk sites at their widest distribution. These bowls were universally hand-made, commonly of a coarse fabric with vegetable temper, rough and cracked, with finger-marks in the interior base where the potter had pressed the clay down to shape it. Both at Susa and at Tell Rubeidheh in the Hamrin bevelled-rim bowls were fired in kilns alongside other, often wheel-made, pottery (Killick (ed.) 1989: 39). It has long been debated whether they were made in moulds, perhaps shaped in the ground by means of an existing bowl,

or modelled entirely by hand using a rather dry or 'short' fabric in roughly measured lumps, as their irregular form usually suggests. This remains an open question, as indeed does their function, an even more extensively debated problem. Whilst most of these bowls, from western Syria to deep into Iran, from southern Turkey to southern Mesopotamia, are roughly the same size, there is only a tendency to standardization with much variety in dimensions. They have been described as votive bowls for cult purposes, as vessels for food processing, or as dry-ration bowls, a hypothesis that has been elaborately developed to reconstruct ration-based, centralized administrative systems. Nissen (1988: 84, fig. 33) uses the pictograph 'to eat' in Uruk IV-III texts, a human head and a bowl (perhaps bevel-rimmed), to support the hypothesis that each of these bowls held a labourer's daily ration. It is possible that they simply indicate the widespread adoption of a common metrological system. However, their ubiquity might only be a reflection of the wide appeal of a simply made container of multiple use or designed for a routine task such as salt or bread-making (cf. Schmidt, K. 1982; Millard 1988; Chazan and Lehner 1990; Buccellati, G. 1990).

The ceramic technology of pottery current in northern Mesopotamia from the Uruk period onwards is even less well known than the southern workshop traditions. However, it is now clear that the last prehistoric painted style of the north, Ninevite 5, which has little or no stylistic relation with the Jamdat Nasr painted style, developed locally (Roaf and Killick 1987). The introduction of Late Uruk pottery from the south appears to have stimulated the development of a local painted style which gradually evolved into the distinctive painted style of Ninevite 5 in the earlier third millennium BC. No technological research has yet been published on this ware.

The distinctive third-millennium North Mesopotamian pottery commonly known as 'stoneware' is unusually dense and hard for pottery of this region. It was made from special noncalcareous clays so far not evident elsewhere in ancient Mesopotamian pottery (Schneider 1989); but it is not stoneware in the modern sense, as its water absorbing capacity is more than 2 per cent in 90 per cent of investigated sherds and it was fired at lower temperatures of 900-1000 °C. On account of its high content of flux (iron oxide contents ranging from 4 per cent to 9 per cent), it is very like stoneware in its vitrification and content of mullite. It varies from grey to red in colour, perhaps in imitation of copper alloys. These variations were achieved by changing kiln atmospheres and by part vitrification of the surface. Schneider has identified two compositional groups, perhaps indicating two primary places of manufacture supplying North Mesopotamia, probably from workshops on the Syro-Anatolian frontiers.

(c) *Potting in the historic periods: c. 3000-300 BC*

(1) *Unglazed wares*

From the early third millennium BC south Mesopotamian pottery, particularly, gives the impression of dull pots, mass-produced. They were increasingly wheel-made, more and more standardized in appearance, with little if any decoration and that now crudely incised or applied in clay rather than painted. As in Egypt, the painted pottery tradition virtually disappeared with the emergence of state systems. There is no evidence of significant technological change in the manufacture of pottery in Mesopotamia in the early historic periods; all the basic methods of clay preparation, forming, and firing seem by then to have been well established and well tried. Two innovations, the introduction of glazes and of the kick-wheel, belong to a later stage. The former appear first on baked clay bodies in the middle of the second millennium BC, probably introduced from workshops in western Syria (see below), whilst the first appearance of the latter in Mesopotamia has not yet been established (see above). Study of Mesopotamian pottery in the historic periods has only just become systematic, with some phases, like the Early Dynastic and Old Babylonian, significantly better known than others. At the same time exclusively typological study is giving way to more technological and analytical investigation. At present no more than a sketch may be offered of the results.

'Kilns' are regularly reported in excavations of Early Dynastic sites but, as on earlier sites, distinctions of function are not always clear. Vertical kilns continue to be those most often used; but this is the period when horizontal kilns became predominant in the arid region of Indo-Iran and Central Asia. Their main advantage was that the smaller size of the fire-pit necessary to produce oxidizing temperatures for each cubic metre of space reduced the consumption of fuel. In a horizontal kiln the firing chamber and the fuel-pit are at opposite ends of the rectangular space. The heat produced near the entrance is drawn by one or more chimneys on top of the firing chamber; in such kilns there is no refractory grid, heavy supports, or vaulted roof as is found in vertical kilns (cf. example at Tepe Hissar: Tosi 1989: 20-2, figs 9-12). It has yet to be established whether such kilns were amongst those used in Mesopotamia, perhaps at sites like Umm al-Hafriyat.

Mynors (1987: 17 ff.) has studied the pottery production of this period at Abu Salabikh, Kish, and Ur. She has argued that once wheel-made pottery began generally to replace hand-made vessels in the Uruk period there was a gradual decline in Sumer in the use of the tempering materials characteristic of the Uruk period. By the end of Early Dynastic I few tempered fabrics remain; Early Dynastic II pottery is charac-

terized by very sandy fabrics, probably without deliberate additions. She interpreted this as part of a transition from primarily household industries in the late prehistoric period to increasingly standardized 'industrial' production in Early Dynastic III. On the basis of distinctive fabric types, restricted exchange of pottery between sites in Sumer may be identified. Mynors (1987: 168) also showed, both by petrographic and by neutron activation analysis, that pottery from Sumerian workshops was travelling southwards to reach Umm al-Nar in the Gulf.

As a direct result of research in the Department of Pottery Technology at Leiden (As and Jacobs 1985: 1986; 1988), the pottery of the second millennium BC is rapidly becoming the best known technologically. This research involves 'pot reading' (reconstructing the forming process from the pots), analyses of clay and fabrics, and experimental forming and firing. Most of this pottery was thrown on a fast wheel; some was made with the help of a tournette; and a small proportion was entirely hand-made. It seems that the raw materials were not selected with great care. The clay was tempered with a lot of organic material (chaff and dung), and was often not very cohesive or plastic.

Among the thrown pottery at Tell ed-Der four categories have been established: thrown from the cone; made from one piece of clay; made in coils; and made in cylindrical parts. 'The lower part of jars and bowls was often thinned down by scraping away the surplus clay after a period of drying. Since the presence of a large quantity of organic material made trimming rather difficult, this was done with a knife while the pot was supported with one hand' (Franken and Kalsbeck 1984: 82). Special study has been made of the manufacture of the tall 'goblets', particularly characteristic of the period, for which Old Babylonian potters had sought ways to prevent drying and firing cracks in the bases by strengthening with clay tempered with extra organic material; a practice adopted generally in the Kassite period. The basic techniques of potters in the Old Babylonian period at Tell ed-Der, Nippur, and Isin seem to have been the same. Most of the pottery was fired at about 800 °C.

Information on kilns remains uneven. Vandiver (personal communication, 1989) believes that kiln 'chimneys' are evident in kilns dating to the second millennium BC at Umm al-Hafriyat. Wasters helped to identify a simple, up-draught, two-chamber pottery kiln of the earlier second millennium BC at Tell Asmar (Frankfort *et al.* 1940: 9, fig. 2). The true functions of kilns found at Nuzi are less evident. One reconstructed by Starr as a brick kiln of the later third millennium BC has been more plausibly interpreted as a kiln for producing plaster (Starr 1937: plan no. 25, pl. 19B; 1939: 55, 329, fig. 46; cf. Delcroix and Huot 1972: 64-5). Others may simply have been domestic ovens (Starr

1937: pl. 22B; 1939: 54–5, 239–40, fig. 36). At Tell Kesoran in the Hamrin the Italian excavators have reported the discovery of eight pottery kilns at a site which they interpret as the industrial area of Tell Yelkhi in the Kassite period (Quarantelli 1985: 69, pl. on p. 167). In the same region a pottery workshop with fire installations was found in level I (twelfth century) at Tell Zubeidi (Boehmer and Dämmer 1985: 28, 30, pls. 70–1). Two earlier second-millennium kilns reported from Failaka are again of uncertain identity, since no diagnostic finds were found in or near them (Højlund 1987: 171–2).

The pottery of Failaka in the second millennium BC is of interest for the clear contrast it offers between a (north-east) Arabian or 'Barbar' tradition of potting and a Mesopotamian tradition, apparent in vessel shapes, in methods of manufacture, choice of clay and temper, and in decoration (Højlund 1987: 163 ff.). Most of the 'Barbar' pottery was primarily hand-made (perhaps with the aid of a turntable) in a coil technique, with some wheel-made vessels; sand and shell, possibly from local beaches, were used as temper. 'The close relationship in shape and ware between hand-made and thrown pottery makes it likely that the same potter mastered both techniques' (Højlund 1987: 168). The wheel-made vessels in the Mesopotamian tradition have distinct fabrics and shapes, matched on the mainland. Two of the 'Barbar' wares, heavily sand-tempered, show signs of poorly controlled firing, perhaps in an open pit, clamp, or simple kiln; the other, generally wheel-made wares, appear to have been fired under much more controlled circumstances.

As in the third millennium, the local pottery of Babylonia throughout the second millennium is very rarely painted and then, in the earlier part of the millennium, only with the most crude designs, predominantly geometric, in shades of red or in black. No analyses of these pigments have been published.

The pottery of Assyria in the second millennium BC awaits the attention of technologists. Most art-historical attention has been paid to the painted pottery traditions. To the earlier second millennium belongs the very heterogeneous category termed 'Khabur Ware'. This relatively common ware was probably produced at many places (cf. Stein 1984, with bibliography). The origin of the later, more homogeneous 'Nuzi Ware' has not yet been fully explained. From about 1450–1300 BC it was current throughout northern and central Mesopotamia in shapes, fabrics, and contexts suggesting a luxury or palace ware, produced to various local patterns. Drinking cups and goblets, derived from Babylonian prototypes, generally have white painted designs (predominantly floral in the west, geometric in the east) on a dark ground varying from reddish-brown to black. At Tell Atchana in the west the pigment was certainly fired (Woolley 1955: 348 n. 2); Starr (1939: 395) appears to

imply otherwise for finds at Nuzi in the east, but this may simply be loose phrasing. Woolley's (1955: 348) comments on colour at Tell Atchana have a wider application: 'the white-on-black effect was what the Alalakh potter aimed at, but he did not always obtain it. His kilns were faultily constructed and liable to draughts, with the result that "flares" are common, and with the oxidization of the haematite pigment a part of the black surface may be reduced to a reddish-brown.'

Until very recently the archaeology of the first millennium BC has been so exclusively studied in architectural or art-historical terms, in the shadow of the texts recovered from palaces and temples, particularly in Assyria, that craft traditions remain very little known. Although the so-called 'palace' wares have received some attention, notably at Nimrud, it is almost entirely typological. These thin-walled, fine wares were wheel-made, often in imitation of metallic shapes, complete with surface decoration sometimes inspired by metalworking techniques. As part of the study of the pottery from seventh-century contexts at Nimrud found in Mallowan's excavations there, Rawson (1954) commented on a small selection of Nimrud palace ware from a potter's point-of-view. The eggshell-thin vessels in this group, particularly, demonstrated the high skill of potters working at this time for the Assyrian court. 'The commonest clay body . . . is of a drab buff-grey-greenish colour, and is of extraordinarily fine and homogeneous texture . . . either a secondary, riverine clay, well washed by nature, or artificially levigated in vats or pits' (Rawson 1954: 169–70). Rawson believed that the finest wares had been thrown to that thinness in their wet condition and that the potter had not used moulds (as perhaps in later Achaemenid 'eggshell' wares) nor worked them in the green-hard state. Their characteristic fingertip impressions derived initially from the potting technique. In some cases the technique of double throwing was evident, when the pot was recentred on the wheel, in an inverted position, to allow the foot to be thrown out of the spare clay on the base. In other cases bowls were inverted and placed on some kind of clay boss on the wheel so that the underside (turned to its completed form in the green-hard state) might be shaved down with an edge as the dish rotated upside-down on the wheel.

Firing procedures were equally well controlled and exploited. The method by which the grey wares among the palace wares were produced is debated. In the final stages, at least, they must have been fired in a reducing atmosphere in the presence of free carbon and no oxygen. One series of dishes, paralleled in Palestine ('Samaria Ware'), had a decoration of concentric red rings on the interior. 'The rings were made by holding the red haematite earth against the sides of the pot as it revolved on the wheel after being recentred probably in the green-hard state . . . the action of the friction

between the surface of the revolving pot and the softish haematite, which may have been moistened, was sufficient to impart a layer of the earth to the surface where the earth was held in contact with it' (Rawson 1954: 169). As with other craftsmen at the Assyrian court, notably ivory-carvers, there may well have been potters who had originally come from Syro-Palestine after initial training there. As has been noted, some scholars argue that the kick-wheel was first introduced into Palestine by the Assyrians at a time when the earliest 'palace wares' of Neo-Assyrian type appear there (cf. Amiran 1969: 291), perhaps implying two-way exchange of technological skills.

Late or post-Assyrian kilns have been published from Khirbet Qasrij (Curtis 1989) and from Tell al-Fakhar (Al-Khalesi 1977: figs. 1, 4), located near the edge of the settlement. A late Neo-Assyrian industrial area, including potteries, has been located between the Sin and Mashqi Gates in the north-west corner of Nineveh (cf. *Iraq*, 51 (1989), 259, cf. 265). The kiln at Khirbet Qasrij is the best recorded (Curtis 1989: 21, fig. 20). It was used to fire small and medium-sized wheel-thrown plain wares. It was for modest, local needs, not for the simultaneous firing of large quantities as in mass-production. When only wall-stubs survive, as is often the case, the restoration of kilns is hazardous. This one probably had a flat floor in the chamber (not arched as in the published reconstruction) and may not have had a permanent clay dome. It might have had a temporary clay and straw dome or a permanent, low, open-topped permanent stack only capped at the time of firing, possibly with sherds. It becomes clear in the Neo-Assyrian period that deliberately made kiln furniture was a feature typical of glazed, not unglazed, pottery production.

The kiln, with associated wasters, at Khirbet Qasrij was found within a paved area with a platform that may have been used for drying pottery before firing. Some holes in the pavement may have accommodated pivots for potters' wheels. A large sandstone slab might have been the surface upon which the clay was made workable. Local calcareous clays were used. They may have been sieved or washed to produce the very fine body fabrics; no inorganic temper was evident, but some vegetal matter had been added. The pottery had been wheel-turned, with legs given additional vegetal temper (?dung) so that they did not separate from the body of the vessel due to differential shrinkage in drying (cf. Nimrud: Rawson 1954: 171). Non-local pottery was evident in a single hand-made cooking-pot, coarsely tempered with quartz, which may illustrate that such objects were widely traded, as in the Mediterranean region, whilst finer wares were locally manufactured. Painted wares and a vessel lined with bitumen, perhaps for transport of a liquid, were also imported (Freestone and Hughes in Curtis 1989: 61 ff.).

The pottery produced in the Neo-Babylonian and Achaemenid periods, before the Hellenization of many items in the standard repertory, shows no sign of innovative craft technology. At Ur Woolley reported that 'on the south-west side of the Ziggurat, close to the south corner of the tower, the ruins of the intramural chambers along the terrace wall and those of the chamber built by Nabonidus between them and the face of the Ziggurat were overlaid by the remains of a potter's works of the Persian period; some of the old walls had been re-used, but between them and over them were the actual kilns and the entire area was strewn with broken vessels of glazed clay, wasters, and the little clay tripods (cf. pl. 31: U.612) used for separating the bowls in the kiln' (Woolley 1939: 144). Later (Woolley 1962: 90) he added 'no less abundant fragments of "eggshell" pottery'; but he never provided any description of the type of kiln in use. The stratigraphical position suggests an advanced date in the Persian period for this work area. Woolley (1962: 90) observed that in the Persian period 'the templet was called into use much more often than in the past' in shaping the necks and rims of vessels with their emphatic collars and grooves. He thought they had been particularly used to produce the fine bowls of 'eggshell' ware introduced in this period (Woolley 1962: pl. 35: U.15195, pl. 38: types 2, 3, 5–7; cf. Fleming 1989).

(2) *Glazed wares*

In the Near East, unlike Egypt, glazes were applied to clay vessels from the middle of the second millennium BC. Such vessels are not reported from Egypt before the Ptolemaic period. The technical developments leading to the emergence of glazed pottery occurred at very much the same time, and probably in the same region, as the first experiments with the manufacture of core-formed glass vessels (see p. 193). Hedges (1982: 102) has pointed out that glazing baked clay was unlikely before mastery of the mechanical properties of glass allowed for controls sufficient to overcome the differing coefficients of expansion involved when using alkaline glazes on a baked clay body. In Mesopotamia the earliest extensive evidence yet recovered for this craft is provided by objects from Nuzi (stratum II) in the first half of the fourteenth century BC. Its earlier history, if any, in Mesopotamia is obscure.

The earliest datable examples of glazed terracotta sherds in the Near East remain those attributed by Woolley to level VI at Tell Atchana (Woolley 1955: 299); but doubts persist about the stratigraphy of this site. Woolley described these sherds as 'a few miscellaneous fragments of green- or blue-glazed pottery' (AT/47/55). Level VII at Tell Atchana was destroyed within the local Middle Bronze Age IIB period, in the second half of the seventeenth century BC, almost cer-

tainly by the army of the Hittite king Hattusilis I. The subsequent level VI is, in ceramic terms, still largely tied to the traditions of Middle Bronze IIB–C, whereas level V is tied to the Late Bronze I period from about 1550 BC. Although a complete glazed jar was found in a grave attributed by Woolley (1955: pl. LXXXIIIe) to level V, three associated cylinder seals indicate that it was cut down into this level at a later date, perhaps in the fifteenth century BC (Collon 1981, nos. 51, 60, 63). Analysis has shown that the glazes on these early examples from Tell Atchana are the ordinary alkaline glazes used by faience-workers, now for the first time applied to a baked clay rather than to a siliceous core (Peltenburg 1969: 80 n. 33). They are not true lead glazes as was automatically assumed at the time of discovery.

Study of early glazed pottery in Mesopotamia is inhibited by the fallibility of published identifications, notably at Ur, where many of the objects so described by Woolley are in fact faience (cf. Woolley 1965: 98). The existing corpus is dominated by finds in the destruction level of Temple A at Nuzi some time in the middle of the fourteenth century BC; this is a context renowned for its range of glazed objects, glass, and faience. Starr (1939: 91, 403; 1937: pl. 92Z) reported a tripod bowl 'covered with an all-over coating of the familiar blue-green glaze' and several small glazed vessels (Starr 1939: 91, 391–2). In Assyria little may yet be said about sherds reported from Billah, Brak, and Tell al-Fakhar (Peltenburg 1987: 13, fig. 3) or about objects from Tell Rimah, save for at least one 'glazed pottery vessel' among a collection of glass and faience from a room in the Middle Assyrian temple (Carter, T. H. 1967: 286). In Babylonia relatively rare occurrences of glazed pottery (and rare glazed figurines) have been reported from Kassite levels at Nippur (Gibson 1975: 16; 1978: 81), at Ur (with due caution), on the island of Failaka (Højlund 1987: 95–6, 188) and Uruk (Boehmer *et al.* 1987: 49–50, figs. 6–8). This does little more than indicate a widespread, if low-level, use of glazed pottery from about 1400 BC in Mesopotamia, with some indication of its first emergence in the north-west.

At Assur, where the Middle Assyrian graves contained faience and glass vessels, glazed pottery is rarely mentioned in the excavation reports (cf. Haller 1954: 115: tombs 37, 51; also grave 133, which is not 'Neo-Assyrian'). However, in his general account of Assur, Andrae (1977: fig. 164) illustrated a range of monochrome glazed pottery jars and bottles of the kind found at Nuzi. An unusual relief plaque, described as 'eine farbigemallierte Tonplatte' (6 × 11 × 2 cm.), was also found at Assur. It is pierced for suspension at the top and is moulded in low relief with a robed Asiatic reminiscent of contemporary Egyptian representations of Asiatics on polychrome faience tiles (Andrae 1913: 133, fig. 231; 1935: 81, fig. 63; cf. Stevenson-Smith 1965: 45,

figs. 69–70). Caubet (1985) has discussed the glazed pottery from Cyprus and Syria.

Although true polychromy had appeared in Near Eastern faience by the third quarter of the second millennium BC, perhaps under the influence of developments in glass vessels, its earliest appearance on glazed terracotta is not easy to establish. Its use was inhibited by a technical problem, since in the case of baked clay the glazes do not so easily fuse with the carrier as in faience, thus a form of *cloisonné* had to be devised with the polychrome set between glaze outlines in order to prevent the glaze colours from running and mixing. This had certainly been mastered, both on bricks and pottery, by the Neo-Assyrian period; but how much earlier it appeared is less easily established. In a simple way it is evident on architectural glazed terracottas of the fourteenth or thirteenth century BC at Tchoga Zanbil in Khuzistan, where extensive use of glazed brickwork is evident for the first time in the Near East (Ghirshman 1966; Peltenburg 1971: 9).

After the twelfth century BC in Mesopotamia, as in Syro-Palestine, there appears to have been a break in the tradition of glazing pottery. But it is possible, especially in Babylonia, that this is more apparent than real, since the material culture of the end of the second and the beginning of the first millennium has not yet been properly identified. In Assyria production of polychrome glazed bricks is again evident by at least the early ninth century BC, and by the eighth century BC, if not before, glazed pottery was again current in Babylonia. It was now more often polychrome. Peltenburg argued that a revival of glazed pottery production in Syria in the last third of the eighth century BC at the latest was ultimately inspired from Babylonia: 'in the second half of the eighth century both Tiglath-Pileser III and Sargon II deported Babylonians to N. Syria, and it seems only natural that glazed vases or even a Babylonian glazer were included' (Peltenburg 1969: 86). Stimulus diffusion along the Euphrates might also have been a contributing factor.

Much of the glazed pottery from Babylonian sites is too badly preserved, or too sparingly published, to allow for any close analysis leading to a definition of local styles and production centres along the lines suggested by Strommenger (1967: 9). The extent of continuity with Kassite craft traditions has still to be elucidated. In contexts at Babylon attributed to the Neo-Assyrian period glazed vessels were apparently relatively rare (Reuther 1926: 22–3, 28, pls. 75a–d, 76: 18; Koldewey 1911: 35 ff., fig. 54; 1913: fig. 152 (colour)). They were glazed in light blue, white, and yellow; polychrome decoration was only occasionally recognizable, usually in white, light and dark yellow, light blue, and dark blue/black. By the Neo-Babylonian period glazed vessels were commoner, again in blue or white glaze, and with polychrome designs consisting of

rows of triangles, rosettes, squares, and zigzags. At Nippur, again in levels of the Neo-Assyrian period, the base glazes were light blue, greyish white, or blue-green in that order of frequency. 'Polychrome designs occur in combinations of dark brown, light and dark yellow, orange, a gray and a blue which probably represent the same original color, light green or yellowish green, and white' (McCown 1967: 79, pls. 100–1). More recently, Gibson (1980: 202) has referred to 'dwellings of the early first millennium containing extraordinary numbers of glazed vessels' at Nippur.

Of particular interest at Nippur is a remarkable group of glazed vessels found there by the pioneer excavators. It is hard to place them chronologically with confidence, but what comparative material there is suggests the earlier first millennium BC. They were 'in a large urn on Hill I, 11 m. below the surface' (Peters 1897: i, plate facing p. 186). A box on four feet, with pyramidal top, is made of a spiked or knobby ware; two smaller boxes, with lids, and three jars, one with a stopper, are more conventional. All were 'thickly glazed with blue and yellow in stripes'. With the vessels were over a hundred small faience objects, bored for suspension: 'some round, some oval, some crescent-shaped, and all coloured, some black and white, and some blue and yellow'. A single published vessel of 'knobbly' ware from the 1976 Nippur excavations appears to be of the same type of ware as this group. Gibson (1977: 27, figure) described it as a 'glazed pottery incense burner'. It was in a burial (no. 61) cut down into level I, dated c. 900 ± 200 BC.

The revival of glazed wares at Ur is not securely dated as Woolley almost certainly included examples of seventh century or earlier date in his 'Neo-Babylonian' category. He offered a detailed comparison between wares of the Neo-Babylonian and Achaemenid periods (Woolley 1962: 90; cf. Hall 1930: 184–5, figs. 147–8); but this has to be used with caution in view of the difficulties of confidently attributing vessels to one or other of these two periods: 'Already by the time of Nebuchadnezzar (II) about one grave in every three can boast a glazed pottery vessel; in the Persian graves the proportion is higher, but more symptomatic is the fact that of a hundred types which are almost if not quite exclusively Persian forty-three are represented by glazed examples . . . we can say that half the characteristically Persian types are glazed whereas of the fifty-nine types listed as peculiar to the Neo-Babylonian period only twelve show examples of glazed ware. The glazed forms are for the most part broad-rimmed shallow bowls or plates . . . slender-necked bottles . . . small squat jars . . . or such exotic forms as the handled flasks and pilgrim bottles.' In one case bowl sherds were decorated with a polychrome design of animals and a tree on a white ground (Woolley 1962: pl. 35: U. 6654). Hall (1930: 184–5, fig. 148) reported half a bowl decor-

ated with 'stripes of blue and yellow outside and a design of blue and yellow spots within'.

In Assyria glazed pottery of the later eighth and seventh centuries BC is still best known from finds at Assur long ago, to which Andrae (1925) devoted a monograph illustrated in full colour. There the predominant forms were buckets, jars, and closed bowls, of various sizes, with polychrome glazes on the exterior. Some of the buckets and jars were of considerable size; the standard jars are generally 8 to 9 cm. high at the most, with larger examples reaching as much as four or five times that size. The manner of publication does not allow for accurate identification of these vessels, which may have been specifically used for cult purposes; a possible role for the outsize vessels. One of these larger jars contained a cremation burial (Andrae 1925: pl. 25A; Haller 1954: 52–3, fig. 63A). 'A favourite grave furniture—at any rate in Late Assyrian times, that is the eighth and seventh centuries BC—were the little bottles manufactured in the mass, at first richly decorated, later quite simple' (Andrae 1925: 34). Drinking cups, or open bowls, and dishes do not seem to have been glazed in this way, so the glazed jars, presumably part of a luxury industry, may have been containers for valuable unguents. Only a few sherds have survived with the colours preserved to something like their original intensity. On a rich light blue, or green, base, glaze designs were rendered in warm golden yellow, ivory, and dark blue. 'On the small objects woven patterns are used, such as the chevron band, and rows of circles, rings, squares, triangles or wreaths of leaves; in the big ones there are besides friezes of battlements, rosettes and bases of pillars, taken from architecture' (Andrae 1925: 34–5). Some of the more elaborate designs employed traditional motifs from the religious repertory: animals flanking 'trees-of-life' with a winged disk hovering above; scenes of worship with altars, symbols, and supplicants.

Similar glazed pottery has been found on other sites in Assyria, but publications are rare. It is said to have been 'not uncommon' at Nimrud (Oates, J. 1959: 138). Mallowan (1966: 120, figs. 62, 187) refers to one large jar decorated with an ostrich hunt, from the North-West Palace at Nimrud and to another, not described, in the main reception room of a private house. That such vessels were treasured long after they had passed from production is illustrated by a blue, white, and yellow glazed Neo-Assyrian jar in a grave of the Hellenistic period at Nimrud (Oates, D. and J. 1958: 130, 152, pl. XXVIII: 15). Comparable vessels were found at Khorsabad (Loud and Altman 1938: pl. 63: 231, 244), and an isolated example has been published from site 'C' at Tell Rimah (Carter 1967: pl. 9).

Westwards into Syria this Neo-Assyrian industry does not appear to have had any marked impact. Peltenburg argued that a distinctive group of glazed flasks,

with a wide distribution in the East Mediterranean, had come initially from workshops in Syria. If influenced from the east, it was by Babylonian not by Assyrian craft traditions. They have design arrangements, shapes, and certain technical traits distinct from those evident at Assur. Areas on the surface were reserved in the base white glaze for later filling-in with green and brown glazes. This layout technique is known in Babylonia but, at least at Assur, outline techniques are used for the purpose in the north (cf. Peltenburg 1969: 83-4, fig. 2j).

The glazed pottery traditions of western Iran were again distinct, with differing methods of glaze application and contrasting colour schemes, though some of the shapes and designs appear also on Neo-Assyrian sites in Iraq (cf. Hennessy 1979: pls. 111-2 (colour); Fukai, S. 1981: pls. 8-9, 10-15 (probably glazed terracotta not faience); Ghirshman 1964: pl. 398; Wilkinson 1967: fig. 14). Such vessels appear at Susa in the eighth to seventh centuries BC (Amiet 1966: pl. 378).

None of the glazes on pre-Islamic Mesopotamian pottery analysed in recent times has proved to be a lead or a tin glaze in the strict sense; they are all alkaline glazes. This was first established by Salvétat in the nineteenth century; but obscured by later inaccuracies and false interpretations (cf. Birch 1858: 143). In a series of analyses Hedges (with Moorey 1975; Hedges 1976; 1982) established some basic facts about ancient Mesopotamian glazes on pottery. Compared with modern alkaline glazes (Hedges 1982: table 2), there is a little more Si and a little less Al or Al + Fe. It is beneficial if the alkali, especially the soda content, is kept as low as possible, since it is the main contributor to the expansion coefficient, and thus the lower the percentage, the better the chances of adhesion. Vandiver (1982^a) has suggested that the adhesion of an alkaline glaze to a clay body was promoted by the presence of soluble salts deposited on the surface as efflorescent products during drying. In the sherds so far examined there is no major difference between the body fabrics of glazed and unglazed vessels, though the former might have been expected to contain more quartz. Thin-section microscopy discerned no differences (Hedges 1982: 99). Nor is there any significant change in glaze composition through time. In the Sasanian period at Kish there was a slight increase in Al and a corresponding decrease in Si, perhaps allowing for a lower maturing temperature and a greater control over the glaze.

Although analyses of glazes on pottery from sites as far apart as Failaka and Nineveh, dating from Kassite to Sasanian times, reveal comparatively little variation in the glaze composition (Pollard and Højlund 1983; Højlund 1987: 188), there are chemical distinctions which may eventually be seen to be indicative of local traditions. At Nippur the glazes were higher in potassium than at Kish and Nineveh. At the same site tin was

a common occurrence, but not lead or zinc. Zinc was ubiquitous at Nineveh, whilst at Kish tin was only found with any frequency in Parthian and later samples, and then lead is commonly found as well. It is also possible that barium in the glaze or in the body might well be indicative of an origin in the Nippur region. Glazes on baked clay from the Kassite levels at Failaka have a remarkable excess of magnesium over lime. This was tentatively attributed to the use of a high magnesium ash in the glazing process, although the possibility of severe effects from weathering could not be ruled out. This trait may also have some connection with the high-magnesia glasses characteristic of Mesopotamia in the second millennium BC (Pollard and Højlund 1983), since craftsmen may have been using salt from local salt-pans.

Among what were considered to be locally produced Late Assyrian glazed sherds from Khirbet Qasrij in the Eshki Mosul region there were examples with soda-lime-silica glazes coloured green (?) with copper. One or two had a yellow coating, which was either a failed attempt at glazing or possibly the result of fritting together glaze raw materials in a pot before application (Freestone and Hughes, in Curtis 1989: 73-4).

Even now, when it has been shown analytically that lead (the flux with a compatible coefficient of expansion to fit a clay body) was not used in significant quantities in Mesopotamian glazes until some time in the first millennium AD, confusions persist through popular misconceptions about what constitutes a true lead glaze. It is important to draw a sharp distinction between a true lead glaze, in which a high percentage of lead (say over 20 per cent) is present as a flux and bonding agent in the glaze composition, and those glazes in which lead is present in relatively small percentages as a colour modifier in specific colours. It is pointless to speculate why lead glazes were not used until so late, save to remark that pristine alkaline glazes are brilliantly coloured by contrast with their duller lead-glaze counterparts. They also offered a potentially greater colour range and may have had a more glossy appearance.

The problem of colourants in ceramic glazes is discussed here in connection with faience (see p. 184).

(iv) WORKING WITH CLAY: ASPECTS OF THE WIDER REPERTORY

Pottery was but one, albeit the most conspicuous, aspect of the manufacture of clay in Mesopotamia. The potters, male or female whether part-time amateurs or full-time specialists, almost certainly from time to time turned their hands to other products made in clay, not least figurines. In view of its prevalence in Sumer, it is hardly surprising that clay modelled by deities, male and female, was a metaphor for creation. A euphemism

Summary of the average composition of oxides for glazes and bodies of Mesopotamian pottery^a

Type	Na ₂ O	K ₂ O	MgO	CaO	Fe ₂ O ₃	Al ₂ O ₃	SiO ₂
<i>Bodies</i>							
Unglazed	1.5	1	5	16	8	16	50
Achaemenid	1.6	1	6	17	7	16	50
Parthian	2	1	6	16	8	15	50
Sassanian	1.5	1	5	16	8	16	50
<i>Glazes</i>							
Achaemenid	8	3	2.5	8	2	4	70
Parthian (Kish)	7	2.5	3.5	6	3	4	70-75
Parthian (Nineveh)	6	4	2	4	-	4	70-75
Sassanian	8	3	4	8	2.5	4-8	65-70
<i>Modern Alkaline</i>	6-10		16-10		8-12		65-75
<i>Faience glaze (Egypt)^b</i>	10	6	5	4	2	1	75
<i>Glass (Parthian)^c</i>	14	2	4	7	2	2	65

a Note that silica is by difference. Comparison is made with modern alkaline glazing, Egyptian faience, and typical glass from Parthian Mesopotamia.

b From Lucas 1962:475.

c From Stone and Thomas 1957.

Source: After Hedges 1982: fig. 2.

for death was 'to return to the original clay' (Barrelet 1968: 7 ff.). The following rapid survey of its varied use does no more than sketch the potential of a material that every man, woman, and child might manipulate and use at some time or another. Such objects could have been fired in pottery kilns or in ovens (cf. Werr 1988: 5, no. 116).

Since they are only recovered in the most careful of recent excavations, and then in fragments, little is known of the *sun-dried clay objects* used in ancient Iraq. Among fragments of such objects from Early Dynastic IIB levels at al-Hiba Ochsenschlager (1974) recognized parts of portable hearths, heavy disks used primarily for cooking and baking, incense-burners, shallow flat-bottomed dishes used for a variety of purposes, portable containers for dry goods, and ovens. In modern villages on the site such objects were made in the summer months by women, who reported that they lasted from one to about six years. They use the best clay available locally tempered with straw and chaff. Children, who are often adept at this work, produce their own toys, models, animals, boats, etc. This is clearly an age-old craft, particularly in the south of Mesopotamia, providing a whole range of household equipment not to be overlooked in assessments of daily equipment in antiquity.

In modern burials, hand-made, sun-dried mud jewellery is a substitute for the real thing; but in archaeological contexts clay beads and amulets are a cheap aspect of the regular repertory. The same is true of seals, notably clay *cylinder seals* (Werr 1988), which appear in the late fourth millennium BC (Matthews, R. J. 1989: 236) and pass into eclipse after the middle of the second millennium BC, when faience and frit become increasingly available for the purpose. The same may also be true of mud jewellery, but evidence is lacking.

Figurines of clay, sun-dried or baked, were manufactured in Mesopotamia from the time of the earliest settlements there, hand-modelled and decorated in techniques used by contemporary potters. Indeed, they may often have been made by one and the same people within any settlement (Barrelet 1968: 54 ff.). From the outset animals and anthropomorphic figurines, primarily female, are the basis of the repertory, though the role of such figures, whether magical in the widest sense or toys, remains much discussed and clearly varied from context to context. The most significant change came some time towards the end of the third millennium, probably in the Ur III period, when plaques made in baked clay moulds were introduced (PLATE 1B). A very varied religious imagery was used to decorate them for some three or four hundred years thereafter (Opificius 1961: 24). About the same time, c.2100 BC building bricks at Telloh were stamped for the first time with bird or animal devices from negatives cut into baked clay or metal stamps; a method closely akin to the production of moulded relief clay plaques (Barrelet 1968: 90-2). Three-dimensional, hand-made figurines of animals and female figures persisted side-by-side with a range of chariot models which appeared during the Early Dynastic period and persisted into the early second millennium BC (Littauer and Crouwel 1979). The high inside fronts ('screens') of two-wheel model clay chariots were a favourite subject for mould-made religious scenes c.2000-1700 BC (Buren 1930; Opificius 1961; Barrelet 1968). Isolated moulds of baked clay for producing these chariot fronts have survived (cf. Barrelet 1968: fig. 16) (PL. IV A); the rest of the vehicle was hand-made as before. Although the wide range of moulded plaques seems not to be site (or temple) specific, it has been argued that the chariot fronts represent the deities, if not the main cult statues,

of cities in which they concentrate (cf. Stone: forthcoming). Elaborate moulded plaques disappeared from the repertory at the end of the Old Babylonian period. Thereafter models and three-dimensional representations of female figures are virtually the only small-scale terracottas to be evident, though clay was used for larger sculptures (see below). It is possible that moulded figures in faience and frit superseded terracotta to some degree after the fifteenth century BC; but changes in cult practices are the most probable explanation for the eclipse of the 'Old Babylonian' terracotta plaques.

In the first millennium BC various distinctive apotropaic clay figurines and plaques appear both in Assyria and Babylonia, variously hand-made and moulded. They were commonly placed in foundation deposits (Barrelet 1968: 110 ff.; Green, A. 1983). Some of the demons and monsters represented have an earlier history. There may indeed have been a conscious revival in imitation of earlier Babylonian plaques. It was not until the Seleucid period that the iconography and methods of manufacture of terracottas were significantly modified under Greek influence.

The use of terracotta for more monumental sculpture is particularly evident in the earlier second millennium BC when vigorous hand-modelling, with effective use of incised and painted decoration, was used to represent gods (cf. Spycket 1981: 226–8, pls. 150–1), a remarkable series of female heads and male statues of less certain identity (ibid.: 252, pl. 173; Hrouda 1977: 39 ff.; 1981: 61 ff.), and guardian animals, notably lions (ibid.: 288 ff., pls. 192–3; Spycket 1988^a, which seem to have been made and fired in separate pieces and subsequently assembled. This is a medium to be expected in southern Mesopotamia, but evidence for its use in other periods is currently very restricted (cf. Spycket 1981). No Old Babylonian terracotta sculpture or decorative brickwork has yet been reported with a glazed surface.

The earliest examples of *glazed terracotta statuary* from Mesopotamia are fragments from Temples B and C in G50 in stratum II at Nuzi, c. 1400–1350 BC. According to the excavator: 'these objects, broken and out of place, give the impression that between the time of Temple C or B (which are identical in this building) and Temple A, a destruction took place as thorough in the case of the objects, if not the walls, as that which obliterated Temple A' (Starr 1939: 110), the last in the series. In these levels were 'the haunch of a lion figure identical with the red and yellow ones but covered with the familiar green glaze . . . an incomplete yellow-glazed Ishtar figure with black on the genitals and breasts' (Starr 1939: 10). The latter was the only Ishtar figurine treated in the round found in this excavation.

The range of glazed terracotta from the later Temple A was greater. In the north corner of G29 was 'a green-

glazed terracotta representation of a woman's breast (pl. 102, E) and fragments similar to it which may have been pieces of another' (Starr 1939: 90, cf. 423). These were taken, though smaller than life-size, to be parts of a composite, large-scale deity statue. In the courtyard was a blue-green glazed terracotta statuette of a standing female worshipper (Starr 1939: 96, cf. 419–20). Traces of small glazed animal figurines, of types found unglazed in the private houses, were also recovered from Temple A (Starr 1939: 97; 1937: pl. 110B, 108); but they in no way compare with the larger animal sculptures in terracotta for which this shrine is best known. There were a pair of lions (47 cm. long) with an even coating of green glaze, standing on an unglazed base (Starr 1939: 97, 430 ff.; 1937: pls. 110A, 111A); and another pair, this time *couchant*, 'covered with a thick yellow glaze which streaks across their red-painted bodies' (Starr 1939: 97, 430 ff.; 1937: pl. 111B). Only one was found in the Temple A *cella*, significantly complete; the others were in fragments in the courtyard outside. Also in fragments within the *cella* was a green-glazed boar's head (Starr 1939: 98; 1937: pl. 112B). It had the appearance of having been a wall knob projection; two tusk-like objects of blue frit may belong to it. There was also evidence for a comparable ram's head (Starr 1937: pl. 110C). More unusual was 'an ear of a lion in terracotta, covered with a deep yellow glaze of exceptional thickness. The rim and veins within the ear were shown in relief and executed in green glass' (Starr 1939: 98). Starr believed that glazing was restricted solely to objects for temple use or to cult vessels.

The standing lions were made in five parts: body and head, with open mouth leading to a hollow interior; front legs; two hind-legs made separately; the base, unglazed save for drips (Starr 1939: 430 ff.). The assembly of these objects was distinctive:

The only adhesive used in joining these separate parts is the glaze itself. By it alone the front legs—dipped all over in glaze—were held in place both above and below. The two hind-legs were similarly cemented to the base and body as well as to each other. Not until the body—also with an all-over coating of glaze—was set in its final position (the hindquarters are not exactly centered over the legs), was the assembled object placed in the kiln. The vitrification of the glaze firmly cemented the sections together, and the excess which oozed from the joints served to make an unbroken surface between the separate parts which were lost when the object was broken up in the destruction of the temple.

(Starr 1939: 431)

The glaze was in very poor condition and the body was a very coarse ware, dull brick-red in colour and friable, with temper of sand and straw. The surface was not smoothed down before glazing and this has affected the lie of the glaze. The glaze provides the adhesive also in the boar's head (Starr 1939: 435), which is made from two perfectly symmetrical sections. The pair of

couchant lions are technically interesting in other ways. They are decorated with a comparatively rare yellow glaze and a type of red paint only found on these objects at Nuzi: 'a foundation of red color applied there before the application of glaze. The color is a brilliant, deep red, losing much of its intensity on exposure to the air' (Starr 1939: 434). The gaudy contrast of deep red ground and intentionally streaked yellow glaze must have been striking in its pristine state.

No glazed terracotta statuary has yet been found in Mesopotamia that matches in scale the guardians of temple entrances found at Tchoga Zambil in Khuzistan in the great fourteenth-century ziggurat complex. As reconstructed these bulls and griffins are almost a metre and a half high and over a metre long (Ghirshman 1966: 49–50, pls. XXXII–XXXV; 1968: pl. LXVIII). Such terracotta temple guardians had been known in Mesopotamia since at least the earlier second millennium BC, but no glazed examples have yet been recorded.

As with other aspects of the glaze and faience industries, there is a hiatus in the evidence after 1200 BC for between four and five hundred years. Even then, although glaze came to be widely used on architectural fittings and pottery, it is very rarely reported on Neo-Assyrian baked clay statuary. From seventh-century Assur, Andrae (1925: 59 ff., pl. 30) reported a horse's head, the hollow body of a pack-animal, and the major part of a figure restored as a female worshipper. All were polychrome glazed, the woman in a garment richly patterned in green, yellow, and blue/black (Klengel-Brandt 1978: no. 288, cf. 289). By the Neo-Assyrian period, if not earlier, in central and southern Iraq small baked clay figures were more commonly glazed, as was contemporary pottery. The most notable examples are a series of tiny horsemen which remained popular through the Achaemenid period, glazed and unglazed (Barrelet 1968: 128–9). As Babylon has yielded at least one glazed Pazuzu head, and even at Assur there may be glazed horsemen, this practice certainly runs back into the seventh century (Reuther 1926: 24, fig. 23; Klengel-Brandt 1978: 60).

The range of what might broadly be described as baked clay *tools* is particularly wide in the culture of southern Mesopotamia, especially in prehistory. But at all times and across the region weights and spindle-whorls, plugs and stoppers, votive and funerary models of tools (as of weapons), and moulds for objects of all sizes were made in clay. Some types were specific to certain periods in prehistory and have consequently been taken as cultural indicators:

1. *Clay sickles* appeared in the Ur-Eridu area in the Ubaid 2 (Hajji Mohammad phase), without displacing flint sickles, and became commoner in the late Ubaid (Safar *et al.* 1981: 148, 258–9; Wright, in Adams 1981: 304). They continue until at least the Uruk period, when they are typically larger (handles thicker than

1.9 cm. and blades wider than 5.5 cm.) than those found in the Ubaid period. They only appear in quantity in southern Mesopotamia and have not been reported in the north. It is still unclear whether or not examples found in later contexts (Jamdat Nasr–Early Dynastic) are simply strays from earlier levels or were still in use. They are commonly taken to be indicative of cereal cultivation as tools for harvesting, but there is sufficient wear-trace evidence to indicate that they were also part of the tool-kit of anyone working with reeds or comparable canal-bank plants. Anderson-Gerfaud (1983: 180–1) concluded: 'Selon nos observations expérimentales, les outils "émoussés" semblent plutôt avoir servi pour faucher des céréales, tandis que la faucille "lustrée" a plutôt servi à couper une plante siliceuse, plus résistante.' The effectiveness of these sickles may have been affected by the proportion of sand in the fabric, since some have a Mohs hardness of 6–7.5 as against a general 4.5–5. They appear to have been fired in kilns with contemporary pottery to comparable temperatures. They were made in moulds.

2. In many contexts before and after the Late Ubaid period in southern Iraq, clay sickles are reported together with *nail-shaped objects of baked clay*, easy to hold in the hand. They are not related to decorative wall cones. The pointed end is often bent over and the head shows signs of wear. The wear is not usually hard, suggesting use on a relatively tender or yielding surface. They are commonly assumed to have been employed as pestles in food preparation, though they might have been used in the processing of animal skins or some other role (Anderson-Gerfaud 1983: 181). Wear-trace studies have not yet elucidated their function. They are widely distributed in the south, but have also been published from sites in the north (cf. Mallowan 1935: 90, fig. 49:8).

3. It is less easy to explain the function of the *baked clay axeheads* widely discovered on sites of the Ubaid period, as at Eridu, Tello, Tell Uqair, and Ubaid (Unger 1938: pl. 63; Parrot 1948: 36, fig. 7r; Lloyd and Safar 1943: pls. XVIIb, XXIXa; Hall and Woolley 1927: 205). Size, context, and wear on their cutting edge indicates that some at least were used, though it is not yet clear exactly how. Others may have served as models for sand-casting copper axeheads. They are not 'models' in the strict sense, since models are usually distinguished by size and condition as, for example, in grave 21 at Tell al-Ubaid, where a clay model of a flint hoe was found beside a real one (Hall and Woolley 1927: 205, pl. XLVI T.O.40).

From remote prehistory the primary clay weapon was the *sling bullet*; clay maceheads also appear, but more rarely. Near the main gate of a heavily fortified Old Babylonian settlement on Mound D at Khafajah was an accumulation of clay maceheads and sling bullets (Hill *et al.* 1990: 219, pls. 52, 57b). Korfmann (1972)

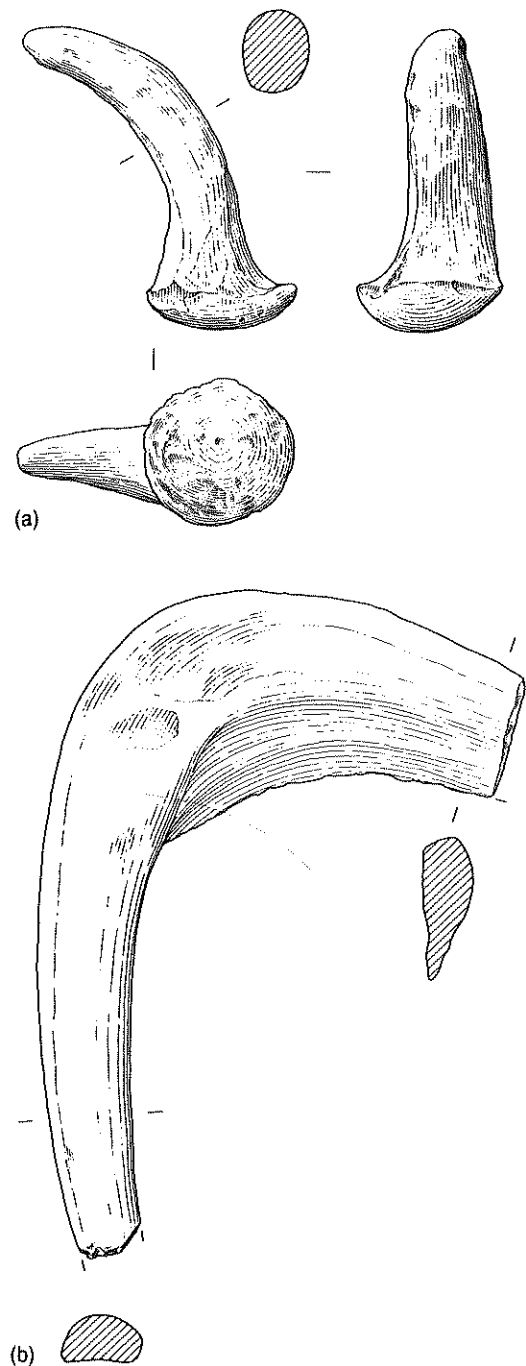


Fig. 11. (a) Baked clay nail-shaped object (?pestle) from Ur, c.4000 BC.
(b) Baked clay sickle, broken through use, from Jamdat-Nasr, c.3200 BC.

has provided full documentation for the sling in prehistory, but evidence accumulated more recently suggests that there is no simple chronological scheme of shapes as he proposed for Mesopotamia. The sling was, as it remains, the poor man's natural weapon, as effective in combat as in hunting in skilled hands. Even when

the bow became common, perhaps not until the third millennium BC, it was widely used. In the earliest settlements, as at Umm Dabaghiyah, they were already systematically prepared in quantity (cf. Kirkbride 1973: 207, pl. LXXXb). There were over 4,000 sling bullets, perhaps originally on the roof, in a house of the Ubaid period at Tell Madhhur (Roaf 1989: 131–4, fig. 18). Stout (1977) conducted experiments to see if there were significant differences in the results when different shapes were used:

Biconical—average distance 90.5 m. (goes to left), average weight 35 grams.

Elongated biconical—120 m. (goes very straight), 57 grams.

Point-ended ellipsoid—103 m. (goes reasonably straight), 28 grams.

Flat-ended ellipsoid—94.5 m. (goes to left), 43 grams.

Apart from its use in building (see Chapter 7) and in ceramics, widely defined, clay was distinctively and unusually the primary medium for *writing and record* until the later first millennium BC in Mesopotamia. It was displaced by papyrus and parchment as Aramaic, written in a linear alphabetic script, came increasingly into use as the language of administration and government. The craft of the scribe falls outside the range of this survey (cf. Edzard 1976–80: 544–68; Walker 1987; Schmandt-Besserat 1992).

2. Working with Faience

The study of ceramics made with clay has been fundamental to archaeological research in the Near East for over a century, but those with sintered quartz bodies have only recently attracted expert attention. Many were tiny and fragile, particularly subject to decay and discoloration in the soils of the region. Moreover, as Stone and Thomas (1956: 138) observed, 'far too frequently excavation reports, especially those dealing with the Middle East, lack precision, and accurate descriptions of the substances found are mainly wanting or may be wholly misleading'. This potential hazard is not eased by classifications that also differ according to the native language of the excavator. Any remedy for these deficiencies will only be made gradually, as more and more objects receive proper scientific study. In the meanwhile it is possible to provide no more than a broad picture of the main trends, in which the details remain very much open to correction. A preliminary step has to be taken with terminology even if (as is all too often inevitably the case) good intentions are thwarted by the variety of the older literature and necessarily popular terminology.

The ancient material known as *faience* has no relationship to objects of earthenware decorated with glaze and enamels, such as the faience of Faenza in

Italy from which the term was originally derived. It is a long-standing misnomer for a *composite material consisting of a sintered quartz body and a glaze*. However inappropriate the term may now be, it is too deeply entrenched in the literature to be discarded. Synonyms used by various authors are: sintered quartz, glazed frit, composition, Egyptian faience, paste, etc. The body of ancient faience is of 'finely powdered quartz grains cemented together by fusion with small amounts of alkali or lime or both, and is usually colourless though impurities have occasionally tinted it brown or grey' (Stone and Thomas 1956: 38). Although glass is treated separately here, there is an important distinction which has to be emphasized in any full definition of ancient faience. In a true glass the various ingredients must become completely fused together in a liquid melt, which is then cooled and acts as glass. The synthetic ancient material known as faience has only been *sintered*: 'the ingredients were heated sufficiently so that some of them melted or reacted to form a very small proportion of liquid, which upon cooling served to cement together the unfused grains' (Brill 1970: 115). This state is often, if rather confusingly, termed 'glassy'; but it needs to be sharply distinguished from glass, particularly when the relevant ancient documentary sources, not in themselves explicit, are under consideration.

Faience can be modelled by hand or pressed into a mould. When dried and fired it becomes harder, though the hardness varies. The material ranges from soft and crumbly, through very compact, to a very close approximation both in hardness and appearance to glass ('glassy faience'). In practical terms in Mesopotamia, where the surviving body is commonly in a friable condition and the glaze often only evident from tiny surviving specks, faience objects are just 'sintered quartz', explaining why such misnomers as 'white frit' or 'white paste' are regularly encountered in the literature to describe them. In nineteenth-century accounts they sometimes appear as 'porcelain' (Layard 1853). *Paste*, like frit (see below), is a particularly unfortunate designation, as 'in modern usage it is loosely used to describe a material formed by fusing powdered quartz and alkaline salts, and coloured with metallic oxides, for making imitation gems. It has no scientific meaning' (Stone and Thomas 1956: 39).

Glaze is a discrete layer of glass on the surface of crystalline (faience) or baked clay bodies. Glazes are conventionally classified by the flux used in manufacture to determine the melting and maturing temperature in firing. 'Alkaline' glazes are fluxed with soda or potash; 'lead' glazes with lead. By contrast, the term 'tin glaze', used particularly in Near Eastern contexts to describe certain glazes on Islamic pottery, indicates glazes, whether alkaline or lead, opacified by the addition of tin oxide. If used alone it turns the glaze

white; if used with another metal-oxide colourant it makes the glaze opaque.

Glass is a material made by cooling a silicate melt in such a way that it does not crystallize and retains some of the characteristics of a liquid. Ancient glass was made by melting together silica and impure soda. However, ancient glazes on beads, which date from a much earlier period than glass, were much more probably formed by the high-temperature reaction of an alkali on silica. It will be seen that the raw materials of faience and glass are the same but employed in very different proportions and with a different technology. Glazes are not found on baked clay (terracotta) until the sixteenth century BC in the Near East. The glazes were coloured (most commonly blue or green) with metallic compounds. True vitreous glazes must be clearly distinguished from slipped, painted or burnished terracotta surfaces. A glaze differs from a paint in that it has to be fused at high temperature whereas the medium of paint is organic and will burn on heating. But, since mixtures of frit, silica, and lime may be 'painted' on to a baked clay surface, and then fired to form a glaze, the term 'paint' inevitably appears as a verb in the following pages.

Frit is the most problematic of the terms relevant to the subject, since it is often used as if it were synonymous with faience (cf. Perkins 1949), from which it should in fact be clearly distinguished. *Faience has a glazed surface* and only when this is totally worn off might an object be mistaken by eye for frit. A frit has a sintered polycrystalline body *and no glaze* (cf. Kuschke 1970). Frit has a very specific meaning in glass technology: 'a calcined mixture of sand and fluxes ready to be melted in a crucible to form glass' (*Oxford English Dictionary*). It is the first stage in production; the raw materials are 'fritted' at a relatively low temperature before regrinding and subsequent melting. In the present context the term 'frit' is used to describe all sintered polycrystalline bodies *which were not glazed*. (Fritting is usually considered a process in which the soluble salts are made insoluble by breaking down the carbonates etc., forming a complex mass of sintered silicates.) It has been suggested that 'unglazed faience' might be an appropriate synonym for 'frit' to avoid confusion with glass technology.

In the case of a coloured frit the colour runs throughout; there is no distinction, as there is in faience, between an inner body of one colour, usually white, and a distinct surface colour. Cakes of differently coloured frits, and the pans for producing them, were found at Tell el-Amarna in Egypt, dating to the first half of the fourteenth century BC. This is the oldest glass factory yet excavated in the Near East or Egypt (Petrie 1894: 25 ff.; Lucas 1962: 19 ff.). Once produced, cakes of frit may be ground into a fine powder for use as a pigment, or for further combination and treatment

to produce objects of moulded frit or glass. In the period covered by this survey, blue was by far the most popular colour for all frit artefacts: other colours occur relatively rarely, usually only for beads or similar small items of personal ornament.

The blue objects are usually sintered mixtures of quartz and the mineral Egyptian Blue, which is a silicate of copper and calcium ($\text{CuO} \cdot \text{CaO} \cdot 4\text{SiO}_2$) identical to the natural mineral cuprorivarite (see below). The term Egyptian Blue is frequently used to describe both the frit itself as well as its mineral constituent. Indeed, it is not yet established if there were blue frits in the ancient Near East from which the mineral Egyptian Blue was absent. The term 'glass paste' (*pâte de verre*) is often applied rather indiscriminately to frit (blue or any other colour) or any opaque glass, most significantly, in this context, by Woolley in his reports on the excavations at Ur.

The problem of ancient terminology for the materials discussed here is considered on pp. 210ff.

Both in Egypt and Mesopotamia the stones most commonly glazed in prehistoric times were either magnesium silicates, like steatites or serpentine, or silicates, such as quartz or flint, which frequently contain iron as an impurity.

If one thing emerges clearly from this preliminary survey, it is the prevailing confusion in the popular terminology for ancient glazed and related materials. But, as this is progressively refined by proper scientific investigation, it will be no easier to apply the emerging terminology acceptable to the scientists, since much of it inevitably turns on features not evident to the naked eye, even a trained one. In such circumstances there is much still to be said for unambiguous, non-committal phraseology for common use, such as: glazed stone; 'glazed composition' for *faience* (giving colour of glaze, and of body if possible); 'unglazed composition' for the frits (giving the colour of the body and evidence that traces of glaze have been sought in vain); and *glass*, which may usually be recognized by eye and is familiar to everyone. Even the current suggestion that 'sintered quartz' or 'soda-lime-silicate' be used for 'composition' prejudices the vital questions.

Although in Mesopotamia it is broadly possible to separate glazed stones from faience and glazed terracotta for coherent treatment, this is not yet the case with frits. In the present state of knowledge, and then only with reservations, may Egyptian Blue be treated independently, for it is not yet known whether there were any other blue frits. Frits of other colours, though known at sites like Nuzi, have not yet been systematically identified elsewhere, so any separate treatment of them is impossible at present. This is anomalous, but unavoidable.

(i) THE EMERGENCE OF GLAZED MATERIALS

The organization of the following sections, for convenience rather more than from any conviction, reflects a prevalent view about the way in which faience was first developed in Western Asia. It is usually argued that the initial impulse came from a desire to reproduce rare stones of a bluish-green colour by glazing commoner dark or dull coloured stones blue-green. It is assumed that this originally happened in a situation where siliceous stones, such as steatite, the ashes of alkaline-rich salt-water plants, and some copper, were in fortuitous combination under heat, presumably in a fire-pit or hearth. The use of malachite as a cosmetic from an early date, and the palettes on which it was ground for this purpose, notably those of sandstone, would have been a possible combination for accidental glazing (cf. Lucas 1962: 172; Peltenburg 1971). Lucas, in fact, successfully experimented with a two-stage method for reproducing faience in which he first glazed solid quartz pebbles using a mixture of natron and malachite. This glaze was then chipped off, ground to a fine powder, and applied to the surface of a ground-quartz body, which was subsequently fired.

How the glazing of stones, or artificial bodies, might have related to the development of contemporary copper-working, if at all, has yet to be clarified; nor is it clear whether the marked absence, in both Egypt and Mesopotamia, of attempts to glaze baked clay at this initial stage is indicative of a particular context for the development of faience. Attention has been called in this connection to Perrot's observation that the clay walls of furnaces at the Chalcolithic site of Abu Matar, near Beersheva, in Israel, 'had become glazed by the products of the combination of metal, silica and bases' (Perrot 1955: 79); but it is not an obvious analogy for the early glazing of soda-lime-silicates.

It is, at present, impossible to say with any real confidence whether the production of faience appeared in Western Asia before it did in Egypt; comparative chronologies are still too imprecise for the question to be resolved. In Egypt beads of green or greenish-blue glazed steatite (perhaps also of other stones) appear first in the Badarian period (Early Predynastic), currently dated to the last quarter of the fifth millennium BC or soon after. Glazed stones, predominantly steatite, continued as one of the commoner materials for beads in Predynastic Egypt. Green-glazed *faience* beads appear first in the Amratian period (Naqada I; Middle Predynastic), c.4000–3500 BC, though not as commonly as was once assumed (cf. Vandiver 1983^a: A-64 ff.). Caution is also required with larger objects, like the hawk pendant from tomb 1774 at Naqada, since it may be made of glazed quartzite or glazed sandstone rather than of faience (Vandiver 1983^a: A-71 ff., pl. 29c). The calibrated Carbon-14

chronology on which the absolute dates given here are based is still open to modification, as there are isolated indications that the Egyptian Predynastic cultures may have begun earlier and changed more slowly than current hypotheses assume. With the exception of an isolated find in Iran (see below), no faience has been reported from anywhere in Western Asia that may be certainly dated before the Ubaid period. Within that long period, currently dated on a calibrated Carbon-14 chronology from about 5400 to 4300 BC, it is hard to place surviving faience beads with any precision though they are certainly in production before its final phase (Ubaid III). This being so, if the absolute chronologies for the respective regions given here are correct, the present weight of evidence would be in favour of first production of faience somewhere in Western Asia, probably in Iran or Northern Mesopotamia, with diffusion into Egypt to the west, the Indus region to the east (cf. Stone and Thomas 1956).

Whatever the force of traditional speculations about origins, it is likely that the heat treatment of stones, from the Upper Palaeolithic period, to facilitate flaking had familiarized men from an early date with the virtues of applying heat to stone. In areas where early faience industries may at present be noted, in Egypt, in northern Mesopotamia, and in the Indus Valley, there is invariably a previous tradition of heat-treating steatite, in some cases actually of glazing it (in the precise sense of the word). This craft continued to flourish for some time side-by-side with production of faience and frit. A 'burnt' steatite bead painted with powdered malachite, a common prehistoric pigment, when fired would produce a greenish-blue glaze. The steatite would provide silica, the whitening process alkali, and the malachite the colourant. From this it is a small step to faience.

In those regions where innovatory faience production is evident by the later fourth and third millennium BC contemporary potting and metalwork exhibits a considerable mastery of pyrotechnology and a willingness to experiment both with ores and pigments. Craftsmen were also skilled in working on a small scale with such materials as stone, bone, shell, and ivory. It is difficult to gauge whether a general restriction on the supply of the real stones stimulated imitation or whether it was in places where the semi-precious stones themselves were readily available to the rich and privileged that craftsmen were moved to produce imitations for those among the less affluent wishing to emulate the privileged. The history of faience in the later second millennium BC (cf. Foster, K. P. 1979: 173) might be taken to suggest that innovatory faience and glass manufacture was more likely where the naturally coloured stones were readily available and widely used; widening social demand, rather than deprivation in the richer sections of society, was the stimulus.

The range of glazed stones may be concisely reviewed:

As *steatite* is soft, it may be cut easily and its fine-grained structure makes it a very suitable medium for small objects like beads and amulets. It is particularly well suited to glazing, as it can be heated without distortion. The heating dehydrates it and dramatically increases its hardness from 1 to 6 or 7 on the Mohs scale. This seems to have been appreciated very early; presumably small objects were first carved in the soft stone then heated to harden them.

Beck (H. C. 1934^a), whose study of glazed stones is still fundamental, defined three different ways through which the surface of steatite was chemically altered in Egypt and the Near East in antiquity:

(a) '*Glazed*': this involves either the application to the surface of the stone of a vitreous glaze, which is then fired on, or use of the cementation process as in faience manufacture (see below). Even when the glaze has flaked away, a very hard surface remains on the steatite. Beck (H. C. 1934^a: 69; cf. Lucas 1962: 155–6) regarded this procedure as 'almost entirely Egyptian', an observation which still stands. Even from Egypt objects of considerable size in glazed steatite are rare, mostly dating between the XIIth and XVIIIth Dynasties, c. 2000–1200 BC (Bannister and Plenderleith 1936), and none has been published from Mesopotamia. Noble (1969: 438) has described the Egyptian method of glazing steatite and pointed out its hardening effect on the mineral. Vandiver (1983^a: A-64 ff.) has published a careful examination of Egyptian glazed steatite beads and seals and Tite and Bimson (1989) have investigated the technology.

(b) '*Burnt*': Beck (H. C. 1934^a: 69; cf. also in Vats 1940: 393–4) explained this as the application of an alkali which was then fired, or of a glaze which was of such a nature that it almost always flaked entirely away and left a very soft surface on the steatite. This is the category to which the commonly termed 'glazed steatite' of Mesopotamia belongs, though it is best known from Indus Valley seals and beads of the third millennium BC (Hegde 1983).

(c) '*Etched*': for this the surface of the steatite was whitened, probably only with an alkali, and heated, after which it was decorated with a pattern in ferruginous clay or some salt of iron. This is an Indus Valley technique not yet independently reported from Mesopotamia.

The history of *burnt steatite* in Mesopotamia is obscured by the absence of any systematic study of beads from the region. In only one case is it certainly known for any other range of objects from the area: a well-defined group of cylinder seals current in Late Protoliterate to Early Dynastic I times. 'Burnt Steatite'

beads are listed in the Ubaid period graves at Arpachiyah (Mallowan 1935: 38), when it was used for 'minute glazed steatite ring beads'. In reporting on the beads from the deep sounding at Nineveh, Beck (in Campbell Thompson and Mallowan 1933: 179) noted 'a third bead from the layer Nin. 2 at a depth of -63' is made of chemically treated steatite. This bead is exactly similar to the white steatite beads . . . from Nin. 3 and Nin. 4, and it is of interest to know that this process is so early.' Nin. 2 would fall somewhere in the early Ubaid horizon (?Arpachiyah TT 8-6); 3 and 4 cover the Uruk IV-III horizons in the south. Some of the treated steatite beads of Nin. 3 were identical in shape and material to Nin. 2, others were long cylinders or barrels (ibid.: pl. LXXIX, figs. 20-3). In a child's grave, as at Arpachiyah, treated white steatite beads were combined with untreated black; two faience beads were associated. In Nin. 4 there was more variety, but the great majority were tiny white steatite beads (cf. Beck, H. C. 1934^a: 76-7).

A cylinder seal attributed to Nineveh 4 in the later fourth millennium BC is of considerable interest (Campbell Thompson and Mallowan 1933: 140, pl. LXV, 16). Beck (ibid.: 181-2) commented: 'The stone appears to have been treated by the application of an alkali combined with great heat, but no silica has been applied; in this way the treatment differs from that of the Egyptian specimens.' Frankfort (1939^a: 34) isolated the group of seals to which this example belongs, noting that shape, material, and designs were at this time, in the late Protoliterate to Early Dynastic I periods, without precedent. Seals of the same general type were also made in faience. The group is represented among sealings at Nineveh (Campbell Thompson and Hamilton 1932: pl. LXIII.11, 14; Campbell Thompson and Mallowan 1933: pls. LXV. 21-35, LXVI. 3, 4, 7, 18-26), and at Jamdat Nasr (Buchanan 1966: no. 72), and by actual seals in the Diyala (Frankfort 1955: 17 ff.), at Kish (Buchanan 1966: 16 ff.), at Fara (Heinrich and Andrae 1931: pls. 69l,m; 72c, d, e), at Telloh (Frankfort 1939^a: 34 n. 2), and in considerable numbers at Susa (Amiet 1972: 143 ff.). The predominance of these seals in northern and western Mesopotamia has been commented on. Le Breton (1957: 108) challenged Frankfort's view that there was no reason to consider them other than of local Mesopotamian manufacture, suggesting that 'their chief centres of fabrication and dispersion should be sought somewhere along the Eastern piedmont' (Buchanan's 'Piedmont Jamdat Nasr' style). Even if they may not be considered specifically 'Susian', Amiet (1972: 143) has emphasized their close affinity with 'Proto-Elamite' glyptic. In the Susa sequence they first appear in level 17 (Amiet 1971: 222); significantly some take a different form, the height and diameter being approximately equal, and have a very close affinity with a contemporary series of

such seals in faience (cf. Amiet 1972: 111 ff.; Collon 1987: 20-3).

The production of burnt steatite objects in Mesopotamia after the beginning of the Early Dynastic period is not well documented and may have ceased. Beck (H. C. 1934^a: 76; in Vats 1940: 393, pl. CXXXV. 4) cites minute burnt steatite beads from PG 55, perhaps a robbed royal grave of Early Dynastic IIIA at Ur; but they are not specifically mentioned in Woolley's final report and seem to be those listed there as 'shell', presumably on the basis of field records (Woolley 1934: 414, 527). They were said to have formed part of a girdle with lapis and cornelian beads. 'The great number of these small beads (i.e. of steatite) in this grave is very extraordinary since the use of burnt or treated steatite is very rare in Mesopotamia at this time' (Beck, H. C., in Vats 1940: 410). What is meant by Beck's remark that 'a number of beads of a very much rougher nature, also found at Ur, are dated to the Persian period' (Beck, H. C. 1934^a: 76) is equally uncertain, since Woolley does not list them specifically in the appropriate excavation report (Woolley 1962). But, as etched cornelian beads reappeared at Ur in the Achaemenid period, following the revival of contacts with the Indus region after a lapse of more than a millennium, comparable treatment might well have been given once again at that time to other stones (cf. Reade 1979).

Beck (H. C. 1935) is so far alone in examining the evidence from Mesopotamia for the surface modification of quartz beads, pendants, and inlay fragments. In each case the surface had been coated with a substance and then heated until it melted. Some of the specimens he tested from Mesopotamia (and the majority from Egypt) 'appear to have had an already made glaze or else the ingredients to make a glaze powdered up and applied to the surface, and then to have been fused'. Another method had also been current in Mesopotamia, and in Iran: 'to these an alkali only was applied instead of a glaze; they were then heated until the alkali fluxed the surface by combining with the silica of the bead and flowed over the surface. These beads have an extremely *high polish* which was at first attributed to sand polish, but a careful examination soon proved that this was not the case' (Beck, H. C. 1935: 21). Some of the Mesopotamian specimens have the surface completely covered with small conchoidal fractures and generally only slight signs of having been glazed (*frosted*). Beck (1935: 25) explained the difference between *high polish* and *frosted* as being 'only that, whereas the latter had a completed glaze powdered and applied to them, the former had an alkali only added which formed the glaze by combining with the quartz of the bead. The object of frosting the surface seems to have been to give a greater surface for the alkali or glaze to work on. In the case where an alkali only had been added, this seems to have attached

itself so firmly that it never flakes off, whereas in the cases where a glaze had been added it seems to have flowed at a temperature too low to attach itself properly and had generally almost entirely disappeared.'

The specimens tested from Ur were 'supposed to date from before 3500 BC, whilst others which are practically identical are dated 900 BC'. This is presumably information supplied by Woolley. As he dated the 'royal graves' at Ur, in 1934, between 3500 and 3200 BC, it may only be assumed that the beads in question date before Early Dynastic IIIA; but their significance is impossible to establish in retrospect. An illustrated bead (Beck, H. C. 1935: pl. II.9) would be acceptable as of Late Prehistoric or Early Dynastic date; a small rougher pendant ('shield') is dated to the later third millennium (ibid.: pl. II.6). Disk beads of glazed milky quartz were reported from Nineveh, but without exact context (Campbell Thompson and Mallowan 1933: 182, pl. LXXIX: 30-2).

The later third-millennium 'bead layer', excavated at Nineveh in 1929-30, yielded evidence for a distinctive combination of glazed quartz and faience tooth-pendants: 'These are made by inserting a large piece of quartz in a piece of faience somewhat resembling a fang, in which the perforation for suspension is made. The quartz portion was covered with soda and then the whole was heated to a great temperature so as to harden the faience and produce a sort of fire polish on the quartz' (Beck 1931: 428; cf. 1935: 28). In a variant of this combination of materials, spherical in shape, a considerable number of tiny pieces of quartz were inserted into faience and then glazed overall (Beck, H. C. 1935: 28). Mallowan (1947: 160, pl. XXVIII) reported that some of the rock crystal beads in Late Prehistoric or Early Dynastic contexts at Brak were glazed.

Although not in a strict sense 'glazed', this section may appropriately end with the best known of all surface decoration on stones found in ancient Mesopotamia: the 'etching' or 'bleaching' of cornelian. This method may also be applied to agate, chalcedony, and feldspar. Beck (H. C. 1933^a) distinguished between decoration in white lines on the background of the natural colour of the stone and a design in black on the artificially whitened surface of the stone. The latter technique is relatively rare. There are no grounds for believing the stones were, strictly speaking, etched, with white material inlaid in a groove. A pattern was drawn on the stone with a solution of alkali (generally soda) and the stone was then heated through a 300-400 °C temperature until the alkali entered into it, making a permanent white design. Mackay (1933) described the actual method as he saw it done by an old man in 1930 at Sehwan in middle Sind. As the soda treatment has a very different effect on different stones, and on different levels of the same stone, this method was sometimes used to heighten colour contrasts in beads (cf. Beck

1935: 34, pl. V:1). The layers most resembling crystalline quartz are those least affected.

Reade (1979) has assembled and discussed the etched cornelian beads reported from Mesopotamia. They first appear there at some point in Early Dynastic IIIA, in the middle of the third millennium BC and are commonest between then and the Akkadian period. Thereafter they decrease and by about 1900 BC have virtually disappeared until they reappear during the Achaemenid period. The technique of decoration was intrusive, from the Indus Valley (Tosi 1976-80^a), where supplies of cornelian were locally available, and the beads themselves found in Mesopotamia are predominantly of foreign, again probably Indus, manufacture. Variants are occasionally identified, usually by anomalous patterns or shapes; but whether these were manufactured in Mesopotamia or somewhere along the way from the Indus is an open question.

If comparisons with Predynastic Egypt are made, it is likely that faience all but replaced glazed stones in Mesopotamian workshops after the early third millennium BC. In the first instance the beadmakers had been concerned with reproducing rare blue-green stones, notably turquoise, by glazing common dark stones. Once they realized that the same effect might be achieved more easily and flexibly with faience they abandoned the glazing of dull-coloured stones.

(ii) A HISTORICAL SURVEY OF FAIENCE IN MESOPOTAMIA

(a) The prehistoric period

The literature on the earliest occurrence of glazed materials in Mesopotamia is particularly hazardous to use, since it is now over fifty years old for the most part and rarely explicit. This is notably the case at Arpachiyah where a variety of glazed materials appear to have been found; but recording of context and description of materials is often both obscure and ambiguous. As Mallowan (1935: 39, 92-3) distinguished 'frit' from 'glazed frit' he may mean the specific distinction used here or he may merely be indicating a distinction between relatively unweathered and badly weathered faience. He also mentions bitumen ornaments inlaid with disks of 'vitreous paste', though whether they were of the Halaf or Ubaid periods is uncertain. If there was no true frit at Arpachiyah, then the 'bluish frit' from Eridu may be the earliest reference to 'Egyptian Blue' (blue frit) in the present literature. However, it may well simply be azurite, used for pigments, as was the case at Arpachiyah (Peltenburg 1987: 12).

Consequently, current evidence for the first appearance of faience objects in Mesopotamia is a matter of considerable uncertainty. Mallowan's identification of 'frit' beads and vessels in levels of the Halaf period, in the first half of the sixth millennium BC, at Arpachiyah

remains isolated and, in itself, unsatisfactory. As Stone and Thomas (1956: 41) commented, 'Mallowan recorded a frit (faience) seal or discoid pendant, unfortunately without stating its provenance, but by implication from Halaf levels' (cf. Mallowan 1935: 91, 98). Both Amiet (1961: 15) and Buchanan (1967: 266) accepted the early dating, though Buchanan's phrase, 'found at such a depth in Halaf levels', is not substantiated by Mallowan's publication. Stone and Thomas took this seal to be a stray from later Ubaid levels. As there is a comparable faience seal, close in shape and design, from Gawra XII (Tobler 1950: pl. CLIX.27), of the early Uruk period, the case for caution is reinforced. Even more problematic is Mallowan's identification of two 'frit' vessels from Halaf levels at Arpachiyah, since these would represent an even more precocious innovation. In the more important instance Mallowan cites the find-spot, in Halaf levels (TT6-7), and illustrates the vessel (Mallowan 1935: 175, pl. XIX.9), which is certainly of a shape known in the Halaf ceramic repertory. It is said to be 'now bleached white'. So long as this early date is unsubstantiated by finds elsewhere, there is always the possibility that both these vessels were of plaster or weathered gypsum, or a related stone, not of faience (cf. Fukai *et al.* 1974: 58).

The general picture is further confused by a presently isolated find in Iran, where a single well-preserved fluted blue faience bead was reported from level 2a of the Japanese excavations at Tall-i-Mushki in Fars, apparently from a Hassuna related chronological horizon of the later seventh millennium BC (Fukai *et al.* 1973: 65, 73, pl. XL.1.1, LV.35; frontispiece in colour). Although this is primarily a one-period site, the bead came from an area where intrusive graves were recorded (Fukai *et al.* 1973: pl. XLVI: section K-K'). The even earlier 'glazed frit' beads attributed to the aceramic Neolithic in Jericho seem likely to be a misidentification to judge from study of other beads found there and in other sites in Palestine at that time (cf. Kenyon and Holland 1982: 789-91).

It is then only from some time in the Ubaid period, from the mid-sixth millennium BC, that beads of artificial materials are first clearly evident on a few sites in northern and southern Mesopotamia, where they may already have been widely traded. The terminology used in reports is too various to allow for rigorous comparisons in the absence of scientific reports. Mallowan (1935: 38, 92, 97) reported glazed steatite and glazed ring beads from graves of the Ubaid period at Arpachiyah as well as 'frit', 'glazed white steatite', and 'bitumen inlaid with discs of vitreous paste' without specific context. At Tepe Gawra (Tobler 1950: 192) 'white paste' was used for beads in strata XIX-XVI (later Ubaid) and even more commonly in the strata succeeding XIII, that is into the Uruk period. It was used for a ring

pendant in stratum XII (Tobler 1950: 195, pl. CLXXIII: 41); from strata XIII-XI came a series of faience stamp seals (Tobler 1950: 178).

In the south in the 'Ubaid Cemetery' at Ur only one grave (PFG/L: Woolley 1956: 88), of the 45 published, contained 'small paste ring beads'; but in these graves beads of any kind were rare. One held steatite beads, three had shell beads. At Eridu the earliest reported 'frit' bead is in Temple XI (Ubaid 3); later Ubaid period contexts in Temple VII yielded a 'frit' stamp seal and in Temple VI three beads 'in bluish frit' (Safar 1981: fig. 117:28, 32-3). At Eridu a late Ubaid period cemetery of 193 graves was cleared, some with more than one skeleton; of the 175 graves reported 6 contained beads of 'frit', sometimes long strings of them, for women and children (Safar 1981: graves 90, 110, 114, 158, 174, 186). At Qabr Sheykheyn in Khuzistan, a Susa 'A' settlement, of the later fifth millennium BC, Weiss (1972: 172) excavated a child's grave 'with bracelets of minute paste beads on its ankles and wrists'; old excavations at Susa itself indicate the appearance of faience personal ornaments in graves of the later Ubaid period (Stone and Thomas 1956: 43).

It is not until the fourth millennium BC that a more varied production of faience objects is evident, primarily in the north. The 'bead stratum' at Nineveh, cited by Stone and Thomas (1956: 42; also Foster, K. P. 1979: 23) in this connection, is in fact a millennium later in date (see below), so cannot be drawn upon. But Gawra and Brak offer sufficient information to establish the general status of the industry at this time. Faience beads were common in burials at Gawra of the fourth millennium (Tobler 1950: 87-8; Forest 1983: 19-110). The 'Eye-Temple' at Brak was set on a platform incorporating a succession of earlier structures. These had been plundered in antiquity through a whole series of tunnels and pits: 'we entered these plunderers' tunnels which led to a stratum of grey mudbricks from which we removed many thousands of objects . . . beads of which there were many hundreds of thousands' (Mallowan 1947: 33). The beads had not only been scattered liberally in the foundations of the 'grey-brick' temple (stratum C), but actually moulded into the bricks. They were predominantly of faience and of glazed steatite (ibid.: 154-6, pl. LXXXIV). Mallowan published Stone's reports on three faience beads: a segmented one of 'soft faience core with traces of light greenish or bluish glaze remaining . . . it exhibits characters which are normally associated with beads of a very much later date, in particular the highly developed technique of manufacture'; a mulberry-shaped bead 'of white faience, and traces of blue glaze remain in the crevices'; and a fluted, biconical bead 'of white faience which was originally coated with a black glaze'. In addition to the faience beads, this general context yielded a remarkable series of faience amulets

or seals, kidney- or rosette-shaped, or with backs moulded as bears, ducks, hedgehogs, hares, and monkeys (Mallowan 1947: 102, pl. X:9; 108-9, pl. XIV:9-13; 117-18, pl. XVI:1; 119, pl. XVII:5-8; Buchanan and Moorey 1984: nos. 146-51, 178-81). There is no reason to assume they are of southern origin as Perkins did (1949: 188).

A late prehistoric house at Khafajah yielded a 'paste mouse amulet' (Delougaz 1967: 27: House 11). At Jamdat Nasr itself faience 'does not seem to have been in very common use' (Mackay 1931: 273); in two cases it was used to imitate forms otherwise made in shell or mother-of-pearl (ibid.: 273-4, pl. LXXII.6, 27-9). In view of this scattered evidence any categorical statements about comparative degrees of use and production are impossible; but, at the moment, it does not seem that faience was much used in the south for beads and amulets. Faience beads are only very rarely mentioned by Woolley in his report of the prehistoric levels at Ur (cf. Woolley 1956: 66, 178: U.14469; 67, 179: U.14943). Faience is not listed as one of the materials used for beads in the 'Kleinfunde' found at Uruk (Heinrich 1936) and is rare in the catalogue of late prehistoric beads from Uruk (Limper 1988), nor does it seem to have been employed for the many animal amulets and seals favoured in the south at this time. In Behm-Blancke's (1979: 66-9, no. 129) catalogue of the excavated prehistoric amulets, only one out of 138 is queried as being of faience, and it is from Khafajah.

At some time towards the end of the fourth millennium BC the use of faience was significantly extended to the production of small vessels, and for this there is evidence from southern sites, though there is every reason to believe, as later evidence confirms, that they were luxury items available only in small numbers. A faience jar, originally blue-glazed, with impressed chevron ornament on the shoulder, was found at Ur in stratum 'H' of Pit F: 'so far as the decayed state of the frit allows of judgement, the vase was moulded round a core which was subsequently removed' (Woolley 1956: 30, 63, 177: U.14422, fig. 9d). Slightly lower in the same sounding were 'fragments of a small vase [in fact a small open bowl] of white frit covered with pale turquoise glaze' (ibid.: pl. 26g: U.14908). Contemporary vessels were found at Khafajah (Delougaz 1942: 137, 142). Scattered information from Telloh, where the shapes are those used in contemporary pottery and the glazes when preserved are simple blues and greens, extends the evidence for vessel production at this time (Genouillac 1934: 36-7, 61). The occurrence of a 'rectangular faience vessel, about 9 cm. high' in one of the rooms at Jebel Aruda on the Euphrates in Syria, a site characterized by Uruk IV material culture, is of equivocal significance. It is not clear whether it is of northern or southern origin (Driel 1983: 7).

Although Proto-Elamite Susa yielded evidence of inlay plaques in faience, as well as bear-shaped amulets, there does not seem to be any evidence of vessels (Morgan and Mecquenem 1912: figs. 22-3; Le Brun 1971: fig. 70:23). Complementary to the 'burnt steatite' cylinder seals of the later prehistoric period in Susiana and inner Iran was a series in faience (Frankfort 1939: 35; 1955: nos. 51, 53, 55, 63, 129, 143, 162; Buchanan 1966: 15-16), produced somewhere on Mesopotamia's eastern periphery.

(b) *The historic period*

The production of simple faience beads and amulets, and the use of faience for globular pinheads and 'handles' (PLATE VIIIB; cf. Mackay 1929: pl. XLIII.2), continued through the Early Dynastic period, though the evidence for Early Dynastic I-II is sparse (cf. Khafajah: Delougaz 1967: 27-9: graves 14, 25; Ur: 'Jamdat Nasr' graves: Woolley 1956: 104 ff., nos. 16, 82, 103, 149, 159b, 161, 239, 295, 325, U.19249, 19316; Kish: Y graves: Moorey 1978: fiche 1: E09 to G03). By Early Dynastic III they were common in graves on certain sites. In virtually every grave in Cemetery A at Kish from which beads are recorded some are of faience (Mackay 1925, 1929; Moorey 1978: fiche 1: C08 to G01), whereas in the Early Dynastic III graves of the Royal Cemetery at Ur it is not so common as might be expected. Of the 650 or so private graves at Ur attributed to Early Dynastic III, less than ten are reported as containing faience beads or faience pinheads; there was faience in two Royal Tombs (Woolley 1934: 524 ff.; Nissen's dating and tabulation 1966: 82, pl. 22). Cylinder seals were occasionally still made of faience; but, as Mackay (1929: 193) remarked of those from Cemetery A at Kish, they are commonly in very poor condition. Faience vessels are still extremely rare from excavations of this period. None was reported from the Royal Cemetery at Ur; but there was a miniature bowl from an Early Dynastic III level in House 6 at Khafajah (Delougaz 1967: 28) and others are reported from Tell Agrab (Delougaz 1942: 268, 281). A macehead of green glazed faience from level 4 of the *Kl. Anten-Tempel* at Tell Chuera has been dated to the second quarter of the third millennium BC (Moortgat 1967: 32-5, fig. 23). It may have been a macehead carried by a deity statue; such maceheads in glass are known later. A fine green-glazed spouted bowl, decorated with a bearded bull *couchant* in low relief, was found in grave 317 on Tell Ingharra at Kish; this dates late in the Early Dynastic or early in the Akkadian period (Watelin 1934: pl. XXXI.7; Moorey 1970: 127-8; 1978: 74). A 'glazed tile fragment' was reported from the surface at Khafajah and might belong to the mid-third millennium BC (Delougaz 1942: 163).

Such meagre evidence does no more than indicate that the repertory of faience-makers by the third quar-

ter of the third millennium BC encompassed not only seals, amulets, and beads, but also moulded vessels, votive weapons, and other small objects. The use of moulds recognized the potential of faience for large-scale, standardized production and began to emancipate the material from a lithic-based technology. The suspicion persists, though it may not be put more strongly, that this industry was more active in Akkad and the north than in heartland Sumer. However, in the first half of the third millennium BC faience beads were already distributed far down the Gulf to Oman (Cardi *et al.* 1979: 80 ff.) and an unusually vigorous and varied faience production was established in the Indus Valley civilization (Allchin and Allchin 1982: 192) by the third quarter of the millennium.

In the north chronologically sound archaeological evidence for the study of faience in the Akkadian period is provided by finds in levels VIII–IX at Tell Taya (cf. also Chagar Bazar: Mallowan 1936: 56–7; Reade 1987: 33, fig. 1; Wilayah: Madhlum 1960: 91–2). These levels yielded beads, 'buttons', and pendants, simple bowls, some with lids and the fragments of an inlaid beard (Reade 1968: 244–5; 249; 1971: 98, pl. XXVd; 1973: 165, pls. LXXVd, LXVIIIb, 167, pl. LXVIIb; Bimson 1973). Vessels similar to those from Tell Taya are reported from Mari (Parrot 1956: 121, pl. LII.1047). At Tell Brak (Oates and Oates 1991: 137) faience objects are reported in brown, purple/black, white, and yellow, with red pigment used on a white frit body. To this period, or to Early Dynastic III, belongs a 'frit lugged bowl painted with black triangles' from a grave at Tell Selenkahiyah (Loon 1968: 30; 1969: 67, figure). A faience model of a four-wheeled wagon is reported from a child's grave at Tell Bi'a in Syria (cf. Strommenger 1990, pl. 101).

Parallels from Tell Taya indicate that the majority of faience beads in the so-called 'bead-layer' excavated at Nineveh in 1929–30 are likely to be of the Akkadian period rather than a millennium older (Campbell Thompson and Hutchinson 1931: 82; Beck, H.C. 1931; 1934^a; 1935); this washed-out level included 'a number of pieces of slag'. There is clear evidence of a wider range of colours than the traditional blues and greens, though black (manganese) had already appeared on 'handles' in Early Dynastic III (at Kish: Moorey 1978: fiche 3: F04). Beck (1931: 427) reported of beads that 'the core was usually black but in some cases it is a rather dirty white. In one case the core nearest to the glaze is white, whilst that nearest the perforation is black. The glaze, which is very opaque, was originally white, green, blue, red and black. The white glaze was sometimes on a white core and sometimes on a black one.' Two unusual types of bead are the bicolour inverted drop pendants and the 'crumb' beads. The former 'have the upper and lower parts of different colours . . . not merely glazed with a different colour but the cores of

the two parts are made of quite different materials . . . The upper part, which is perforated, is almost always black, whilst the lower part has a white or colourless core. This part was glazed in colours . . . whilst some were red others were yellow and blue.' Crumb beads, oblate or spherical, and with crumbs of faience over the surface, mostly had a dark core, and were originally glazed blue or red. Beetle- and vase-shaped amulets appear, as well as tiny faience ducks, known on other sites in the north and at Ur (cf. Foster, K.P. 1979: 27–8). Only 19 of the thousand or more private graves at Ur dated to the Akkadian or Neo-Sumerian periods are reported as containing faience beads; 10 held 'glass paste' beads (Nissen 1966: 82, pl. 22).

Small moulded statuettes of animals *couchant* in faience reported from Assur (Andrae 1922: pl. 49a.60, lower, Haller 1954: 6 ff., pl. 7f), Kish (Watelin 1934: pl. XXXI. 4–5), and Susa (see below) are less easy to attribute precisely to the Akkadian period. They probably appeared then, but may still have been in production towards the end of the third millennium BC, the period to which the Assur graves probably belong. The most interesting single tomb-group for the history of faience at this period is one at Susa, since it included both a jar and a small bowl of faience with one of these animal statuettes (Amiet 1966: 234–5, fig. 172). This grave also contained a copper or bronze macehead of a group which includes an example inscribed for King Naram-Sin (c.2254–2218 BC; Calmeyer 1969: group 10, 26–7). Another aspect of the faience repertory in the Akkadian period is illustrated in House K (Room 291) of level XI at Nippur, where the American excavators found 'part of a mosaic with composition tesserae adhering to or set into backing preserved as white film in the ground'. An ochre red border and tiny squares formed a pattern with pale blue squares and crescents. It was too damaged to be lifted (McCown 1967: pl. 153:26). Many of the so-called 'Guti Seals' were made of faience in the period c.2250–2100 BC (Boehmer 1957–71).

For the first time, at the very end of the third millennium BC, documentary evidence may begin to throw light upon the production of faience and related materials. A well-known text from Ur (Legrain 1937: no. 1498) of this date describes the activities of a set of craftsmen for one year, listing raw materials, finished products, and scrap items for reprocessing. In the section on lapidaries (Loding 1981: 11 ff.) the first stone mentioned is the unidentified *dušū*-stone (?agate). It was used predominantly in jewellery, among other things to represent sun-disks; but of particular interest in this context are later references to the manufacture of artificial *dušū*, of glazes with the colour of this stone, and of leather dyed this colour (cf. CAD, s.v. *dušū*). In the Ur text it is followed by cornelian and lapis lazuli, and then by a section indicating that the stonecutters

may have been involved in the manufacture of objects from artificial materials. First listed is *bu-uz-hi-li* (stone) in two blocks; this term is very rare in Ur III texts. The first element in the name (*bu-uz*) has been related to the material later known as *būšu*, a 'primary glass' in Oppenheim's (1970: 35 ff.; 39 ff.) terminology or 'faience' in Foster's (1979: 17), whilst *hi-li* ('abundant') is just a descriptive term. Ur III texts also refer very occasionally to *anzahhu*, at least once as the material from which a bowl was made. It is grouped in an inventory list, not among the stone vessels, but with the more precious items. In Oppenheim's view (1970: 19 ff.) this material was also a 'primary' glass; but Foster (K.P. 1979: 17) believes it was a natural stone (?quartzite). The artificial materials in the early texts were predominantly used for bead manufacture. Exactly what they were is still an open question. The textual evidence is ambiguous and the material remains too scanty to resolve the question.

Archaeological evidence for the relatively short Ur III period is inevitably restricted. The graves at Assur included more animal figures of faience and at least one small bowl (Haller 1954: 8–9, graves 5–6, 8, 11, 17). Of the animals Andrae (1925: 61) noted that 'glaze [was] mostly white, but occasionally traces of light blue and yellow can be found'. At Nippur there is no publication of glazed vessels in the relevant levels (McCown 1967: 78); but there was a concentration of 'frit' beads in room 197 of House I (ibid.: 97: table III). At Ur stratigraphical problems confound attempts at accurate dating, as in the case of the faience beads 'found against the outer SW wall of Dungi's (Shulgi's) mausoleum' (Woolley 1974: 102: U.17891). Only one instance is reported where faience inlays 'presumably from wall decoration' may certainly be associated with structures of the Ur III period: in Room 1 of Shulgi's Mausoleum (ibid.: 9: U.16298); comparable pieces from the *Enunmah* may be slightly later (Woolley 1974: 47, 50: U.225). Although it is difficult to date them closely, it is likely that a distinctive series of faience frog amulets first appeared at this time. This animal had long been a favourite with Sumerian jewellers (Buren 1939: 101–2); Genouillac (1936: 107, fig. 46; cf. Woolley 1976: pl. 93j: U.1274) reported a yellow-glazed example from Telloh probably of Ur III date.

It has been argued that north Syria, not Egypt, was the source of inspiration for the development of faience production in Crete sometime in the later third millennium BC, when Minoan metalworking was also influenced from this region (Foster, K.P. 1979: 56 ff.). Foster's view, however, that 'north Syria and north Mesopotamia were dynamic and innovative centers of faience production, actively involved in the spread of the art throughout the Near East at the end of the third millennium' (ibid.: 59) might be true; but the material evidence for it is, at present, very restricted.

In south Mesopotamia Ur is a key archaeological site for the earlier second millennium BC, though once again caution is necessary in studying the artefacts, since their stratigraphical contexts are often equivocal. Faience beads and amulets were very rare; out of almost two hundred published graves, only one was reported to have contained faience beads (Woolley 1976: LG/27: U.16319). Animal amulets in faience, probably of this period, were more commonly picked up in an area, to the east and north-east of the city, known as Diqdiqqah, where Woolley believed many of them had been made (ibid.: 217: U.1269–86; 218: U.1580, 1715; 226: U.6863; 236: U.16128; 243: U.16735–6; 248: U.17002) 'The frog is the most common subject, the duck and the squatting monkey are common, the fish and the tortoise occur, but rarely; the flower-petalled rosette . . . model hair-combs' (Woolley 1974: 86). 'Humbaba' masks were also made in faience. Comparative evidence suggests that a miniature faience bucket from a disturbed grave at Ur should not be dated before the fourteenth or thirteenth centuries BC (Woolley 1974: 227: U.7057, pl. 96d; see below). A fluted blue-green faience bottle (Woolley 1974: 58, 253, pl. 96A) was reported from the *Giparu*, Room C.25; but there is no certain evidence that the context is earlier than the middle of the second millennium BC. The same applies to small fragments of blue glazed faience vessels, reported to be like pottery type 63, found in room A.9 of the same building, but in the upper part of a drain-shaft (Woolley 1974: 46, 183, pl. 105: U.6871). A 'very delicate' faience bowl from a grave in Room B.12 of the *Giparu* (Woolley 1974: 51, pl. 96: U.6829) was associated with a faience face-pendant of a type known to date to the thirteenth century BC (Woolley 1974: U.6820, cf. also U.3254; 1976: 184–5; for date Peltenburg 1977: 177 ff.). Peltenburg (1987: fig. 2) has published a fragment of a monochrome blue glazed faience vessel from Telloh, depicting minor deities in relief holding vessels with flowing water, probably of early second-millennium date.

A child's grave of the early second millennium BC at Susa contained a faience doll's head (0.027 m. high), set on a silver shank, with cavities for inlay (Amiet 1966: fig. 215). In the palace at Mari isolated finds indicated the use of faience for mosaic inlays, probably in pieces of wooden furniture, as in Room 49 (Parrot 1958^a: 37). The best recorded was an example in Court 70 (Parrot 1958^a: 234–5; 1959: 105–7, fig. 76, pl. XXXIV), where faience mosaic seemed to be reproducing the patterns of a carpet (cf. Pierre 1987: 557). In the north, in the Old Babylonian period and later at Chagar Bazar, amulets, animal figurines, beads, and face-pendants of faience continued in production as before (Mallowan 1947: 174).

The sparse Mesopotamian evidence indicates no

fundamental change in the faience repertory from the Late Protoliterate to the end of the Old Babylonian period, with a concentration throughout on personal ornaments, an intermittent use for inlays, and a restricted production of vessels. In view of changes to be seen in the second half of the second millennium BC, a wider perspective is appropriate at this point. Faience manufacture was introduced into Palestine from Egypt some time in the first quarter of the second millennium BC. Although it developed some characteristics of its own, it remained very much an offspring of the Egyptian tradition (Sagona 1980), as did the faience industry of Byblos (Dunand 1958: 741–80), whose contacts with Egypt were traditionally close.

No systematic study of the development of faience production in Anatolia or Syria has yet been published, though it is often assumed that it was Syrian workshops which were supplying Anatolia in the Middle Bronze Age. The relative rarity of faience objects (cf. Özgüç, T. 1986^a) on sites of the Hittite Old Kingdom and Empire, and the activity of Syrian workshops in the Middle Bronze Age, have sustained the view that much, if not all, of the faience found in Anatolia in the earlier second millennium BC was imported (cf. Foster, K. P. 1979: 46). However, the question remains open, with a distinct possibility that palace workshops in Anatolia were manufacturing faience objects at this time.

Özgüç (T. 1986^a) published a selection of faience objects from Kültepe, where they were found either in pot graves under houses or in debris in levels Ia–b of the Karum. They included nine female figurines, some fragmentary, in a style Özgüç took to be foreign, though he regarded a double seated statuette, comparable to a seated male figurine from Acemhöyük, as more likely to be local workmanship. So, indeed, may be a number of faience animals in a distinctive style. Stronger evidence for local production may be provided by a series of faience stamp seals bearing a symbol akin to the 'Hathor' headdress, which presently concentrate on sites of the Late Colony period in Anatolia. Whether rare faience vessels from Alishar and Acemhöyük (Özgüç, T. 1986^a: 207:8, fig. 1) and Kültepe (Ib) were locally made or imported, as Foster (1979: 46) argued, remains an open question.

The evidence from Alishar and Alaça Hüyük throws light, particularly, on the currency of faience vessels at this time. At Alishar the evidence comes from level II, a very mixed context. This stratum was between three and four metres thick, embracing two major building phases, with subdivisions within each of them. The oldest phase was 11T (terrace), the most recent 10T (Osten 1937: 3). Most of the cuneiform tablets were found 'in the refuse of level 10T'; 'three tablet hoards were on actual floor levels, all belonging to level 10' (1937: 108). All the datable tablets from Alishar belong to the period of Karum Kanesh Ib, contemporary with

Shamshi-Adad I of Assyria (c. 1813–1781 BC), whose reign provides the *terminus post quem* for the abandonment of level 10. That it survived very considerably longer, if only in restricted use, is indicated by various seals and seal impressions; an impression from 10T bears a hieroglyphic Hittite inscription (Osten 1937: 227, fig. 254; c. 1456, pl. XXV; Boehmer 1967: 61 n. 11) of the 'Old Hittite Period'; an agate cylinder seal ('found in Q28 on the floor level of the large mansion of Level 10T') is in the Kassite style (Osten 1937: 295, fig. 246 (d. 2235)); and two 'Mitannian' cylinder seals (ibid.: fig. 246: c. 200, d. 2365) were found in Alishar stratum II. A faience cup found in the same level (Schmidt, E. F. 1932: 111, colour pl. III, pl. X:b 1868) was compared by Schaeffer (1948: 322) to similar unpublished vessels found at Ras Shamra in *niveau* II, either of *Ugarit Moyen 2* (c. 1900–1750 BC) or early 3 (c. 1750–1600 BC). Osten (1937: 286) also reported that 'in 1929 and 1931–2 one fragmentary frit cup and several sherds of frit vessels were found. They show on the outside a greenish to greenish-blue glaze, whereas the inside is sometimes dark brown, almost black. The rim piece (ibid.: pl. I:4) was found in M 33–4 in close association with cuneiform tablet d.2200.' Of the excavations in near-contemporary levels at Alaça Hüyük, Arik (1937: 40) wrote: 'L'abondance des morceaux de faience de couleur jaunâtre, blanche ou bleu clair, aux parois très minces, supposés avoir été importés de l'Égypte ou de la Mésopotamie et dont semblables ont été recueillis en quantité à Alisar; les débris ornés des dessins en relief en forme de grappe de raisins (Al. 633), également abondants à Alisar; les récipients à fonds pointus, munis, de passoire et ornés de petits reliefs en forme de mamelons, confirmait notre attribution.' Alishar II also yielded faience figurines of nude females (Osten 1937: 193, fig. 230: d.2966, 2971) and the feet of animal figurines (ibid.: 205, fig. 243: d.2210, e.1631).

In Syria, as in Palestine, a degree of local production has long been accepted. Four faience vessels from level VII at Atchana (Woolley 1955: 297) represent an important fixed point in the development of the industry in Syria. They belong to the contemporary black and blue glazing tradition by then firmly established there with parallels at Ras Shamra (Ugarit) (Peltenburg 1987: 15, fig. 1). Mazzoni (1987) has discussed the faience objects from Ebla (Tell Mardikh) in Middle Bronze II, seventeenth century BC, made of 'pinkish sandy clay . . . covered by a thick light blue/white glaze . . . painted in black'. They include hand-made human and animal figurines as in Anatolia, miniature vessels, and a vase in the shape of a female head. A rich grave contained a faience vessel, now without its original pair of rim handles, in shape and decoration reminiscent of a rock crystal vessel found in the palace at Acemhöyük (Matthiae 1980: 13–14, fig. 14). The modelled and

incised vessels are novelties at this time, but they are extensions of an existing tradition of blue and black glazing.

In the Middle Bronze Age in Anatolia and Syria faience was still a luxury product with a limited repertory of forms and colours, usually found on sites with palatial buildings. As in Palestine, Egyptian influence in styles and manufacturing methods is sporadically evident, but local workshops, perhaps attached to palaces, had evolved their own characteristics. There is so far no clear evidence, by contrast, that this was the case in Mesopotamia, where there is a marked gap between the faience of the later third millennium BC, as at Tell Taya, and that evidenced in northern Iraq in the second half of the second millennium BC.

None of the faience and frit from the Middle Bronze Age in Syro-Anatolia or Mesopotamia has yet been scientifically examined, but a group of faience beads from a tomb (c. 1800–1600 BC) at Dinkha Tepe in north-west Iran, close to the Kel-i-shin pass into Assyria, has (McGovern *et al.* 1991). These beads might be imports from the west; but the existence of a number of small-scale local production centres in Iran, as in Syro-Anatolia, may not be ruled out at this stage of research. The white frit has a very pure silica composition; tiny traces of surface glaze were noted. The dark frit, which covers white frit cores, has much higher levels of copper and manganese oxides; traces of glaze were again evident. In contrast with the later Nuzi frits, the silica particles are larger, less well ground and fired, and the composition is markedly different, but the Dinkha Tepe beads illustrate an earlier stage in a common tradition.

In the history of faience production, as in that of glass and glazed pottery, there were significant changes in the range and intensity of production in the Near East in the middle of the second millennium BC as the Middle Bronze Age gave way to the Late Bronze Age. Unfortunately, particularly in Mesopotamia, no archaeological sequence of any kind bridges the transitional period effectively. In Mesopotamia the new developments first become evident in the material culture of stratum II at Nuzi, long taken to be typical of the fifteenth century BC, but more likely to represent craft achievement in the first half of the fourteenth century BC (cf. Stein 1989, for chronology). Here faience and frit are most commonly encountered in the form of beads. Vandiver (1982^a: 74) has reported that 'in the Harvard Semitic Museum collection as well as in the field accession records, the relative numbers of beads occur in the following descending order: glass, frit, stone, shell, glazed quartz body, and non-glazed clay beads. An estimate of the ratio of glass to frit beads is that the glass exceeded by a factor of ten the number of frit beads.' Starr (1939: 94, cf. 446) found enormous quantities in Temples C–A at Nuzi, notably in Temple A. The frit beads, predominantly blue,

'seldom occurred in more elaborate form than representations of frogs and flies . . . invariably small'.

Frit was produced in five colours: blue, brick-red, white, black, and yellow, each with a different composition and structure. Blue is the commonest; Starr (1939: 447) noted the red as very rare. Blue frits were sintered mixtures of the minerals quartz, calcite, and 'Egyptian Blue'. The ratio of Fe : Si was higher for the red than for the blue; the ratio of Ca : Si for the blue. The black frit was high in a volume fraction of dark blue glass. Yellow frit was considered to be iron-stained white frit. Copper only occurs in the blue and red beads. 'Unground joining seams along the hole axis of cylinder beads are evidence that the material was plastically formed around a polycrystalline brown core. The exterior is harder than the interior indicating that prior to firing, the dried surface of the frit beads often was ground differentially . . . several red beads were formed by stacking several small frit spheres around a core' (Vandiver 1982^a: 82 ff.).

Vandiver (1982^a) found that 'beads made of a glaze coating on a white, friable polycrystalline body rich in quartz (often known as Egyptian faience . . .) are relatively frequent in the Nuzi collection'. The tubular beads fall into this category. The melon-shaped beads were, however, 'more similar to the frit beads (in that there is a friable brown core and the surface is ground) than to the above category'. The glaze did not adhere as well to the melon beads. The melon bead glaze was higher in Mg, more nearly approximating to the glaze composition and maybe the local product, whilst the cylinders could be imports.

In his final report Starr carefully distinguished between 'frit' and 'faience'. In Temple A he found a simple blue 'frit' cup of delicate proportions and the fragments of another 'frit' vessel (Starr 1939: 91, cf. 1937: pl. 56, I, L). Only two fragmentary vessels of 'faience' were published (Starr 1939: 461; 1937: pl. 119, I, J). Both were found in the palace rather than in the main temple complex, where so many of the faience/frit objects were concentrated; Starr considered them to be imports. Beck and Jackson reported on them as 'faience', but Barag (1970: 137, 139–40) included them as mosaic glass in his corpus. Starr (1939: 461) quoted Beck and Jackson's spectroscopic examination as follows:

A spectroscopic examination shows that the Nuzi examples most certainly have a lime flux.

On examination, it is evident that this bowl contains red, yellow and white patches in it, and possibly black, although the last may be accidental. The colouring matter of the red is iron in the form of ferric oxide in great numbers of comparatively large particles which are totally opaque to transmitted light. The yellow colouring matter is the same as that used in the yellow beads of Mesopotamia and Egypt. It is probably due to ferric oxide, but the exact way in which it is introduced is not yet known.

The second vessel was similarly of 'kneaded' white, red, and yellow, but with the addition of 'occasional spots of deep blue like that of the well preserved Nuzi glass'. Subsequent research has shown the yellow colourant on other vessels in Mesopotamia, as in Egypt, to be lead antimonate.

The only other major group of faience objects presently published from Mesopotamia, likely to be as early as those from Nuzi II, was found in the temple at Tell Rimah (phase II, Room 5). The destruction level from which they were recovered is not independently dated. The excavator, on the strength of close parallels with the material culture of Nuzi II, has dated it to 'about 1450 BC' (Oates 1982: 97). In view of the previous comments about the *terminus* of Nuzi II, it might well be half a century or more later. The repertory at Tell Rimah, in faience and frit, is in some ways more varied than at Nuzi, embracing cylinder seals of the 'Mittanian Common Style' (a widely distributed category); tiny cylindrical cosmetic containers with lids, their sides decorated in sunk relief with facsimiles of the seal designs, and with human faces; a bird-shaped vessel decorated on the outside with brown glaze, on the interior with yellow (Dayton 1978: pl. 11); and a range of beads and zoomorphic amulets (Carter, T. H. 1965; this paper does not always distinguish finds from phase II clearly from phase I). A small group of comparable frit and faience objects was found at Tell Chuera (Moortgat and Moortgat-Correns 1976: 38 ff., figs. 14-15); as at Chagar Bazar (Mallowan 1937: 122, 137, pl. 14A).

The first phase of expanded faience production in Mesopotamia and Syria has sometimes been termed 'Mittanian' (c. 1550-1350 BC), not merely in chronological terms, but because it has been assumed that their empire stimulated and facilitated the production and diffusion of such luxury objects. At this stage the manufacture of vessels and of other more elaborate objects was largely, if not exclusively, a prestige technology, situated in the workshops of temples and palaces, as at sites like Nuzi and Tell Rimah. Their output found its way largely into shrines and palace apartments, or into the graves of wealthy servants of palace or temple. At this time local production seems largely to have served local purposes. In the following, or 'Middle Assyrian' phase (c. 1350-1200 BC) this situation persisted and expanded to more prestige production centres. However, the wide circulation of a standard repertory of certain vessels and personal ornaments, now found more commonly in graves, may indicate a more broadly based hierarchy of production centres, some outside the great organizations of the state.

Assur and its neighbourhood has provided one of the most important groups of faience for the 'Middle Assyrian' phase. Apart from finds in the Assur Temple at Kar-Tukulti-Ninurta, hardly used after the reign of its founder Tukulti-Ninurta I (c. 1243-1207 BC), these

objects are concentrated in the Ishtar Temple at Assur, itself founded by the same king, but used until the reign of Assur-resh-ishi I (c. 1132-1115 BC). The variety of the repertory is remarkable and likely to represent a local industry, though some individual objects may be imports. There is a range of beads, amulets, rosettes, and gaming pieces (Andrae 1935: 96-100, pls. 39-40); various 'nail-heads' or pommels (ibid.: pl. 41); fragments from furniture (ibid.: pl. 38); human statuettes and model footwear (ibid.: pls. 34-5); human eyes and genitals (male and female) (ibid.: pl. 36); animal statuettes and protomes (ibid.: pl. 37), and a small repertory of vessels (ibid.: pl. 42). By contrast, Tell al-Fakhar (Al-Khalesi 1970: pl. 27) illustrates the availability of faience at this time in a less important northern town.

Phase I at Tell Rimah, dated textually to the thirteenth century BC (tablets of the reign of Tukulti-Ninurta I), produced another collection of faience/frit objects, notably face-pendants (cf. Peltenburg 1977) and small 'rosettes' said to be 'characteristic of phase I' (Oates, D. 1965: 74; Carter, T. H. 1965: 53, fig. 7). Such 'rosettes' have a wide distribution, appearing, for instance, in contemporary levels at Nimrud (Mallowan 1950: 174), at Assur (Andrae 1935: 97, pl. 40; Eickhoff 1985: 52 ff., pls. 6-9), and at various smaller sites in the area of the Saddam Dam Salvage Project and the Eski Mosul Salvage Project in Iraq as well as at Tell Fakhariyah in Syria (Kantor 1957: 43-4). The exact purpose is still debated; as they commonly have pierced fittings on the reverse they may have been sewn on to garments. A varied selection of frit and faience in the standard repertory of forms was found in the early thirteenth-century destruction debris of the 'Mitanni Palace' at Brak (Oates, D. 1987: pls. XXXIX-XL).

It is the vessels at this period which particularly well illustrate a commerce in standard shapes. Any attempt to establish whence individual types, or specific examples of them, originally came is hazardous. Long ago Hall (1928) isolated and discussed the striking similarity between the faience vessels found as far apart as Enkomi in Cyprus and Assur, though his concept of Mycenaean-Minoan production centres for them has not survived. Peltenburg (1972; 1974) has more recently considered the problem in detail. In a summary of his examination of faience vessels from Cyprus he classified them into two major groups: *Egyptian or Egyptianizing* and *Western Asiatic*, subdivided into *North Levantine Style* and *International Western Asiatic Style*: 'there are other vases from Cyprus which show no Mycenaean influence and which, because they are also made in Mesopotamia, and because there is no good evidence as to where they first occur, are best considered as belonging to an international Western Asiatic Style' (Peltenburg 1972: 136). He cited in particular 'blossom bowls', with oblong pentagons arranged like petals around the exterior (cf. Foster, K. P. 1979: 51) and a

type of small bucket, whose distribution is particularly striking. Although usually found in graves, it is reported from a domestic context at Tell Zubeidi in the Hamrin, where in one case six were found together (Boehmer and Dämmer 1985: 57, nos. 554-5, 556-7, 559-60, pl. 142). They have been reported in Mesopotamia predominantly from central and southern sites: Babylon (Reuther 1926: 15, fig. 10a-c, pls. 47, 12b; 48, 17.4; 58, 34.2; 58, 49d), Isin (Hrouda 1977: 61, pl. 28 (Gr. 34); 1981: pl. 35 (Gr. 87, 91)), Kish (Genouillac 1924: 15, pl. VIII.4, pl. 50:143, 65:143), Uruk (Boehmer *et al.* 1987: 49 ff. pl. 60: 695-7), and Ur (Woolley 1962: pl. 58: 233, 1976: 59, 100, 183, 227, pl. 96d; unpublished examples in the British Museum). Along the line of the Euphrates they were found at Mari (Parrot 1937: pl. XV.1) with outliers at Megiddo in Palestine (Guy 1938: 188, pl. 168.1; fig. 185.2; Loud 1948: 155, pl. 191.8). In this case centres of production may be postulated in Babylonia, with distribution up the Euphrates.

By way of contrast a distinctive group of late fourteenth- to thirteenth-century face goblets, represented at Assur (Andrae 1935: pl. 33), belong 'almost wholly to the north Levant where they are also made of wood' (Peltenburg 1972: 134, pl. XXIV; cf. Culican 1971); though even they show marked stylistic differences. A characteristic of Peltenburg's 'Western Asiatic' group is the use of yellow glaze either to pick out details or to line the inside of a vessel. Channel-spouted bowls, as Hall appreciated, are another category of vessel found at Assur (Haller 1954: 42, 64, pl. 16e, h; cf. also Layard 1853^a, pl. 85), and at Tell Fakhariyah in Syria (Moortgat 1959: 36, fig. 4), as well as in Cyprus (Foster, K. P. 1979: 51). Even simple hemispherical bowls of standard types are widely dispersed in Syro-Mesopotamia (cf. Kuschke 1970).

Parrot (1975: 7) modified his earlier dating of the 'Assyria Cemetery' at Mari after finding a faience plaque in tomb 656 bearing the name of Amenophis III of Egypt (c. 1402-1364 BC); but, as Peltenburg (1977: 192) pointed out, there is consistent evidence from other sites, notably Tell Rimah, for dating the distinctive face-pendants, also found in the Mari cemetery, to the thirteenth century BC. The graves in this cemetery, in Courts 106 and 131 of the earlier palace, were well furnished: 'caractérisé par d'élégants récipients en fritte vernissée (pl. XV.1): bonbonnières à couvercle, ampoules, coupes, jarres, godets', as well as the face-pendants (Parrot 1937: 83; cf. Mallet 1975). As the repertory of forms has much in common with Mari, it is broadly to this period that the faience vessels from Babylon belong (Reuther 1926: 15, fig. 10). At Babylon the excavator interpreted the contemporary 'fire-pits' as kilns for the manufacture of faience objects, but the site is reported in too little detail to check this suggestion. Two sets of graves, designated as

either from *Alteren Kassitischen Schicht* or the *Jüngerer K. S.*, yielded a variety of beads and amulets in faience (Reuther 1926: pls. 47-8, 58) in addition to vessels.

More recent excavations at Nippur revealed in Kassite levels 'a few examples of glaze on a body of siliceous paste' (McCown 1967: 78). Within the brickwork of the altar of the Kassite Ningal Temple at Ur Woolley found an assortment of objects including two faience vessels and a faience pot-stand (Woolley 1965: 103: U.3304, 3314, A, B); a bronze worshipper statuette (Woolley 1965: pl. 28: U.18628), similar to examples from Nuzi II, was also included. Isolated vessels are reported from graves and buildings of the Kassite period in the Hamrin region (Boehmer and Dämmer 1985: pl. 27: 18-19, pl. 142: 547-51; Invernizzi 1980: figs. 68-9).

That there was a faience/frit industry serving the Kassite court is evident even from the relatively meagre range of finds so far published from excavations at Aqar Quf (Dur Kurigalzu). As early as level IV, built on virgin soil some time in the first half of the fourteenth century BC, Room 15 produced the model head of a camel(?) and 'fragments of several small objects made of frit . . . some of which were the horns of small animals' (Baqir 1945: 13-14, pl. XXVII). A finely modelled stag's head from level IB, a century or more later, was described as 'in limestone or more probably frit' (ibid.: pl. XXVII). Some tiles may be glazed sintered quartz rather than glazed terracotta; according to the excavator: 'several tiles were found at level IC and at level II. They are made of chalky material, and some still retain traces of blue and yellow glaze' (ibid.: 14).

It is by no means clear where the primary centres of faience production were located in this period of extensive production from about 1350 to 1100 BC; but they may not be considered in isolation from the contemporary glass and metal industries. Although workshops at such sites as Assur, Nuzi, and Tell Rimah apparently supplied local temples and palaces with simple votive objects and personal ornaments, some production of vessels for trade is evident. Vessels of Peltenburg's 'International Western Asiatic Style' have been found in Cyprus, in Syro-Palestine, and in Mesopotamia. So wide a distribution of such a relatively fragile commodity is significant. They were clearly part of a luxury trade; but how far this extended beyond gift-exchange at court level it is impossible to gauge at the moment; nor may it be said with any confidence where they were made, though workshops in Syria are most commonly favoured. Both Ras Shamra (Ugarit) and Meskene (Emar) have produced industrial debris indicating local faience production (Louvre collections). Some scholars (cf. Culican 1971) have seen their stylistic homogeneity as indicative of a single source, or a very closely related group of workshops, whilst Barrelet (1968: 108 n. 3) and Peltenburg himself prefer the concept of a multiplicity of manufacturing

centres; the latter arguing that, though western influences may have been crucial in initiating certain types of production, 'some apparently Mesopotamian vases occur in the west during the apogee of this style, c. 1400–1200 BC' (Peltenburg 1974: 108).

It is no easier at present to define the relative roles of many local production centres, as against a few major ones, in the distribution of much more commonplace objects. 'Mittanian Common Style' cylinder seals of faience are found throughout the Near East, and into the peripheral regions, in the Late Bronze Age. Dabney (1984) argues that distinct groups, locally manufactured, are evident at Nuzi, at Alalakh in Syria (c. 1550–1200 BC), and at sites in Palestine (c. 1350–1200 BC). An equally extensive distribution of simple faience beads of standard design is illustrated by the occurrence at Marlik, near the Caspian Sea in Iran, and at Ur, of strikingly similar faience pomegranate and double-spiral beads in the fourteenth and thirteenth centuries BC (Maxwell-Hyslop 1971: 194).

A distinctive group of faience face-pendants also demonstrates the difficulty of attribution. Peltenburg (1977) demonstrated a Mesopotamian concentration in their present distribution pattern and argued for a thirteenth-century date. He cogently challenged Kühne's (1974) earlier view that they were of 'Hurri-Mittanian' origin and should be dated to the eighteenth or seventeenth centuries BC. In Mesopotamia they have been reported from sites like Abu Ghuraib, Billa, Isin, Kish, Mari, Nippur, Tell Rimah, Shuweimiyeh in Haditha, Sippar, Tell ed-Der, Ur, and Uruk; from Susa and Tchoga Zanbil in Khuzistan; from Gezer in Palestine, Hala Sultan Tekke in Cyprus, and Ebla (unstratified) and Ras Shamra in Syria. Peltenburg (1977: fig. 217) pointed out the contrasting distribution of the earlier metal and moulded glass nude female figurines, mainly of the sixteenth to fourteenth centuries BC, which at present have a Levantine concentration and are unreported from Mesopotamia (cf. Barag 1970). He also urged a separation of the 'face-pendants' from the 'face goblets' in any study of faience production in the Late Bronze Age.

The most spectacular faience and glass industry of the fourteenth to thirteenth centuries, so far known, is that revealed at Tchoga Zanbil in Khuzistan by Ghirshman's excavations (1946–62). This city, focused on a spectacular complex of shrines and funerary palaces, with underground vaulted tombs, round a monumental ziggurat, was founded by Untash-Napirisha in the second half of the fourteenth century BC. Faience was extensively used there for personal ornaments and seals, for vessels, including small cosmetic containers shaped as female heads, for human and animal statuettes, and for votive maceheads (Ghirshman 1966; 1968: *passim*; Amiet 1966: figs. 267–9, 272). More scattered evidence from earlier excavations at neighbouring

Susa had indicated the existence of a Middle Elamite faience industry, but not its great range (cf. Amiet 1966: fig. 317). This industry's activity seems to have been largely extinguished by the Babylonian invasion of the later twelfth century BC, when there is a break in recognizable production in Khuzistan until about the eighth century BC. A contemporary glass and faience industry on the island of Failaka in the Bay of Kuwait appears to have been more closely connected with this Elamite craft tradition than with that evident in Babylonia (cf. Pollard and Højlund 1983).

The difficulties involved in any study of the material culture of Mesopotamia between the eleventh and ninth centuries BC are recurrently evident in a survey of her crafts. It is virtually impossible to tell whether certain industries passed completely into eclipse when archaeological evidence is absent, consistently so in this case, or lingered on in isolated centres whose products were not widely distributed. When specialist products reappear after an interval, albeit in fresh forms and styles, the latter is an obvious inference. In certain cases, as with glazed terracotta in architecture, there is some textual evidence to support continuity. When material evidence becomes available again, it indicates that the Neo-Assyrian repertory in faience in no way matched that of the Middle Assyrian period. The stimulus for revival may well have been western, ultimately perhaps Phoenician, since Egyptianizing traits are particularly evident in Neo-Assyrian faience amulets and pendants (Oates, D. 1968: pl. XXXVIa–c).

It is to western Iran that attention must first be turned. Here, as with glass, the destruction of level IV at Hasanlu, in the eighth century BC, offers a valuable *terminus ante quem*, earlier by at least a century than any yet available in Mesopotamia. Two published faience vessels from level IV at Hasanlu provide an archaeological horizon for a whole series of similar vessels reported from clandestine excavations in western Iran in the last quarter of a century (cf. Fukai 1981): a small, blue-glazed faience box-shaped vessel, with feet and with holes for securing a lid to a round mouth, and a cone-shaped, footed goblet, of cream-glazed faience, decorated with crude geometric designs in blue and brown (Dyson 1968: 90, centre, left; pl. XXXIX, colour). Fukai (1981) has provided a finely illustrated survey of the art-market examples, many casually attributed to 'Ziwiye' (Muscarella 1977); but, at present, it is impossible to give them a close dating in the range ninth to seventh centuries BC, save for those most nearly matching the Hasanlu examples. Fukai's English text does not always clearly distinguish between glazed terracotta vessels (and tiles), which were also found both at Hasanlu and Ziwiye in controlled excavations, and faience. The body material of some of the latter (Fukai 1981: 11, pls. 16–17) is given as 87.2 per cent silica (faience). (Some of the chemical analyses, as pub-

lished in the English text, are problematic.) Analyses of the glazes showed that for the dark purple colour 'iron, manganese and titanium compounds were used'; for the blue, no lead, 'but (they) contained cupric oxide, as well as calcium and potassium, that functioned as a fluxing agent'; for the yellow, containing 24 per cent lead, 'the element imparting colour to the yellow glaze was antimony, titanium was used in order to strengthen the yellow colour'; the white glaze did not contain lead (Fukai 1981: 21). Although west Iranian glazed tiles of the Iron Age often show Assyrian influence in their decorative motifs, the faience vessels have much more distinctive characteristics. They seem to constitute a repertory of shapes and designs largely independent both of the earlier Middle Elamite and of the Middle Assyrian industries, and are as yet unrepresented in contemporary Mesopotamia.

Study of the Neo-Elamite faience industry is complicated by chronological problems and recurrent uncertainties about whether the vessels are indeed faience, as seems most often to have been the case, or glazed terracotta (cf. Amiet 1966: figs. 370 ff.). Miroshedji (1981: 9 ff.) has argued that the cylindrical pyxides with moulded decoration are Middle Elamite in date. It is the cuboid and variously shaped containers with incised designs rather than moulded decoration, sometimes polychrome, that are Neo-Elamite, though they were probably not made after about 650 BC (cf. Fukai 1981: 6–7). The local seal industry of Susiana in Neo-Elamite times also continued the earlier tradition of using faience (cf. Miroshedji 1982: 52–3).

In Mesopotamia in the seventh century BC, and for an unknown length of time before that in the Neo-Assyrian period, beads, amulets, and seals were manufactured of frit and faience, as were such traditional items as eyes for inlays into statues and votive maceheads. In the Ninurta Temple at Nimrud Layard (1853: 357–8) discovered a miscellaneous collection of objects, some of which were made of faience; from the same building Mallowan (1966: 82) recovered 'a glazed faience receptacle, and two banana-shaped objects made of frit'. Although faience was used in Neo-Assyrian times for cylinder seals in a variety of styles, it is most obviously employed for seals cut in what Buchanan (1966: 106, nos. 606 ff.) called the 'Debased Linear Style'. Production of such seals may have begun as early as the mid-ninth century BC (Parker 1955: 103 ff.). It was to continue into the Persian period. They are well represented among the cylinder seals excavated at Assur (Moortgat 1940: nos. 689–731) and at Nimrud (Parker 1955; 1962). The frit/faience repertory of a small provincial town of the period is illustrated by finds at Tell Rimah (Oates, D. 1968: 132–3) and further afield at Sultantepe (Lloyd and Gökçe (1953: 49–50; Lloyd 1954: 107), where western influence is evident both in amulets and vessels. In Andrae's (1925) publi-

cation of the Neo-Assyrian glazed terracotta vessels found at Assur, very little reference is made to faience. It encourages the assumption that polychrome glazed terracotta vessels had virtually superseded faience vessels in the Neo-Assyrian period. Andrae (1925: 35, 42, pl. 18c) described only one faience bowl: 'a centre rosette of yellow, light blue and white petals in turn, around them a wreath of spots and yellow circle . . . The glaze is different from that on the earthenware bottles, much thinner and more delicate.' It might be an import from the west.

Although the Neo-Assyrian court patronized a vigorous industry producing glazed architectural terracotta and glazed baked clay vessels, there is no evidence that there was a comparable Neo-Assyrian faience industry producing its own distinctive repertory of vessels and votive objects. Where there is evidence of faience amulets and beads, seals and pendants, they may merely be another aspect of the Syro-Phoenician technological and commercial impact on Assyria, rather than an indigenous revival of the craft well known before in Middle Assyrian times. Artisans working in this tradition were resident in Assyrian centres.

The same would seem to be true of Babylonia in the first millennium BC where glazed terracotta was the preferred medium. Isolated finds from the Achaemenid period need not be the products of local workshops. From Ur Woolley catalogued a small vessel-stand of 'green faience' (U.227: Woolley 1962: pl. 31) and a 'box of glazed frit, made to take a swivel lid, originally blue' (Woolley 1962: U. 16731), from a grave attributed to the Persian period. At this time, as in the previous period, faience or frit pendants and amulets, especially 'eyes of Horus' in an Egyptianizing style were widely distributed across the Near East.

Wherever it is possible to check, Woolley's (1962: 103) summing up of the position at Ur seems to apply:

While it would be rash to say that any new materials for beads were introduced in the Persian period it is true that one of the oldest materials, paste or glazed frit, was now employed in new shapes and with a greater richness of design. Small pendants of brown, red, yellow or blue paste in the form of miniature tools such as axe-heads and adzes are common on necklaces and there are many varieties of polychrome beads, ovals of green with yellow ends . . . rosettes and spotted eye-beads far more gay in appearance than anything we have from the Neo-Babylonian age. Glass too is more commonly used, and there are examples of the inlaid or mosaic beads which are often associated with Phoenicia [cf. Oda 1965 for technical comments on such beads from Iran].

(iii) METHODS OF MANUFACTURE

As has already been pointed out, faience bodies were made primarily from silica (sand or powdered sandstone, quartz, or flint) and alkaline binding agents

(natron or plant ashes). As there are no known ancient descriptions of manufacture, ancient methods have been reconstructed in modern times from a combination of evidence: from analyses of ancient faience and glazes; from their structural examination under a microscope; and from experimental attempts, under controlled conditions, to reproduce ancient faiences. In the circumstances it is not surprising that a number of different proposals are current. Sometimes they vary over fundamentals, more often over details of procedure, since the proposed methods and recipes do not always reproduce the characteristics of the originals. Even with the ancient Egyptian faience industries, which are relatively well known, opinions vary, and it is only recently that a multifaceted approach has begun to provide a broader basis for study (Kaczmarczyk and Hedges 1983). As there is very little published information on Western Asiatic faience, technological study has to proceed by comparison with Egyptian procedures. In these circumstances it cannot be stressed enough that this is only an interim solution. It is already apparent that there are aspects of the production of vitreous materials in the Near East which differ from the Egyptian traditions to a greater or lesser extent (cf. Caubet and Kaczmarczyk 1987; 1989).

For the whole of the Near East there is virtually no archaeological information on the manufacture of faience. Schaeffer's (1962: 37) suggestion that faience might have been fired in the same kiln as tablets at Ras Shamra is very unlikely from the evidence cited. There is no reason to think that a kiln excavated at Tell Asmar (Frankfort *et al.* 1940: 50-2, pl. X, figs. 39-40) was used to fire glazed materials despite Delcroix and Huot's (1972: 59) comment that 'l'existence de "très petits dépôts de cuivre en deux endroits de la chambre" peut s'expliquer par l'emploi de ce métal comme colorant'.

The only convincing evidence for a workshop manufacturing faience, primarily beads (including wasters), has been identified at Tyre in Late Bronze Age levels (Bikai 1978: 7-8; Brill 1978^a). In a courtyard of stratum XVI the excavators found a 'work table' and a 'basin' for grinding and preparing raw materials, including calcium carbonate; in the overlying stratum XV the courtyard appeared to remain in use for the same purpose. This time there was evidence for a kiln, incorporating a pithos, and a pile of selected sea pebbles.

Stray terracotta *kiln setters* with glaze adhering to them might indicate local glazed terracotta or faience production. When the setters are actually made of faience (if the evidence holds), they even more probably indicate local faience production, as at Assur (Andrae 1935: 99-100, pl. 39s, u, x). *Wasters* may be equally equivocal in their implications. Reuther (1926: 15) reported large lumps of bluish-white glassy material from 'Kassite' levels at Babylon, but precisely what

vitreous material was in production is not certain from such evidence. To judge by Egyptian analogies, a faience-worker's tools would have been simple. *Moulds* are most confidently identified when they are associated, as at Tell el-Amarna in Egypt, with the type of faience objects made in them (Petrie 1894). Unfortunately, the distinct possibility of manufacture in the earlier second millennium BC in the Diqdiqqah area at Ur is not confirmed by industrial debris in the published record (Woolley 1976). Baked clay and stone moulds reported from Neo-Babylonian and Achaemenid levels at Ur were for the manufacture of scarab-like seals or beads of faience or glass (cf. Budge 1922: 82 [BM 114, 195]; Woolley 1962: 112, pl. 30: U. 3340; cf. pl. 31: U. 3296).

Reisner's (1923: 134 ff.) description of the faience industry of the Egyptian Middle Kingdom, as illustrated by the remarkable range of finds from Kerma in Nubia, is still the best concise report of the debris from an ancient faience industry. Until such information is available for the Near East, one paragraph of his account suffices to indicate the kind of industrial evidence likely to be yielded eventually by excavation there:

The conclusion that the workshops for the manufacture of glazed objects were at Kerma is borne out by the discovery of accidentally glazed setters, misfired pieces of faience, lumps of copper oxide, lumps of *keriak* (silicate), mortars, pestles, charcoal, and beds of wood ashes at Lower Deffufa. There were also a number of spoiled beads, as well as quantities of carnelian and quartz crystals from which beads were made. One oven was seen just north of Room C, but it was too damaged to be drawn. It was of pottery, truncated (?) cone shaped, about 80-100 cm. in diameter, and apparently heated from outside. As the pottery was probably baked in open kilns, this oven may have been used for glazing faience and stone.

(Reisner 1923: 135)

Webb (1978) has usefully reviewed the scattered evidence for faience manufacture in the second quarter of the first millennium BC in Egypt and the Western Mediterranean.

(a) Cores and manufacture

Lucas (1962: 158) and more recently Kaczmarczyk and Hedges (1983: 123) have demonstrated that ordinary sand, sometimes washed and sifted, sometimes not, was the standard basis of Egyptian faience. Powdered quartz was exceptional; only for white faience does there seem to have been a clear preference for powdered quartz. The oldest Western Asiatic object tested so far, a bead of the fourth millennium BC from Brak, was shown to have an ordinary faience body. The copper percentage suggests that it was originally glazed blue or green; a very high Na:K ratio indicates that natron, ordinary salt, or low potassium plant ashes, were the alkali source (Mallowan 1947: 254-5;

cf. Stone and Thomas 1956: no. 26). Bimson (1973: 183) demonstrated that, despite its clay-coloured appearance, a lid fragment of the third quarter of the third millennium BC, level VIII at Tell Taya, had a high quartz body with clay content of only 5 per cent. Contemporary faience beads from the same site had 'typical coarse sintered-quartz' bodies. The body of a late third-millennium pedestal vessel from Chagar Bazar was made of very fine-grained quartz sand in which were mixed a scatter of iron-rich silicate particles, the iron oxide giving the body a pinkish colour (Tite 1987).

At Nuzi, in level II, about 1400/1350 BC, faience beads were relatively infrequent. Vandiver (1982^a: 90) distinguished two main types. The cylinder beads have 'a fully oxidized body and a glaze that adheres well . . . similar in style and technology to the common Egyptian tubular beads'. The melon beads, shaped by grinding, are different: 'the glaze does not adhere well . . . the interior of the body is gray-blue due to incomplete oxidation, and large oval and spherical pores and small black flakes indicate the possibility of an organic additive . . . The melon bead glaze is higher in Mg and more nearly approximates the glass composition.' Analyses by Pollard (in Pollard and Moorey 1982) of contemporary faience bodies from Tell Rimah showed a marked degree of purity, with the potassium and calcium contents generally less than 0.5 and 1.0 per cent respectively, and the iron concentration less than 0.5 per cent.

In Egypt, although a considerable percentage of bodies were white (Kaczmarczyk and Hedges 1983: 186, table XXX), there were many cases in which the body had been deliberately pigmented as background for the glaze. This was the difference underlying the variants of Egyptian faience first distinguished by Lucas (1962: 161 ff.) and recently refined by Kaczmarczyk and Hedges (1983: 218 ff.). The bodies of later third-millennium BC faience at Tell Taya, for example, appeared to the naked eye as white, yellow, or pink (J. Reade: personal communication). Whether the body material had been deliberately pigmented to form a suitable background for the glaze or whether, as may more often have been the case in Mesopotamia, the colour derived naturally from the sand of which the body was made is an open question. Similar variations are evident in faience bodies from other Mesopotamian sites.

Noble's (1969: 436-7) experiments for making self-glazing Egyptian faience, offer an appropriate basis for a general consideration of production (cf. Tite *et al.* 1983): 'Ingredients are mixed with a little water and kneaded into a gritty paste. In working with the material it becomes apparent why large and complicated shapes were not made from faience by the ancient Egyptians. If the paste is too damp, it readily slumps and will not hold its shape; if it is too dry, cracks and

is non-plastic. With just the right degree of moisture, it can be modelled into simple forms or pressed into one-piece terracotta molds . . . The mixture is not allowed to dry in the mold; it merely serves to form the piece, which is then removed and allowed to dry freely.' Throwing faience vessels on a potter's wheel, owing to the limited plasticity of the material, is extremely difficult (Allan *et al.* 1973: 170, pl. 4). It is unlikely to have been used save for simple, and comparatively small, open shapes. Vessels were made in a number of other ways. If the Halaf period dating of the vessels from Arpachiyah is correct, and this is unlikely (see p. 172), they were being made before the introduction of the potter's wheel. Vessels might be moulded either in one piece or in sections, and the pieces assembled or modelled round a form of straw and reeds or something similar, which would burn out on firing, but commonly leave a negative impression inside the vessel. Detail or finishing was sometimes done, after moulding, with a sharp instrument. The vessel might also be made solid and, after partial drying, the excess material scooped out before firing. Amulets, seals, and some beads were mould-made. Where evidence exists, simple open moulds of baked clay sufficed. Beads could also be roughly modelled round a tube or wire, and later ground, scraped, or incised (Vandiver 1982a). Some beads show signs of having been bored after firing.

Experimental work has indicated that Egyptian faience was fired at between 800 and 950 °C (Noble 1969: 950 °C; Kiefer and Allibert 1971: 870-920 °C; cf. Kühne 1974). Such a range of temperature is sufficient to release the metallic oxides for colouring and to flux the surface salts for the glaze. These temperatures were well within the range of ancient Mesopotamian kilns (Tite and Maniatis 1975). In publishing the late third-millennium faience from Tell Taya Reade (1973: 184) noted that: 'two of the season's blue faience vessels were also of interest: one apparently bore the marks of the tripod setter, on which it must have rested in the kiln, and another had fragments of green metallic filings, presumably copper, adhering to part of its surface, as if the colour was sometimes achieved without mixing a compound properly into the glaze'. Peltenburg (1972: 133) recognized the presence of tripod-stand marks on Late Bronze Age faience vessels of his 'Western Asiatic Style'; this includes vessels from Assur. They are also evident on Middle Assyrian faience bowls from Tell Mohammad Arab (M. Roaf: personal communication). Although terracotta tripod separators have been regularly recognized amongst pottery from Sasanian and later levels in Mesopotamia, they are not normally reported earlier. It is likely that the setters to separate earlier glazed pottery and faience vessels were cruder and may not be easy to recognize away from a kiln.

(b) *Methods of glazing* (Vandiver 1983; Tite *et al.* 1983)

Dipping or application of a glaze. It was for long assumed that ancient Egyptian (and other) faience glazes had been manufactured by the almost universal method of glazing used for pottery in more recent times. For this, pre-mixed ingredients are applied to the surface by dipping or brushing to be subsequently fused by kiln firing (cf. Petrie 1909: 107; Beck, H. C. 1934^a: 69; Lucas 1962: 172 ff.). For this the powdered raw materials (quartz, calcite, natron) are mixed with water. When applied to the dried body, the porous body absorbed water from the glaze mixture leaving a fine, powdery coating which melted during firing to form a glaze. The characteristics of such a method most obvious to inspection by eye are the uneven application of the glaze and drip or flow lines. The thickness of the glaze depends in this method on body porosity and the water content of the slurry. The body has little interstitial glass and the interface of glass and quartz phase is not well defined. This is evident in a late third-millennium vessel from Chagar Bazar examined by Tite (1987: 35) which had 'a very poorly developed glaze consisting only of interstitial glass with no continuous surface layer. It is therefore similar in microstructure to faience produced in the laboratory by the direct application of a raw as opposed to a fritted glazing mixture to the surface of a quartz body which was then fired to a lower temperature (c.850 °C).'

Self-glazing by efflorescence. In this faience production process (Noble 1969) water-soluble alkaline salts such as sodium or potassium carbonates, sulphates, and chlorides, in the form of natron or ash, migrate during the drying from the body to the surface by capillary action as water evaporates from the surface. The alkalis effloresce, or precipitate as salts on the surface, forming a white powdery layer (referred to by Binns *et al.* 1932, as 'wicking out'). When the dried faience object is fired in an oxidizing atmosphere the alkaline surface layer acts as a flux and the surface fuses to form a glaze. An appropriate colourant is included in the recipe to provide the required glaze colour. Binns *et al.* (1932) termed this method 'self-glazing'. In this method the drying rate is critical; a thicker coat of glaze is formed on those parts of the surface which are exposed to a greater flow of air and have a faster drying rate. There is much interstitial glass in the body and the interface is usually narrow and well defined.

Self-glazing by cementation. As no glaze slurry is applied prior to firing, this method is also called 'self-glazing', though it is distinct from the previous one (Wulff *et al.* 1968; Kiefer and Allibert 1971). The object is modelled from crushed quartz mixed with an adhesive, then embedded in a powder of hydrated lime,

powdered quartz, alkaline plant ash, and the required colourant. Smith (C. S. 1972: 102) has described the ensuing reaction: '(this) is heated to promote the formation of a reaction-layer of sodium silicate glass containing about 73 per cent silica. The composition is molten at 800 °C and it wets the silica, but does not wet the lime, so that the (objects) are virtually levitated by surface tension in the midst of the bed of powder without sticking to it. The same principle was later used in making the first hollow objects of glass, the so-called sand-core glass vessels, but the "sand", of course, was a non-wettable material, probably lime, certainly not silica.' Wulff *et al.* (1968) and Tite *et al.* (1983) have shown, however, that firing temperatures of 1000 °C are required. There is little interstitial glass in the body and the interface is thick and well defined.

Recent studies of a long chronological series of Egyptian faience objects (Vandiver 1982^a; 1983^a; also Kaczmarczyk and Hedges 1983) have shown that all these methods were at one time or another in use in Egypt, often simultaneously. After the prehistoric period of experimenting with the forming and glazing of beads and amulets, self-glazing by efflorescence was standard procedure. Already by the first part of the third millennium BC, during the Protodynastic period (Dynasties I–II), application and efflorescence were in use, occasionally even on the same object. Cementation may not have been current until the Middle Kingdom; there is not sufficient evidence as yet to date its first appearance in Western Asia.

(c) *Production and nature of individual colours in glazes*

Kaczmarczyk and Hedges (1983: 140 ff.) have summarized the chemical nature of glass pigments in general in so far as they are relevant to faience manufacture. In a work of this type detailed scientific data is not appropriate, but certain points need to be made. A single element may be responsible for producing several different colours depending on its state of oxidation and whether it is present as a compound or in solution. When in solution in a glass, the combined effects of composition and firing conditions are crucial, as is most clearly illustrated by iron. Under oxidizing conditions, and with low concentrations of alkali, it is possible to obtain a solid solution of iron oxide giving a pink colour; under oxidizing or only mildly reducing conditions a blue or green colour is produced, but strongly reducing conditions produce grey or black glazes. Thus, whilst chemical analysis can throw light on the production of different colours, it does not of itself offer evidence of the maker's intentions, particularly with early glazes. Browns and reds were probably not deliberately distinguishable for some time; whilst green and blue are difficult, since there are so many intermediate states with little chemical difference between them.

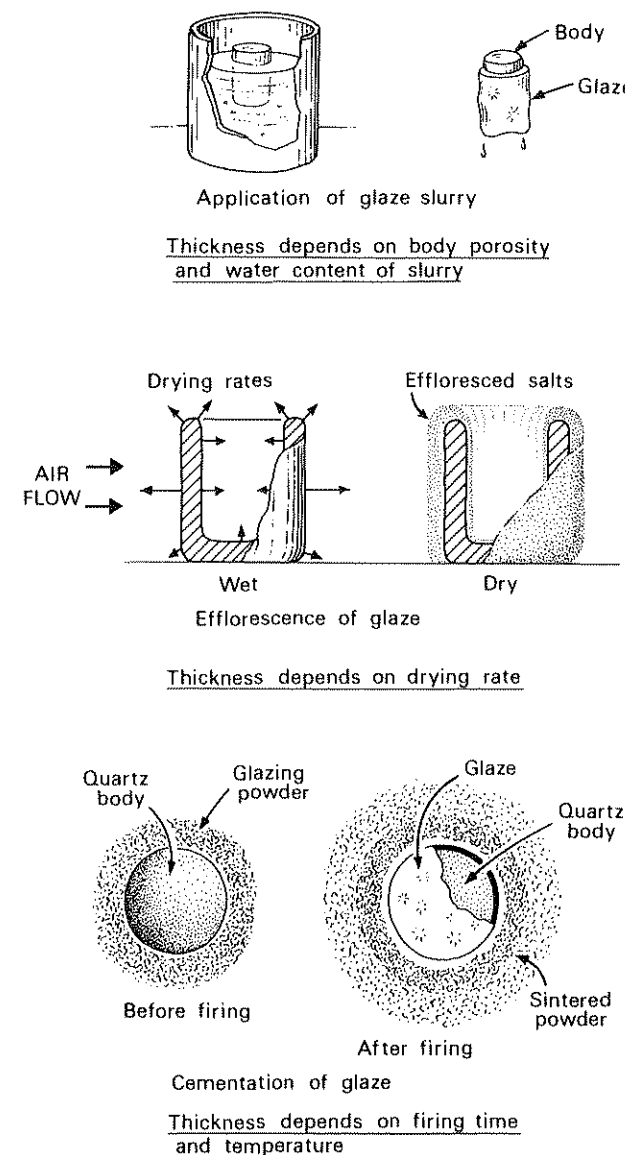


Fig. 12. Three methods of glazing faience as explained by Vandiver (after Vandiver, in Kaczmarczyk and Hedges 1983: fig. 23).

Only with deliberately manufactured polychrome faiences may the maker's intentions be more certainly inferred.

In Western Asia, as in Egypt, it was only after glass workers had pioneered polychromy, in the middle of the second millennium BC, that it entered the faience-worker's repertory (Peltenburg 1971: 9). Even then they were slow to develop techniques best suited to their own material. In Western Asia different coloured glazes on faience rested side-by-side, directly applied to their carriers, or were applied one on another, following closely the procedures of glass-workers.

For ancient Egypt the following colour development broadly applied: green, blue and brown glaze appear

in the fourth millennium BC; black, white, and purple appear in the First Dynasty, c.2900 BC; yellow was added by the early XVIIIth Dynasty (c.1500–1350 BC), with more intense blue, indigo, and violet later in the same dynasty. In Mesopotamia blue, green, and black may be observed by the end of the prehistoric period; brown/red and yellow are reported by the end of the third millennium BC; and a greater variety of shades by the Kassite and Mitannian periods. Hedges (1982) has tabulated the metal oxides in a series of Mesopotamian faiences dating from prehistoric times to the Achaemenid period; but much detailed work remains to be done. Conclusions about regional groupings on the basis of compositional traits may only be soundly based on large batches of analyses to avoid the misreading of anomalous fluctuations.

Bimson (1973) pointed out that the glaze on a faience vessel-lid of the Early Akkadian period from Tell Taya was coloured by copper with lead present in small amounts, 'however, the lead content was not high enough to affect the colour given by the copper, which is "turquoise" blue as in an alkaline glaze and not grass-green as in a lead glaze'. At Nuzi Vandiver (1982^a) reported that pre-melted ground glass was used as a raw material in glazes on both clay and on sintered quartz bodies, though more work is still needed on the technological relations between faience and glass at Nuzi. At Tell Rimah (Pollard and Moorey 1982; Dayton 1978: 436–7) the yellow glaze contained lead and antimony, with the lead greatly in excess and free of zinc; lead antimonate combined with copper was used as a green pigment. The black pigment in glass and faience was ferruginous manganese of highly variable iron content (cf. Caubet and Kaczmarczyk 1989). Manganese had been used for black faience at Kish in the middle of the third millennium BC (Pollard and Moorey 1982). The Tell Rimah faiences differ from like colours in the Egyptian repertory very little. Kaczmarczyk and Hedges (1983: 288) recorded only two clear distinctions: the absence of zinc in lead-containing glazes and the very much higher iron concentrations. Hedges (1982: 98) noted nickel in the black glaze of Western Asiatic faience, but not in Egyptian. He also reported finding antimony in Egyptian faience only when a yellow pigment (lead antimonate) was involved; in Western Asia it seemed to appear as often with, as without, lead.

Peltenburg (1974) has published unquantified analyses by McKerrell of glazes on Late Bronze Age faience vessels from Kition in Cyprus, including objects which he believed had been made in Syro-Palestine and possibly also in Mesopotamia. The white faience did not have a tin glaze; the glaze was produced by the addition of alkali to the recipe for uncoloured cores, as elsewhere at this time. The supposed existence of tin glazes in the ancient Near East appears to be a misconception,

based on misreadings of early analyses. The main colourant for green was copper; sometimes a mixture of copper-blue and lead-antimonate yellow. Yellow was produced with lead antimonate or iron oxide. In blue the colourant was commonly copper (or by the second millennium, at least, bronze i.e. oxidized scale, the corrosion products of a copper-tin alloy). Calcium antimonate was used as an opacifier, creating a matt blue, possibly a feature specifically distinguishing the 'Western Asiatic' from the 'Egyptian' manufacturing traditions (Peltenburg 1974: 110; Hedges 1982: 98).

(d) *Notes on analyses of Mesopotamian faience*

Isolated analyses are cross-referenced in the preceding text. So few analyses of *faience* from sites in Mesopotamia have yet been published, and even then in a manner difficult to correlate, that it seemed wisest just to give references here and not to attempt any correlation at this stage:

1. BRAK: Stone and Thomas, 1956: 64, 66, no. 26: *late prehistoric* segmented bead (body only).
2. JAMDAT NASR: Hedges in Moorey 1978: fiche 3: F05: *late prehistoric* beads.
3. KISH: Hedges in Moorey, 1978: fiche 3: F04-5: personal ornaments and vessels, *Early Dynastic I to Achaemenid*.
4. UMM EL-JIR: Hedges in Moorey, 1978: fiche 3: F05: *Early Dynastic III and later* beads.
5. TELL AL-RIMAH: Dayton, 1978: *passim*; Pollard and Moorey, 1982: personal ornaments and vessels, c.1400-1200 BC.
6. CHAGAR BAZAR: Tite 1987: vessel fragment; *later third millennium* BC.
7. TELL TAYA: Bimson, 1973: beads and vessel-lid, *Akkadian period*; *Neo-Assyrian* polychrome sherd, whether of baked clay or sintered quartz is not stated.
8. FAILAKA: Pollard 1987: 5 later second-millennium fragments ('*Kassite*').

3. Working with Egyptian Blue

The blue frit commonly referred to as Egyptian Blue was produced in antiquity by firing an intimate mixture of quartz, calcite, and a copper compound together with a small amount of alkali. The resulting frit consists of unreacted quartz and the mineral Egyptian Blue together with varying amounts of glass. Egyptian Blue is $\text{CaCuSi}_4\text{O}_{10}$, which is identical with the mineral cuprorivarite, very rare in nature and apparently not worked in antiquity. In the literature of the subject Egyptian Blue is used to describe both the bulk material and the constituent calcium-copper tetrasilicate mineral, which is the origin of the distinctive blue colour. The positive identification of Egyptian Blue frit is not possible by visual examination, but requires X-ray dif-

fraction analysis. Consequently, there are recurrent confusions between Egyptian Blue and other blue frits, sometimes even between Egyptian Blue and blue faience or blue glass. Moreover, as Peltenburg (1987: 12) has pointed out, azurite, not least in prehistoric contexts, has at times been mistaken for Egyptian Blue.

As well as providing a pigment, when powdered, Egyptian Blue may be mixed with a binding agent, moulded and refined, to make artefacts. It has the distinction of being one of the glazed materials that survived into the Graeco-Roman period, so that it is not only referred to in classical authors, but appeared in the pioneer eighteenth-century excavations at Pompeii in Italy, where it rapidly attracted the attention of chemists. The secret of its manufacture appears to have been lost between about the fourth and the nineteenth centuries AD. In the fourth century BC Theophrastus (*On Stones*, 55, ed. Caley and Richards: 1956) commented as follows on *kyanos* (cf. Foster, K. P. 1979: 10 ff.; Hittite: *kuwanna*; Mycenaean Greek: *ku-wa-no*):

Just as there is a natural and artificial red ochre, so there is a native *kyanos* (cf. sections 39 and 51: lapis lazuli and azurite) and a manufactured kind such as the one from Egypt. There are three kinds of *kyanos*, the Egyptian, the Scythian and the Cyprian. The Egyptian is the best for making pure pigments, the Scythian for those that are more dilute. The Egyptian variety is manufactured, and those who write the history of the kings of Egypt state which king it was who first fused *kyanos* in imitation of the natural kind; and they add that *kyanos* was sent as tribute from Phoenicia and as gifts from other quarters, and some of it was natural and some had been produced by fire. Those who grind colouring materials say that *kyanos* itself makes four colours; the first is formed of the finest particles and is very pale, and the second consists of the largest ones and is very dark. These are prepared artificially . . .

In the first century BC Vitruvius (VII. i. 1) recorded that Egyptian Blue (*caeruleum*), the invention of which he credits erroneously to Alexandria, was made by fusing together sand (which in the case of Egypt is a natural mixture of quartz and calcium carbonate), copper filings, and natron. Pliny (xxxiii. 57-8), about a century later, called *caeruleum* a kind of sand.

There is no direct textual information in Akkadian on Egyptian Blue. Oppenheim (1970: 13-4, 77) believed that it might be the material referred to in certain cases where artificial lapis lazuli was implied; but there is no certainty about the contexts he cites.

(i) HISTORICAL SURVEY OF USE IN MESOPOTAMIA

In view of its name, something may appropriately be said first about the appearance of Egyptian Blue in Egypt, although there is at present no certainty that it originated there rather than somewhere in Western

Asia. Lucas (1962: 340 ff.) summarized the matter, but rather more detail is needed to establish the possible date of its earliest appearance in Egypt. Samples attributed to the IVth Dynasty have yet to be identified by analysis. The more important occurrences of the Vth Dynasty, from the ruined Sun Temple at Abu Gurob and in the decoration of Per-Neb's tomb at Giza, have been analysed (Ransom Williams 1932: 29 ff.). Stevenson Smith (1946: 256) extended the history of Egyptian Blue back into the IVth Dynasty with three major cases of its use, identified by eye, attributed respectively to the reigns of Cheops, Chephren, and Shepseskaf. On the absolute chronologies at present used for the Old Kingdom in Egypt, this would indicate well-authenticated use by about 2400 BC, with more or less certain extension back to about 2550 BC, that is the range of the Early Dynastic III period in Mesopotamia. The possibility of its even earlier occurrence in Egypt has been raised by at least one 'blue paste' vessel attributed to the Protodynastic royal tombs at Abydos of the earlier third millennium BC (Petrie 1920: pl. XXIII: 14); but this is a vessel of faience with a blue core.

Blue frit has been identified in a cavity in a late prehistoric limestone inlay fragment of typical Mesopotamian type, now in a private collection (Kozloff 1981: no. 2); but the analysis was only a preliminary one. As with so much else in the history of materials in Mesopotamia, the numerous graves of the Royal Cemetery at Ur offer the first real check on its appearance, but here the looseness of Woolley's terminology creates its own problems. 'Glass paste' beads, as distinct from frit or faience, are first listed for two graves of the early Akkadian period (PGs 1517, 1601: U. 13531, 13598; Woolley 1934: 587-8). This may be Egyptian Blue. There is then a long interval, until the third quarter of the second millennium BC, before it can be traced again (at Nuzi), although there is no reason to believe that it ceased to be used, if only sporadically, for beads, amulets, etc. Stratum II at Nuzi yielded numerous blue frit beads (Vandiver 1982) and also half a moulded macehead, found in a private house, which Gettens identified as Egyptian Blue (in Starr 1939: 460). It is reported as inlays in a gold bracelet of the Kassite period from Dur Kurigalzu (Maxwell-Hyslop 1971: 164, pl. 127). Both scaraboid seals and small 'ingots' of Egyptian Blue were reported from Late Bronze Age levels at Ras Shamra (Louvre display, 1983) and the material was widely used for jewellery in the Late Bronze Age.

After the technological Dark Age, from about 1200 to 900 BC, the best information on artefacts of Egyptian Blue comes from the destruction debris of level IV at Hasanlu in north-west Iran. As this site is known to have had diverse commercial contacts with Syria and Mesopotamia it is always difficult to assess which of the objects found there were produced in or near Hasanlu

and which were imported from countries to the west, across the Zagros. These finds include complete and fragmentary vessels, some moulded with low-relief designs, some modelled three-dimensionally in zoomorphic shapes: a beaker (Chase 1971: fig. 5:1; Dayton 1978: fig. 334A); a beaker fragment (Porada 1965: pl. 33); and a 'lion vessel' with gold overlays (Loon 1962). A solid lion-head fitting (Dayton 1978: pl. 22:2) and a so-called 'sistrum handle' (Chase 1971: fig. 5:2) indicate the existence of a wide repertory of objects. A sheet-bronze ram's head rhyton has blue frit inlays in its eyes, eyebrows, and nostrils (Dyson 1960: 128, upper left) and there are comparable blue inlays in a gold knife-handle (Porada 1965: pl. 31). Art-historical criteria indicate local production both for the vessel fragment decorated with rampant goats and for the knife-handle, whilst the 'lion vessel' might well be an import.

It is usually assumed that the main stimulus for the production of objects in Egyptian Blue at this time came from somewhere in Syro-Phoenicia, though local evidence is extremely rare and virtually confined to coloured inlays in carved ivories, predominantly those in the so-called 'Phoenician Style' (Barnett 1975: 240), only occasionally in 'Syrian' ivories. Both are best known from sites outside their homelands. Inlaid 'Syrian' ivories were found in Hasanlu IV. From seventh-century levels at Nimrud has come evidence which might be taken to indicate a trade in blocks or ingots of Egyptian Blue. In Room ZT of the north wing in the North-West Palace 'one large amphora, ND 1975, of a type familiar from Palestine, contained inside it lumps of Egyptian Blue, which was the substance principally used for the incrustation of ivories' (Mallowan 1966: 180). In Room SW 6 of Fort Shalmaneser 'there were large lumps of bright Egyptian Blue, ND 6448, which was certainly stored for the purpose of incrusting ivories, for the material used in the "*cloisons*" is identical . . . The discovery of these raw materials implies that there were repair shops in the arsenal where, as we have already seen, there was presumed evidence of shell carvers in SW 3' (Mallowan 1966: 408). Here Mallowan is assuming that craftsmen, working in the 'Phoenician' style, perhaps themselves expatriates, were exercising their skills in the palace workshops using raw materials brought from elsewhere. Both Dayton (1978: 32) and Tite and others (1981) have published analyses of the Nimrud ingots. Dayton (1978: 32) also published from the same site two other raw materials which he described respectively as 'a stick of very bright "hyacinth blue" chalky material', which gave a strong tin reading, perhaps indicative of bronze scrap as a colourant, and a trace of cobalt; another, similar stick, was paler blue.

Although in referring to glass fragments from the throne-room of the Burnt Palace at Nimrud Mallowan

noted that they 'are associated with several specimens of Egyptian Blue' (Mallowan 1966: 209), few have yet been published. He illustrated an Egyptian-style head-dress, presumably from a composite statue, of faience and Egyptian Blue (ibid.: fig. 144: ND 1075 (i)). From the Ninurta Temple at Nimrud Layard (1853: 357-8) had reported: 'Figures of winged deities, etc., of clay, coloured in the mass with a blue derived from copper; eyes, beards, hair and ornaments . . .' Surviving examples are now in the British Museum, including one fragment of a winged goddess (Layard 1853: 357, left = BM 118785); a beard fragment was also illustrated by Layard (1853b: pl. 55:1). In carved ivories the inlays are sometimes of glass over a backing of Egyptian Blue (Barnett 1975: 240).

That vessels, of forms also current in metal, were being made in Egyptian Blue is evident at this time from a *phiale* found at Tell Halaf (Hrouda 1962: 66, pls. 49: 1-3; 50:1) and from two vessels found in Tumulus P at Gordion in Turkey, where both were regarded by the excavators as luxury imports (Young 1981: 30 ff., pl. 14). One was a juglet, the other a lotus-handled dish. Comparable vessels, in stone and in Egyptian Blue, are reported from Iron Age Cyprus. Despite 'Egyptianizing' traits, there is little reason to postulate an Egyptian source, for there, if anything, green frit was more popular than blue in the Late Period (Kaczmarczyk: personal information).

It has long been recognized that Egyptian Blue was a material particularly characteristic of collections of scarabs and small objects in 'Egyptianizing' style found throughout the eastern Mediterranean during the eighth to sixth centuries BC (James in Payne, H. 1962: 467-8), though, as has been noted, it was not a material then much used in Egypt. When found in Egypt it is usually on Delta sites, such as Naucratis and Tanis, renowned for their communities of foreigners: artisans, traders, and mercenaries. Throughout Western Asia, including such sites as Assur, Nimrud, and Nineveh in Mesopotamia, Egyptian Blue was also current at this time for seals, amulets, and beads (cf. Buchanan and Moorey 1988, nos. 20-30: Al Mina).

The German excavators at Babylon revealed a variety of Egyptian Blue artefacts. In the 'Principal Citadel' of the Kasr Koldewey reported finding 'remains . . . of large reliefs consisting of a beautiful blue paste, similar to lapis lazuli. The figures were made up of separate pieces, each of which only contained a small part, such as a lock of hair. On the back of these separate pieces there was a prismatic addition, by which they were affixed to some background of which we know nothing' (Koldewey 1914: 158-9). A miscellaneous collection of precious and semi-precious stones, largely objects or fragments of them, were found in what had originally been two baskets in a mudbrick house under a building of the Parthian period ('Amran

Perlen-Depotfund'). Koldewey (1914: 221) believed them to be the raw materials of a bead-manufacturer; inscriptions indicate a date for at least some of the objects in the Neo-Assyrian and Neo-Babylonian periods. Among them were objects of imitation stone, including large, blank cylinder seals of 'blue paste' (Koldewey 1914: 48) and various frit seals. They belong to a distinct class of cylinder seal, dated between the ninth and seventh centuries BC, assembled by Moortgat from examples excavated at Assur, Tell Halaf, and Babylon (Moortgat 1940: nos. 689-731); in some cases the material 'blue frit' is specifically mentioned. Egyptian Blue was also used at Babylon for mould-made vessels. Reuther reported a fragmentary relief vessel showing a nude female clasping her breasts 'in blue paste (imitation lapis)' (Reuther 1926: 140-1, fig. 90). He also described a small vessel as being of 'imitation lapis' (ibid.: 223, pl. 75A).

The range of Egyptian Blue production in the Achaemenid period is best represented in the excavations at Persepolis in Iran. Uninscribed and inscribed wall-pegs were found in 'Xerxes' Harem (Schmidt, E.F. 1957: 50, fig. 4, pl. 42:27). Inlay beards made of this material continue directly an earlier tradition (Schmidt, E.F. 1957: 72, pl. 42: 14-15). Some other Egyptian Blue objects were distinctively Egyptian (ibid.: 68, pl. 31:3). In the chart of the 'Royal Tableware', 14 (of 317) footless plates, 1 (of 7) footed bowls, and 6 (of 182) sherds, are described as 'composition' (ibid.: 91, table VIII). A buff-coloured pottery sherd, from a store-room (21) of the Apadana, had blue pigment incrusting on part of its interior surface to a maximum thickness of 0.05 cm., perhaps indicative of local manufacture (ibid.: 133). By far the finest object in Egyptian Blue, found more recently by the Iranian Antiquities Service at Persepolis, is the head of a young prince or princess (Porada 1965: pl. 45; Spycket 1980), wearing a mural crown. It is 6.5 cm. high and was probably once the head of a statuette.

In his report on the Egyptian Blue at Persepolis (in Schmidt, E.F. 1957: 133 ff.) Matson proposed a process of manufacture, which subsequent research has indicated is almost certainly incorrect.

(ii) COMPOSITION AND MANUFACTURE

Among the first to analyse Egyptian Blue in modern times was Sir Humphry Davy (1778-1829); but the most significant of the early studies was published by Fouqué in 1889, when he identified the compound as the calcium-copper tetrasilicate $\text{CaCuSi}_4\text{O}_{10}$ and defined the optical characteristics of the crystals. Various scientists then attempted to make Egyptian Blue, most notably Laurie and his colleagues in 1914. They systematically investigated the effect of the firing temperature and the concentration of alkalis, whilst repro-

ducing Egyptian Blue by heating together fine sand, copper carbonate, calcium carbonate, and sodium carbonate (fusion mixture); the blue crystals were formed at about 830-850 °C. Chase (1971) investigated the firing temperature range over which Egyptian Blue could be produced and the effect of different firing atmospheres; among his test samples was one from Nuzi. Bayer and Widemann (1976) used differential thermal analysis to investigate the formation and stability of Egyptian Blue used as a pigment. More recently Tite and his colleagues (1981; 1984; 1987) have sought to obtain information on the ancient methods for producing a wide range of Egyptian Blue textures varying from soft and friable to hard and semi-vitrified, and from light to dark blue in colour. Their samples included material from Egypt (late Old Kingdom onwards) and from sites in Syro-Mesopotamia of the Late Bronze and Iron Ages. Kaczmarczyk's (personal information) analyses of Late Bronze Age Egyptian Blue from Ugarit (Ras Shamra) indicate the use of both copper and bronze scrap as colourants and no marked chemical distinction in composition between Syrian and Egyptian material at this time.

The conclusions of Tite and his colleagues (1987) are the most comprehensive currently available, since they cover a range of colours, hardnesses, and textures, through a number of industries across an extended period of time. They found that an excess of silica (5-40 per cent), over and above that necessary to produce the Egyptian Blue mineral, and a much smaller excess of either calcium oxide or copper oxide, was a recurrent feature. The amount of glass was primarily determined by the alkali content (Na_2O and K_2O), which varied from less than 0.2 per cent up to about 5 per cent. The Neo-Assyrian objects sampled, with a low alkali content (0.5 per cent), tended to be softer and more friable than earlier ones from Egypt, the majority of which had a higher alkali content (1-5 per cent). It is not, however, yet possible to use such traits, or variations in firing procedures, to establish on technological grounds the possible initial centre of production of Egyptian Blue or to distinguish the products of individual workshops in later periods.

A single firing at about 900 °C for high alkali composition and at about 1000 °C for the low alkali material was normally sufficient to produce the coarse-textured Egyptian Blue. This tended to be dark blue in colour, its hardness depending on the amount of interconnecting glass in it (i.e. on its alkali content). Tite and his colleagues (1987) decided, after their experiments, that it was 'unnecessary to introduce the idea of multiple firings in order to explain the production of coarse-textured Egyptian Blue'. The coarse-textured material would have been ground for use as a pigment with the range of colour from dark to light being obtained by finer grinding. By contrast, for the fine-textured fabric

'a two-stage firing cycle with grinding and moulding to the required shape between the first and second firings would normally have been used to produce . . . the Egyptian Blue crystals uniformly interspersed among the unreacted quartz grains'. The second firing was at between 850 and 950 °C. It tended to be an undiluted light blue in colour and soft, if the alkali content was low; pale light blue and hard, if the alkali was high. The numerous small objects of the second and third quarters of the first millennium BC are almost invariably fine-grained to facilitate moulding, so they tend to be light rather than dark blue in colour. The blocks of 'Egyptian Blue' found at Nimrud are likely to have been the raw material from which objects would have been produced by grinding, moulding, and refiring, and may indeed be evidence for an artificial material traded from a restricted number of production centres in the Neo-Assyrian period, as glass certainly was, for manufacture into artefacts more widely.

(iii) ANALYSES OF EGYPTIAN BLUE FROM SITES IN MESOPOTAMIA

(a) Nimrud and Nineveh (see Tite *et al.* 1987, 41), sample analyses

Oxide	Nineveh: Neo-Assyrian cylinder fragment	Nimrud: Neo-Assyrian 'curl' inlay
(% wt.)		
SiO ₂	65.0	65.0
CuO	18.4	18.1
CaO	14.0	10.4
Na ₂ O	0.09	0.03
K ₂ O	0.16	0.01
Al ₂ O ₃	0.4	0.3
FeO	0.37	0.36
MgO	0.62	0.55
SnO ₂	0.1	0.1
As ₂ O ₅	0.01	0.01
PbO	0.02	0.02

(b) Khirbet Qasrij (Neo-Assyrian): Tite, in Curtis 1987:60.

4. Glass and Glass-making

Glass has a homogeneous, non-crystalline structure, quite different from faience and Egyptian Blue. In a glass, at some point in the process of manufacture, the ingredients become completely fused into a liquid melt, which is cooled and then sets as glass. In its softened form, glass is remarkably tractable. It can be rolled into sheets, drawn into tubes, rods, or threads; it can be cut with shears or teased into shape. It can be pressed into moulds or blown like a bubble from the end of a pipe,

as was discovered in the first half of the first century BC somewhere in the Levant.

As finds of early glass in Mesopotamia were for a long time relatively rare and nearly always ill-preserved (cf. Saldern 1970: 204), they took some time to attract the attention accorded to the well-preserved, brilliantly coloured polychrome glass objects from tombs of the New Kingdom in Egypt. Pioneer scholars of glass history, like Kisa and Bissing, dismissed the claims of Mesopotamia as an early producer, despite well-documented finds at sites like Nippur (Peters 1897: ii. 134 ff.) and Babylon (Koldewey 1914: 255 ff.). Meissner (1920: 235) thought otherwise, arguing that the industry in Mesopotamia was as old as that in Egypt. The spectacular finds in stratum II at Nuzi, well published by Starr (1939: 457–9), opened a new era of study, though this report was not available when Fossing wrote his memorable *Glass Vessels before Glass-Blowing* (1940). This contained the first attempt to isolate a group of early 'Mesopotamian' glass vessels, to recognize a local industry as early as 1300 BC, and to define its relationship to Egypt, whilst making clear independent Mesopotamian developments.

Since 1960 the study of Mesopotamian glass vessels and to a lesser extent of other artefacts has been set on a firm typological basis by Harden (1968), Barag (1962; 1970; 1985), and Saldern (1966; 1970). Oppenheim (1970) gave the subject a fresh dimension with his detailed investigation of textual sources for glass manufacture, whilst Brill (1970; 1978) and others have pursued complementary analytical studies of composition and technology.

(i) HISTORICAL SURVEY

(a) *The prehistory of glass production (to about 1650 BC)*

Since Beck's fundamental review of the evidence, published in 1934, there has been remarkably little progress in the study of the earliest glass reported from the Near East, though the database slowly increases. Beck was able to list only seventeen objects, not all of them of certain date, and not one of them a vessel, made before about 1500 BC in Egypt or the Near East. Although the list may be lengthened sixty years later, there is still no firm evidence for vessel production before the middle of the second millennium BC. Most of the early specimens were, and remain, beads found singly or in relatively small groups. None of Beck's examples, nor any of the subsequent finds, may confidently be dated before the middle of the third millennium BC. Beck's main conclusion, that regular glass production originated in Western Asia rather than in Egypt, has also stood the test of time (Barag 1970: 132; 1985: 35 ff.).

Beck's caution over the proper dating of two glass beads attributed to level 4 (c.3200–3000 BC) of the Great Pit MM at Nineveh remains justified, though an

exact dating is still no clearer (Beck, in Campbell Thompson and Mallowan 1933: 180–1, pl. LXXIX, 25–6). As Beck cogently remarked, 'it seems to me most improbable that these beads can be as early as stated'. One was pale blue, spherical in shape; the other 'a hexagonal cylindrical bead, which has been cut from a hexagonal rod' and had been a brilliant green. From its specific gravity Beck considered it to be a lead glass.

If these two beads are put to one side, the earliest glass bead yet reported from the Near East is probably that from Tell Judeideh in the Amuq Plain of Syria, where it was attributed to phase G, dated in the earlier third millennium BC (Braidwood, R. J., *et al.* 1960: 341, fig. 258). It is a well-preserved short, oblate spherical bead, pale yellow-green in colour. Matson (*ibid.*: 341) reported that:

The bead was formed around a straight rod (d. 3.6 mm), which gave the core a uniformly cylindrical shape, but the outer surface, which was probably shaped by rolling the soft glass on a flat surface after it had been gathered on the rod, is misshapen and pock-marked. The presence of so many seeds and cords in the glass indicates that it was melted at a fairly low temperature at which the viscosity was still quite high, so that the glass had the stiffness of thick molasses. It could not be stirred or worked easily in such a state, so that it was not cleared of seeds and cords. Had it been possible to use a higher melting temperature, a better quality of glass could have been made.

In grave 5A of pit L4 at Nuzi (attributed to stratum IV: Starr 1939: 32, 515) was 'a plain, straight copper pin of even diameter, 14 cm. long, with a large glass bead, 15 mm. in diameter, serving as a bead . . . It is, in fact, in much sounder condition than the majority of the Nuzi glass beads (i.e. of Stratum II)' (Starr 1939: 380). In the same grave was a cylinder seal, still on its copper pin, assigned by Boehmer to the later Akkadian period (c.2350–2150 BC) (Starr 1937: pl. 55F; Boehmer 1965: no. 1566); broadly the chronological horizon to which this grave was attributed by the excavators, who found a concentration of 'Old Akkadian' texts in stratum IV (Starr 1939: 516). Since such 'bead-heads' on pins had earlier been made of lapis-lazuli, the association of the earliest glass, as the earliest faience, with the reproduction of semi-precious stones is evident. Unfortunately, Starr did not illustrate this find.

In 1989 two glass beads were found at Nippur directly associated with tablets of the Akkadian period in what was taken to be a secure context (Gibson 1990: 5). Both beads had been made by fusing bits of barely workable very viscous glass round a rod (Vandiver: personal communication). One, a spherical white and olive-green bead, was of soda-lime-silicate composition. The other, a barrel-shaped bead, with hexagonal cross-section, was made of yellow and bluish-green glass, of a complex, multi-phase lead-silicate composition. This was surprising, since lead-antimony glasses and lead-stannite

colourants have not previously been recognized before the Parthian period. The microstructure of the yellow and green bead is at present unique, unlike any later glass containing lead stannite. The precise significance of these beads is an open question; on a tell like that at Nippur the agencies of intrusion are manifold so must always be held in mind in studying isolated beads.

Glass fragments have been reported from excavations in levels of the Akkadian period at Tell Brak, including a piece of raw glass. It is cylindrical in shape (2.4 × 2.2 cm. as extant), bluish-white in colour (Oates and Oates 1991: 138). Of equal technical significance is a pale blue-green chipped glass rod from the main level of the Northern Palace at Tell Asmar in the fill of Room E 16: 16 (Delougaz 1967: 189–190; As. 31: 671; cf. Gibson 1982). Objects littered about the floor of this room included a small upright-handled jar (B.526: 471); an important hoard of jewellery (including faience objects) was found buried below the floor of the room (*ibid.*: 190, 245; As. 31: 868–926). Frankfort *et al.* (1934: 56) provided the following description of the context for Beck's technical report:

It was found above 16 E 16 in the layer of debris corresponding to the period of the desertion of the Akkadian palace, which, as we have seen, contained almost exclusively objects of Sargonid times. It was found definitely beneath walls of a ruined building which had contained tablets of the 38th year of Shulgi. The foundation of the walls of the building stop half a meter above the level at which it lay.

Frankfort himself dated it to the Gutti period or 'more probably to that of the dynasty of Akkad'. Gibson's (1982: 534) revisions in the dating of this area would not invalidate this conclusion; though the tablet (*sic*) would now be dated Shulgi 40 or 41. Beck published two technical comments on this find (Frankfort *et al.* 1934: 56 ff., fig. 51; Beck, H. C. 1934: no. 7, figs. 2 and 3); he reported that 'it appears to have been modelled or moulded to its present shape, and had not been cut out of a solid block. The glass is very pure; it has a few small bubbles but is surprisingly free from striae or inclusions of quartz or dirt.' The object was not analysed. It looks as if it might be a type of glass tube regularly used in manufacture.

Perhaps the most famous single piece of raw glass from Mesopotamia is the small lump (BM 115474), excavated at Abu Shahrein (Eridu) by Hall in 1919, now in the British Museum (Barag 1985: no. 179). 'In the rubbish but not in the floor of the house, immediately beneath the Bur-Sin [Amar-Sin] pavement, was found a lump of opaque blue vitreous paste which I recognized as true glass' (Hall 1930: 213). This would date it to the dynasty of Akkad or the early Ur III period. Beck (H. C. 1934: no. 8, figs. 4 and 5) concluded: 'This specimen may have been meant to be carved or to be re-melted and moulded to the desired

shape; or even, it may have been intended to grind it up and use it as a glaze. In any case it was probably a manufacturer's piece of material and the probability is that it was made in the immediate neighbourhood of where it was found.' The glass is pure ultramarine in colour; it has been analysed by Garner (1956: 147 ff.), who identified the colourant as cobalt (0.15 per cent): 'although the amount of copper is 0.40 per cent, three times that of cobalt, it has a much weaker colouring property and in fact would hardly influence the colour at all'. The cobalt was identified as one of the arsenical ones, either *cobaltite* or *erythrite*, and attributed to an Iranian source, perhaps the mines at Khemsar, near Kashan, which yield an *erythrite* of beautiful amethyst-pink crystals, whereas the *cobaltite* of Azerbaijan is a metallic grey in colour and much less likely to attract attention. The cobalt is free of manganese, zinc, and nickel, strengthening the case for an Iranian source.

Oppenheim (1970: 19–20) called attention to the very rare appearance in texts of the Ur III period of a material known as *anzahhu* (Sumerian AN.ZAH), once as a bowl, once as a raw material. He believed it to be a 'primary glass'; that is, a key intermediate material in the production of a finished glass. The *Chicago Assyrian Dictionary* translates it as 'an imperfectly fused, crude, frit-like glass'; but Foster (K. P. 1979: 17; cf. Loding 1981: 12) has taken it to be a mineral, perhaps a type of quartzite. Whatever the case, and the available evidence is indecisive, it does not provide certain evidence for glass vessels at this time. At most, if an artificial and not a natural substance, it complements the archaeologically attested production of faience vessels and the imitation of coloured stones in glass, as on the Nuzi pinhead.

Oppenheim (1970: 85) also argued that the Tell Asmar and Eridu fragments 'indicate a technical turning point in the history of Mesopotamian glass-making. We may read here the level at which the anonymous craftsman who produced the "primary glasses" (see p. 36) was supplanted by the chemist. The new alkali-silicate glasses were combined with the "primary glasses" in order to produce imitation of coloured stones.' This goes far beyond the present evidence of archaeology. What the known material culture indicates is a developing tradition in the manufacture of imitation stones, whose composition varied considerably. But before the sixteenth century BC little, or none of it, was of glass in the accepted modern sense (ingredients fused into a liquid melt). It was various types of sintered quartz, glazed and unglazed, i.e. frit and faience, particularly when used for anything other than beads.

It was in his analyses of the Old Babylonian word-lists of the earlier second millennium BC that Oppenheim isolated certain substances as what he called 'primary glasses' (see above): *anzahhu*, *kutpu*,

huluhhu, and *huhû* (Oppenheim 1970: 19 ff.). Virtually nothing is known of these substances; but, in what Oppenheim saw as a significant, undated, sub-period, *anzahhu* played a major role in the production of imitation coloured stones. 'It may be assumed that their composition varied greatly and that the mentioned designations refer not only to uses and colours, but to specific still unknown properties as well. These materials were used to make beads, inlays, cylinder seals and probably bowls . . . ' (Oppenheim 1970: 84). Oppenheim (1970: 84–5) extended his philological analyses into the area of cultural history by arguing that all the early designations of his 'primary glasses' were not Akkadian words and that even the Sumerian AN.ZAH, from which *anzahhu* is derived, could well be a loan word from some unknown source. Although he admitted that the ultimate origin of these words had not been established, he hazarded the guess that they came 'into Mesopotamia from the northwest together with the substances they denote'. Such a view is hard to substantiate from the available archaeological evidence, even if philologically sound; but it is not impossible.

In the long series of third-millennium graves at Ur, commonly known as the Royal Cemetery, Woolley (1934) catalogued two instances of glass beads, one from a Late Akkadian grave (PG 1213): 'some glass ringbeads' (U.12003); the other from a Neo-Sumerian grave (PG 973): 'beads . . . glass' (U.11427). From only one of the 198 graves attributed to the Isin-Larsa period (LG 121), of the earlier second millennium BC, does he report 'beads 18 chiefly cornelian and some glass' (Woolley 1976: 205). Both the identification and the archaeological context of the 'glass' beads from the *Enunmah* are equivocal; they were near a drain in Room 9 (Woolley 1974: 50). In the main text they (U.152–3) appear as 'minute crystal and pebble beads and a few larger paste and stone beads' (ibid.: 50). In the catalogue U.153 is put in Room 13 and listed as 'beads, minute, of transparent white glass and opaque glass paste' (ibid.: 84). This would appear to be an example of the common visual confusion between rock crystal and glass. The supposed early glass beads from Tell Farah (Shuruppak) were also finally said to be rock crystal (Beck, H. C. 1934: 10). Although Beck was almost certainly right to reject as 'before 1600 BC' some red beads from Ur given him by Woolley for examination, the others from the site he examined may not be independently dated. Beck (H. C. 1934: 18) reported that 'they were found with a series of faience beads definitely stated by Woolley to date before 1600 BC. The dust consists largely of broken down glass of at least two sorts, one practically colourless, the other yellow glass so common in Egypt during the XVIII dynasty.'

At Assur various votive deposits were placed in the

corners of the Ziggurat. Two sets were excavated. The lower, on bedrock, included some glass beads. On the comparative dating of associated brickwork the excavator attributed this bedrock deposit to Shamshi-Adad I (c.1813–1781 BC) though it is not certain that it was not contaminated by Shalmaneser III's workmen a millennium later (Beck 1934: 17; Andrae 1938: 90, pls. 45–6; Haller and Andrae 1955: 2 ff.). The upper deposit also contained glass beads. It included silver and gold disks inscribed for Shalmaneser III (c.858–824 BC). However, an inscription of Adad-nirari I (c.1305–1274 BC) from Assur speaks of 'the great new Ziggurat built by my father Arik-den-illi' (c.1319–1308 BC) (Edzard 1964), so these beads might be fourteenth century in date. Glass beads, with others of agate and faience, were found in an old Assyrian grave at Assur (no. 486; Haller 1954: 39). At Tell Asmar from houses below the Southern Building which are attributed to the Early Larsa period, in the first century or so of the second millennium BC, the excavators reported a 'glass tubular fragment' and a 'glass bowl fragment' (Delou-gaz 1967: 263, no. 31: 547; 264, no. 31: 58). No details have yet been published about either of these finds; if correctly reported, the latter would be of great significance at this date.

In a list of stone vessels from the archives of the Old Babylonian palace at Mari are two made of *zakûkîtu*. This word has been compared to the Hebrew for 'glass'. But as Durand (1983a: 224) remarked in publishing this text: 'Qu'il s'agisse de "vrai verre" ou de "pâte de verre" est une chose indécidable par ces deux seules occurrences.' Oppenheim (1970: 17 n. 33), in a later text describing the glazed brick surface of the temple of Ezida in Borsippa, rendered the Akkadian word *zakakatu* or *zakukutu* as 'pure glass'.

(b) *Changes in the production of glass, c.1650–1150 BC*

There is nothing in the material record before the Kassite period in Mesopotamia to indicate anything other than an infrequent and irregular production of glass, predominantly for personal ornaments, which showed little, if any, appreciation of the material's special properties. The isolated finds dated before the middle of the second millennium BC have sometimes been explained as no more than compositions intended as faience, which turned completely vitreous when over-fired, whilst the glass tubes, the lump of glass from Eridu, and the glass vessel from Tell Asmar have been seen as by-products of glaze manufacture. Thus they would hardly substantiate the existence of a distinct, controlled production of glass, as might be assumed from some readings of contemporary texts.

However, if a more positive view is taken of the earliest glass finds from Mesopotamia, closer to the case argued by Oppenheim (1970: 76, 83, 85), it is necessary to lay emphasis on one particular point. Since the

scribes, upon whose lexical lists Oppenheim drew, were cataloguing the words for stones, they would naturally have been interested in any artificial substitutes. Even if the sparse surviving material record before 1650 BC continues to show that such imitations were predominantly of faience or frit, it indicates the emergence of some production in glass. The reproduction of coloured stones in glass was long to remain a significant aspect of glass manufacture in Mesopotamia. Indeed, the very existence of the so-called glass texts in later Middle Babylonian and Neo-Assyrian times is evidence for its persistence. Since the modern student of early glass technology tends to see the production of glass vessels as the key factor in the development of pioneering glass industries, it is easy to forget that this was only one aspect of expanded production after 1650 BC and not, as it happens, the one of particular interest to contemporary scribes.

In any attempt to elucidate the course of innovation late in the Middle Bronze Age it is important to demonstrate that the material evidence from Egypt and other parts of the Near East before that time is comparable to the evidence from Mesopotamia and scarcely more common. Elsewhere in the Near East there still appears to be no hard evidence for glass beads before the Middle Bronze Age, save for the isolated bead from Tell Judeideh (see above). The presence of 'glass' beads in an Early Bronze Age grave at Jericho (Kenyon 1960: 171), as indeed later in the Middle Bronze Age tombs (Kenyon 1960: 351, 368, 406), some termed 'glasslike', still rests on uncertain identifications made in the field.

In Anatolia Schliemann reported three small glass spheres and a glass bead from the Burnt City of Troy (IIg); but there is some doubt about their context (Schliemann 1884: 478, 480) and much debate over the absolute dating of this level. Both at Bogazköy (Büyükkale) and at Alishar there is evidence for glass beads in Middle Bronze Age levels (Boehmer 1972: 175, no. 1809; Osten 1937: 284–5, fig. 309). In Syria Woolley (1955: 269) reported polychrome glass beads from the temple of level VII at Tel Atchana. In Iran blue glass beads, said to be coloured with cobalt, have been reported from graves at Geoy Tepe, usually assigned to the period between 1800 and 1600 BC and probably earlier rather than later in it (Burton-Brown 1951: 127 ff.; Crawford H. E. W. 1975: 12) and from Dinkha Tepe, coloured by cupric ions (McGovern *et al.* 1991: 399–400). Thus, within the broad network of Old Assyrian trade contact, there is some firm evidence for glass bead production which seems more than accidental.

The evidence for Egypt has been admirably summarized by Lucas (1962: 181; cf. Cooney 1960: 11; Peltenburg 1987: table 2):

There is, therefore, no doubt whatsoever that glass beads and tiny glass amulets date from as early as about the Fifth

Dynasty (c.2465–2323 BC), and it is exceedingly probable that they were all of Egyptian manufacture and that they were the outcome of the use of glass as glazing material for steatite and quartz (both solid and powdered). Some of these early beads, however, are not normal glass, but what elsewhere I have called 'imperfect glass' . . . Though possibly intended as faience, which is glazed quartz frit, they are not, since the material is of similar composition throughout without any coating of glaze, and, therefore, they must be classed as glass. This imperfect glass consists of glass matrix in which a considerable proportion of uncombined quartz is embedded.

The status of two *udjat*-eyes of black and white glass found at Sedment, dated to the Tenth Dynasty, is equivocal (Lucas 1962: 182). None of the other 'early glass' objects from Egypt has survived critical examination in recent years. The occasional production of glass in the Middle Kingdom and through into the Second Intermediate period includes beads (Lucas 1962: 181) and some inscribed scarabs (Martin 1971: nos. 441, 1198).

It is towards the close of the local Middle Bronze Age, some time in the sixteenth century BC, that the first evidence appears in Western Asia to suggest major technological changes in the manufacture of glass, involving the appearance of new production techniques (e.g. fusing, maverling, trailing), the use of special tools, and the inclusion of different metal oxides to provide a range of colours not commonly used, if used at all, in earlier times. Now for the first time craftsmen were exploiting the particular properties of glass; a change particularly well illustrated by the new process of coiling viscous glass round a core to make vessels.

The earliest evidence for such vessels is not only sparse, but equivocal. Woolley (1955: 300: AT/39/225; cf. Barag 1970: 151, no. 3; 1985: no. 7) reported sherds of polychrome glass vessels from level VI at Tell Atchana (Alalakh), for which the lowest accepted dating is the later sixteenth century BC (McClellan 1989); the subsequent level V was also reported to have contained sherds of glass vessels. By contrast, no other finds of this kind may yet be safely dated before the second half of the fifteenth century BC. Caution is still in order in any assessment of the context of these finds at Tell Atchana, since there are sherds of pottery and faience vessels attributed by Woolley to levels VI–V that are demonstrably of a later date in the local Late Bronze Age.

A new repertory of moulded glass objects was also evident in Atchana VI, notably a nude-female plaque (Woolley 1955: 247, pl. LVIb; Barag 1970: 188 ff.); another was in a grave attributed to level V (Woolley 1955: 220: AT/39/106; Barag 1985: no. 45). Stratum IX at Megiddo (c. 1550–1475 BC) yielded a glass nude-female plaque (Loud 1948: 82, pl. 241:4 as 'fayence') as well as a complete, moulded, plain glass disk-pendant and moulded, blue glass spacer-beads (Loud

1948: pl. 210: 39, 41; cf. Barag 1970: 192), as well as other glasswork; production extends back into Megiddo X. At this time gold jewellery was sometimes inlaid with glass as at Ajjul (McGovern 1985: 71, 104; Maxwell-Hyslop 1971: 118–20). Examples of moulded blue glass, star-shaped disk-pendants, nude-female plaques and spacer-beads in the Aegean, in archaeological contexts of the sixteenth or fifteenth centuries BC, have been identified as oriental imports (cf. Barag 1970: 89 ff.). As such they are further support for the argument that there were active glass workshops in Syro-Palestine by the final phase of the local Middle Bronze Age (cf. Barag 1985: 35 ff.), from which glass beads and inlays may also have reached Egypt before the end of the Second Intermediate Period.

As no site yet excavated in Mesopotamia has occupation levels securely dated to the critical period, c. 1650–1450 BC, independent evidence is hardly to be expected there. However, relevant evidence is not wholly absent even now. In 1854 Loftus found a cist grave at Nimrud in what Mallowan was later to call the Burnt Palace. In it were a number of moulded blue glass spacer-beads, only one of which may currently be identified in the British Museum. With them was a bronze flange-hilted dagger and a rare type of bronze axehead very closely paralleled in Middle Bronze IIC (c. 1600–1550 BC), at Shiloh in Palestine (Curtis 1983: 74, pls. VIIb, VIII; cf. Finkelstein and Brandl 1985: 21, figure), at a time when moulded glass spacer-beads were current locally (cf. Barag 1985: no. 17, with comparanda). On this evidence the Nimrud examples are unlikely to date after 1500 BC and are part of an exceptionally wide distribution of this class of glass object, reported from Iran to Greece. A mould for casting them is reported from Bogazköy (Boehmer 1972: 217–18, no. 2229, pl. LXXXVII). The Nimrud glass spacer-bead is an isolated indicator of the importance of the Syro-Palestinian glass industry as the possible stimulus for developments in Mesopotamia, first fully represented by the glass from stratum II at Nuzi in the late fifteenth or early fourteenth centuries BC (see below), as also in Egypt.

At present only in Egypt is it possible to carry the history of glass from the sixteenth century through the fifteenth century BC. The Boston Museum of Fine Arts has a tiny glass plaque, inscribed with the names of Ahmose (c. 1550–1525 BC) and Amenophis I (c. 1525–1504 BC) which is taken to be contemporary with the later part of Ahmose's reign (Gordon 1982). 'An elemental analysis (in the Boston Museum by Van Zelst and Sayre) by means of energy dispersive X-ray fluorescence spectrometry showed the presence of calcium, a main element in glass production, copper as a colourant, antimony as an opacifier, strontium as an impurity coming in with calcium, and iron as an impurity' (Gordon 1982: 294).

The first regular production of core-formed glass vessels in Egypt is still hard to date. If two glass sherds found in the debris of the tomb of Tuthmosis I (c. 1504–1492 BC) really belong to his reign, then production may have begun by the end of the sixteenth century BC; but this remains doubtful (cf. Barag 1970: 181). It is to the time of Tuthmosis III (c. 1479–1425 BC) that the earliest reliable evidence belongs. Vessels of this reign represent an important initial stage of development, since shapes and designs were not yet standardized. In Barag's (1970: 83) view, some show no evidence of foreign influence at all, whilst one has adopted decoration familiar in Mesopotamia and two may be actual imports from that area. It is possible that following the Asiatic campaigns of Tuthmosis III the skills of glass vessel production, if not actual glass-workers from Syria, were first established in Egypt; but it is not until the reign of Tuthmosis IV (c. 1401–1391 BC) that a standard local repertory (most evident a generation or so later at Tell el-Amarna) is first evident.

Standard composition appears to have been established earlier. Two clear glass 'name-beads' of Queen Hatshepsut and Senenmut, from Deir el-Bahari, to be dated between the years 7 and 16 of her reign (c. 1473–1458), are made of a soda-lime-silica glass with relatively high magnesia, comparable to that from Tell el-Amarna. 'Although this glass is more than 100 years older than the Amarna glasses, it is clear that the general character of second-millennium BC Egyptian glass was already established' (Bimson and Freestone 1988: 11).

Although all too frequent references to the 'invention' of glass somewhere in Egypt or Western Asia in the second quarter of the second millennium BC are inappropriate, there was at that time an expansion of the glass repertory and a concentration of inventiveness so significant that interest in where the change took place and under what circumstances remains undiminished. It is usually argued that the innovative workshops were those producing objects of faience for the courts and temples of Turkey and Syro-Palestine towards the end of the Middle Bronze Age. It has been particularly noted that the moulding of personal ornaments, and amulets shaped as nude-female figurines, in faience is exactly matched in the first phase of developed glass production.

As the glazing methods used in the manufacture of faience in Western Asia in the Middle Bronze Age have still to be comprehensively investigated, their relevance to the invigoration of glass production is still an open question. Vandiver (1983a: A-136) has suggested that application glazing rather than other types of glazing (see above) foreshadowed the methods of core glass production, as they did those of glazed terracotta manufacture. Smith (C. S. 1981: 202, 248), however, has argued that the cementation process for faience manu-

facture ('self-glazing') involving 'very subtle behaviour of alkalis and silicates in differential contact with lime and silica surfaces (cf. Wulff *et al.* 1968)' gave rise directly to the manufacture of the earliest so-called 'sand-core' glass vessels in which the 'sand' was a non-wettable material, probably lime, not silica. If so, it would be instructive to know whether this technique was first widely used for faience production in Syro-Palestine in the mature Bronze Age, as it seems to have been a Middle Kingdom innovation in Egypt. The simultaneous appearance of evidence for the earliest glass vessels and the first vessels of glazed terracotta at Tell Atchana in Syria at the very end of the Middle Bronze Age is certainly not coincidence. They are two aspects of a single major technological breakthrough in the court or temple workshops of the region at this time. Glazing terracotta was unlikely before mastery of the mechanical properties of glass allowed for controls sufficient to overcome the differing coefficients of expansion involved when using alkaline glazes on a baked clay object.

Peltenburg (1987: 14) prefers a rather less exclusive derivation of expanded glass production from local faience industries:

had glass been developed in an exclusive faience-working tradition then it could be reasoned that the breakthrough is likely to have taken place during a time of increased tempo in the production of faience, particularly of larger scale works such as vessels. The vessels moreover should also carry polychrome glazes in view of the appearance of an impressive array of colours on the earliest glass vessels . . . one is struck however by the relatively low numbers of preceding faience vessels and the absence of polychromy . . . polychromy seems to be an integral component of the technological revolution that brought about the establishment of glassworking industries . . . there are no published developments in faience production from this area [modern Syria and northern Iraq] therefore which overtly presages the emergence of glass.

Peltenburg further argues that the socio-political context for the change is to be sought within the newly established 'Hurri-Mitanni' political supremacy and that the critical technological relationship may have been as much with metalworking as with faience production methods. In his view both the combination of vitreous materials and metals in single objects and the use of metal oxides as colourants for glazes brought the two crafts together: 'it may be that there are decisive differences in the production of faience and glass which link the latter more closely to metalworking. In contrast to faience-workers who formed their glaze essentially in a cold state . . . glass as an independent substance involved a hot technology . . . hot working the glass in a molten state both for body forming and decoration is much more akin to metal than faience working' (Peltenburg 1987: 21–2; cf. also Tite 1987).

Although a special connection with the Hurrians is

debatable (cf. Moorey 1989), the force of Peltenburg's case for the skills of metalworkers as critical to the transformation of glass production in the middle of the second millennium BC is powerful. It allows for a more subtle innovative interaction of all three crafts, faience manufacture, metalworking, and glass-making, than previous models have done. Initially, and no doubt throughout the Late Bronze Age, glass vessels were prestige packaging for precious oils or unguents, or for special use as tableware. They are most likely to have come, as at Tell el-Amarna and Malkata in Egypt, from court or temple workshops, where a whole range of artisans would have been working in close proximity, sometimes in the production of one and the same object incorporating metal, glass, and glaze as well as many other materials.

Oppenheim (1973) investigated the direction in which the invention of glass vessel manufacture spread across the Near East in the third quarter of the second millennium BC through two key Akkadian words. A text from Ugarit indicated that they were synonymous: the expression *ehlipakku*, perhaps of Hurrian origin, and the word *mekku*, of West Semitic origin. The former is attested at Boghazköy in Anatolia, in Alalakh (Atchana), Ugarit, Qatna, and Nuzi, but does not appear in glass texts; the latter was used in Tyre, Ugarit, and in Assyria. This commodity, by one or other name, is requested by the Egyptian pharaoh in the 'Amarna Letters' from a number of rulers of city-states in Palestine and the Lebanon, including Ascalon and Tyre. *Mekku* is translated in the standard dictionaries as 'a kind of precious stone' (CAD, s.v.: cf. AHw, s.v. 'stone'), whilst Foster (K. P. 1979: 21) rendered it 'finely powdered quartz'. On the basis of his study of the Mesopotamian glass texts, Oppenheim (1970: 57 ff.; 1973: 261) argued that it was the 'raw material used by craftsmen who fashion the glass containers'; that is, an artificial glassy material. Even in the key text (Oppenheim 1970: 55–6) *mekku* does not have to be glass; it might be a natural mineral ingredient used in the manufacture of frit or glass. Through his translation Oppenheim postulated an export trade in raw glass from Syro-Palestine. This would now seem to be endorsed by the discovery of glass ingots in the wreck of a late fourteenth-century ship, sailing from east to west, off Ulu Burun (Kas) in Turkey (Pulak 1988: 14). They are discoid in shape and the deep blue ones were coloured with cobalt. How early this trade existed remains to be demonstrated.

However, as Oppenheim well appreciated, there is something anomalous about an Egyptian pharaoh keenly requesting raw glass 'in spite of the fact that all ingredients necessary to produce glass objects were abundantly available in Egypt' (Oppenheim 1973: 263). Indeed, production is exceptionally well illustrated by the glass factories of the mid- to later fourteenth

century at Tell el-Amarna, with their instructive range of industrial debris (cf. Lucas 1962: 191 ff.). It has also been argued that the cobalt blues analysed to date from Egypt and Mesopotamia 'clearly indicate that different sources of cobalt have to be sought for the Egyptian and Mesopotamian brands of cobalt' (Kaczmarczyk and Hedges 1983: 290), whilst Brill's results from lead-isotope analysis of pigments appear to indicate a comparable distinction: 'the results establish beyond reasonable question that the yellow pigments were manufactured at different places, the Egyptian in Egypt and the Mesopotamian elsewhere . . . so the yellow pigment itself was not—in this instance—an article of trade' (Brill *et al.* 1974). Syrian glass-makers may well have been instrumental in accelerating the spread of true glass production in both Egypt and Mesopotamia, as well as in the Aegean world, from early in the Late Bronze Age. Whether or not *mekku* was indeed glass, international contacts at court level in the fourteenth century were quite sufficient to diffuse luxury objects, raw glass, and relevant technologies between Egypt, the Mittani, and Babylonia (cf. Oppenheim 1973: 263 ff.).

The most remarkable collection of early glass from Mesopotamia is that recovered from stratum II at Nuzi, equally well known for the associated faience and glazed terracotta found there. Barag (1970: 136 ff.) has provided the basic typological study of the vessels, but much remains to be done on the other glass objects. Vandiver (1982^a; 1983) has begun to examine the technology of the industry and her work has already shown the variety of techniques in use. This glass was concentrated in the destruction level of stratum II (Starr 1939: *passim*), which may not date much before 1350 BC (Stein 1989). As there is a general tendency to date Nuzi stratum II to the fifteenth century BC, it is important to stress the possibility that many of the excavated objects may be a generation or so after the end of that century and so more nearly contemporary with the Amarna glass factories in Egypt than is often appreciated.

No cemeteries were excavated at Nuzi, so all the glass came from the town, where it was concentrated in Temple A (Cella G29, Court G50, Room H7, and Street 8) and in the Palace (Rooms L8 ('shrine'), M79, and Court M100), with further finds in the 'House of Shilwi-Teshup' (Rooms 44, Court 15, and Court 7) and in Room C22. One of the more remarkable discoveries about the beads found in such quantity in Temple A at Nuzi was the probability that a significant number (especially unpierced ones) had been part of the architectural decoration, though no wall was preserved to a great enough height to show exactly how (Starr 1939: 92 ff.). This was 'substantiated by the discovery of an unbaked brick in the northwest end of the room, in which had been set a row of elliptical and circular eye-

beads' (Starr 1937: pl. 119, KI). Two plaques, one of limestone, the other of baked clay, which had been 'overlaid with coloured glass in which geometrical and conventionalized tree-of-life designs are inlaid' (Starr 1939: 93; 1937: pl. 131, A, B), were assumed also to have been attached to the mudbrick walls. The excavator thought that even a substantial number of pierced beads had been strung as wall-hangings and 'were not special offerings to, or decorations for, the statue of the goddess', as would commonly be assumed of beads found in temple contexts.

Thousands of beads were recovered (Starr 1939: 94, 445 ff.) with many fragments of core-formed glass vessels, whose shapes (goblets, piriform bottles, shallow bowls and stands) were those of contemporary pottery, some of which was glazed. Apart from a shallow monochrome glass bowl, the reported Nuzi glass vessels were polychrome, with blue as the primary base colour; thread decoration was in white, yellow, orange (amber), and pale blue; rim twists were of blue and white or brown and white. A variety of geometric patterns, meanders, festoons, feather-patterns, chevrons, and twists, were used. A bowl from the Palace (Starr 1939: 461; 1937: pl. 119J; Barag 1970: 140, no. 14, fig. 13) resembles the mosaic glass better represented at Assur. Barag described it as 'made of red-brown, opaque composition mixed with thin yellow and white threads'. Equally unusual is a goblet-fragment, again from the Palace, published as 'faience' by Starr (1939: 461; 1937: pl. 119I). Barag (1970: 140, no. 15) is more cautious. It is of a mixed opaque composition, red-brown, yellow, dark blue, and turquoise(?) faded white in which dark blue spots are glass. Further sherds from similar vessels were found.

This uncertainty usefully serves to illustrate the dangers of trying to categorize by eye the products of an industry that was both inventive and various (cf. Vandiver 1982a; 1983), producing a number of closely related artificial materials. Several lumps of deep blue, raw glass were found, but in a locus (C62) whose exact position on the site is obscure (Barag 1970: 140-1, fig. 16). Glass was used for ceremonial maceheads and 'staff-heads' (Starr 1939: 459-60). Among pendants, round ones with or without moulded stars are the best known (Barag 1970: 40) and have been associated with the cult of Ishtar, whose devotees are perhaps also represented by the moulded nude-female glass plaques found at Nuzi and elsewhere (Barag 1970: 140).

The glass finds from Nuzi, now in the Semitic Museum at Harvard, have been the subject of a special technical study by Vandiver (1983) and what follows draws heavily on her account. Accepting that most of the finds date from the later fifteenth or earlier fourteenth century BC, she argues that they do 'not represent the incipient stages of an emerging technology';

much had already happened. Artistic skill was matched by technical expertise; the range of chemical compositions was relatively limited, though the number of colourants was large; the related soda-lime-silicate technology at Nuzi was also sophisticated and various. The glass repertoire included artefacts whose find-spots suggested that they were luxury objects for the rich; but glass beads were very widely distributed on the site. Glass, like faience before it, was used to imitate semi-precious stones and shells. Patterns drawn from nature, as well as amulets shaped like birds, flies, frogs, flowers, and stars, were characteristic of this industry. The technical repertoire was equally diverse: rod-forming for beads; moulding for 'Ishtar' amulets; disks of molten glass impressed with designs; rare examples of rotary grinding of cold-glass blocks; core-formed polychrome vessels; free-formed amulets.

Although at this stage, as with expanded faience production, this is an industry primarily concentrated in the palaces and temples of major cities, it is not strictly correct to say that 'nearly all' early glass is found in temples (as Peltenburg 1971: 8). As noted above at Nuzi, personal ornaments have a wider distribution. More elaborate artefacts of glass are certainly concentrated in palaces, temples, and in rich graves, as would be expected of a luxury material. This is not incompatible with simpler production in 'cottage industries', away from palace and temple workshops, at least by the later fourteenth and thirteenth centuries, when glass is more widely evident and was much used for beads, and even cylinder seals, as in ordinary graves at Tell Mohammad Arab (M. Roaf: personal communication).

The glass finds at Assur, another site with an active faience industry at the same time, are mostly dated to the thirteenth century and again display considerable technical variety. Oppenheim (1970) suggested that the glass texts assembled six hundred years later in Ashurbanipal's library at Nineveh had first been codified at Assur about this time. The archaeological evidence certainly indicates a local industry making glass of all kinds (mosaic and core-formed vessels, inlays, and probably plaques) as well as a complementary production of artefacts in glassy (sintered quartz) materials. Core-formed glass vessels and sherds of them were largely found in graves, notably in tombs 37 and 133, which held glass contemporary with that from Nuzi II, and in various parts of the Ishtar Temple (Barag 1970: 141 ff.), erected by Tukulti-Ninurta I (c. 1243-1207 BC). This glass has not yet been fully published, though much of the associated 'faience' has. It is usually dated to the thirteenth century BC, though some of it might be slightly earlier. So far as it is possible to judge at present, the variety of shapes and decoration is greater than at Nuzi, though the colour range is comparable. The mosaic glass fragments (Haevernick 1968; Saldern 1970: 215, no. 7) are outstanding and constitute the most important

second-millennium BC group of such glass yet published. The fragments are from vessels as well as inlay plaques for walls and for furniture, using red, blue, yellow, green(?), and white glass. Cullet was also found, reinforcing the case for local production. Figured mosaic designs include human beings, animals, and floral devices reminiscent of contemporary motifs on seals.

An important collection of glass was found at Tell Rimah. There, once again, there was evident indication of an active contemporary faience and frit industry. The majority of the fragments are 'from Middle Assyrian levels with a terminal date of c. 1250 BC and a mean date of 1300±50 years' (Oates, D., cited by Harden 1969: 29). They were found in the late phases of level 2 (cf. Barag 1970: 145). Core-formed vessels were represented by complete examples and by sherds; moulded glass by pendants, nude-female plaques, and demon masks; beads by a variety of polychrome types. Scholarly attention has, however, concentrated particularly on fragments of a series of straight-sided, button-based goblets made of opaque mosaic glass arranged in chevrons of green, white, blue, and yellow canes (Saldern 1966^a; 1970: 206, 213 ff.; Harden 1969). One almost flat fragment may be part of a plaque or a very large vessel. No industrial debris or raw glass has been published from this site. Two mosaic glass beakers from Marlik in north-west Iran may be exports from workshops in Assyria specializing in the production of such mosaic vessels (Saldern 1966^a; 1970: 208b; Negahban 1989); they are from graves likely to belong to Iron I (c. 1350-1000 BC). Fragments of mosaic glass vessels were found at Haft Tepe in Khuzistan, demonstrating wide distribution in Iran (Negahban 1991, pl. 56: 478).

Mallowan (1947: 77 ff.; 84; cf. Barag 1970: 146) reported polychrome sherds from glass vessels of the fourteenth or thirteenth centuries at Chagar Bazar and Brak, but nothing to compare with finds in renewed excavations at the latter site in the 'Mitannian Palace', which may have been destroyed by Adad-nirari I (c. 1305-1274 BC). Local production was evident from several ingots of raw glass, with remarkable fragments of mosaic glass including geometric and floral patterns (Oates, D. 1987: 187, pl. XXXIXa).

An important collection of glass fragments was recovered from the royal palace at Dur Kurigalzu (Aqar Quf), the Kassite capital, in contexts dated from the mid-thirteenth to the mid-twelfth centuries BC (Baqir 1945: 9-10). A text from level II, dated to the third year of King Kashtiliashu IV (c. 1232-1225 BC), refers to glass given to artisans for decoration in the 'Place of the Stag' (Gurney 1953: no. 22). The published information on these glass finds is limited to the more usual types and little or no reference is made to sherds of core-formed vessels; mosaic glass was especially plentiful (cf. Barag 1970: 148 ff.; Saldern 1970: 207-8). Some

of the mosaic glass found in level IV at Hasanlu in north-west Iran has been convincingly attributed to a 'Kassite workshop' (Marcus 1991).

At Dur Kurigalzu glass plaques (with relatives at Tell Rimah) of two main types were reported: some were plain (or variegated?), otherwise of red glass inlaid with white, turquoise-blue, red, and perhaps yellow glass in designs of stars, eye-like disks, lozenges, and birds of prey (Saldern 1970: nos. 3-4). Mosaic glass was also used in the manufacture of bowls and other vessels (Saldern 1970: nos. 5-6; Barag 1970: 148). Texts indicated that workmen at Dur Kurigalzu were being issued with a variety of precious materials for palace decoration, so here again, as at Assur, Brak, Nuzi, and Tell Rimah, royal and temple workshops are likely to have included glass-makers.

Further to the south, in Babylonia, glass of this date remains rare. The pioneer excavations at Nippur produced a group of fragmentary moulded glass votive axeheads with dedicatory inscriptions for various Kassite kings (cf. Brinkman 1976: 71 n. 289; Peters 189: 134 ff., 143 ff., 373 ff. with an analysis; cf. Neumann 1927). They had been hoarded, perhaps by a jeweller, with comparable objects of lapis lazuli and other ornamental stones in the Parthian settlement at Nippur (Barag 1970: 148; Saldern 1970: 215 no. 8). A grave of the Kassite period at Ur contained a piriform glass bottle (Woolley 1965: 87, 105: U.7660; Barag 1985: no. 6 for dating) and what may be a contemporary black glass rod of nine threads, marked at one end by pincers (Woolley 1965: 79 n. 1; 105: U.7593). On the island of Failaka glass, faience, and glazed pottery were recorded in Kassite levels, with some evidence for production in local workshops (Pollard and Højlund 1983; Pollard 1987). From the middle of the fourteenth through the thirteenth century BC cylinder seals in what has been called the Pseudo-Kassite style were often made of glass, as at Tchoga Zanbil (Porada, 1970; see below), whereas the contemporary seals cut in the First Kassite style were made in hard stones (cf. Matthews, D. M. 1992: 6). At much the same time glass, sometimes coloured blue with cobalt, was being used for a restricted range of seals in Phoenicia, including those of the kings of Sidon (Gubel (ed.) 1986, nos. 243-4).

Evidence of a varied glass industry, of the later fourteenth and thirteenth centuries BC, was revealed in the ziggurat area at Tchoga Zanbil in Khuzistan. Long rod-formed tubes made of black (or very dark blue) glass decorated with a white thread were used as decoration on wooden doors (Ghirshman 1966: 30, 65, 74, fig. 20, pls. XXV.1, 4; LII.2-3). Similar tubes are also known from Susa (Barag 1970: 149 n. 88a). Convex glass disks and eye-shaped roundels were used at Tchoga Zanbil to decorate bricks (Barag 1970: 149; Saldern 1970: 216). The existence of active Middle Elamite metal and fai-

ence industries indicates that the local glass industry may have been no more dependent on Babylonia for technological information than they were (cf. Saldern 1970: 208).

In view of the general rarity of glass finds in Babylonia, and in the period from about 1200 and 750 BC in particular, the scattered glass inlays found in the main temple complex at Larsa are of particular interest. At some time during the reign of Adad-apla-iddina (c. 1068-1047 BC) when Rooms 15 and 13, and Courtyard I, were paved, various inlays, predominantly of blue glass, one a beard fragment (Huot *et al.* 1978: 193-4, fig. 27b), another an animal's horn (Huot *et al.* 1983: 209), were being used in the decoration of statuary. If these pieces were indeed manufactured at this time, they go some way to bridging the gap between the flourishing glass industries of the thirteenth century BC and the known return of glass production some time in the ninth century BC. A published analysis (Huot *et al.* 1976: 21-2, 28) indicates a standard Mesopotamian glass, with copper (or possibly cobalt) as the blue colourant.

A review of glass typical of Mesopotamia in the second half of the second millennium BC is not complete without reference to a fragment of distinctive mosaic glass of this period, now in the Freer Gallery of Art in Washington, DC as part of the founder's collection for which it was acquired in Egypt in 1909 (accession no. 09. 604). There seems no reason to doubt the source, particularly in view of its pristine condition, which makes it of unusual interest to students of Mesopotamian glass accustomed to the poor condition of fragments found locally. Its lozenge designs in red, white, blue, and turquoise-blue, though slightly pitted, are as fresh as could be desired. It is slightly concave and measures 2.8 cm. in width (Saldern 1966: 9 ff., fig. 11; 1970: no. 11, fig. 5). It is probably part of a vessel like those found at Tell Rimah.

(c) Revival of glass production (from about 900 BC)

Towards the end of the second millennium BC, in Egypt and the Near East, glass production subsided so much that it appears from present evidence to have all but ceased. Thereafter, for the period before the fall of the Assyrian Empire in western Asia, only two sites at the moment provide archaeological *termini ante quem* for significantly varied finds of glass: level IV at Hasanlu, in north-west Iran, destroyed in the eighth century BC (Dyson and Muscarella 1989; Medvedskaya 1991), and the destruction level in the various major buildings at Nimrud dated to about 614/612 BC. In neither case is a full publication of the glass finds available.

Among the published glass from Hasanlu IV two fragmentary beakers and the remains of a third are outstanding examples of the mosaic glass tradition established in Mesopotamia in the Kassite and Middle

Assyrian periods (Saldern 1966: 9 ff.; 1970: 209 ff., 216-17). Scholarly opinion is divided upon whether they were indeed made in Mesopotamia (cf. Marcus 1991) long before the level from which they were retrieved, or whether they are, for the present, a completely isolated indication that this craft tradition survived into the early first millennium BC, possibly only in western Iran. No glasses of this specific type are known from a Mesopotamian or Syrian site after the second millennium BC. Little has been reported of the other glass found in Hasanlu IV. It is known that no 'Phoenician' ivories inlaid with glass were found there, but some in the 'Syrian' style had inlays, though none has been scientifically identified as glass (Muscarella 1980: nos. 222, 229, 267). Barag (1970: 194, no. 216) reported square moulded shafts of blue glass, possibly parts of furniture, and a bead with a head of an animal(?) made of black glass with white and yellow(?) twisted canes marvered in.

At Nimrud moulded cut-glass fragments are overwhelmingly more common than polychrome core-formed glass sherds in the published record (Saldern 1966; 1970). They mark a number of crucial changes. Traditionally, glass in Mesopotamia had imitated the appearance of opaque, precious and semi-precious stones, not only the blues of lapis lazuli and turquoise, but also the varied colours of banded agates. Now fresh chemical discoveries (see below) allowed for the imitation of rock crystal, which was popular at the time and worked in shapes and decorated by techniques exactly reproduced in glass (Mallowan 1966: fig. 143). Glass alabaster, notably a well-known example inscribed for Sargon II (Saldern 1970: 218, no. 17; Barag 1985: no. 26), small handled jars, hemispherical or similarly shaped bowls, and variously shaped cups, were mould-made in glass, varying from extremely thin to very thick, from practically clear to a pale green in colour. These vessels were ground to shape and polished (Gwinnett and Gorelick 1983; Gorelick and Gwinnett 1986). Some were decorated with cut designs, usually geometric, or, less frequently, incrustated with mosaic glass, or painted. The technical skill required to produce such bowls with thin walls led Turner (1955) and Saldern (1966: 627-8) to speculate on the possibility that the blow-pipe, or another unrecognized process, different from regular moulding, had been familiar to the glass-makers. However, it is probable that a lost-wax casting technique was used.

As there is still no evidence that Egypt had an industry producing cast and cut glass vessels from the XXIV to XXVI Dynasties (c. 724-525 BC), the initial manufacture of these vessels is commonly assigned either to Phoenicia, where, as with core-formed glass, there is again at present no local evidence, or to Assyria itself. Barag (1982: 17 ff.; 1985: 52 ff.) has cogently argued the case for Phoenicia, albeit on circumstantial evidence,

attributing the concentration of finds at Nimrud to Phoenician craftsmen (or men they had trained) active in Assyrian court workshops. He isolated a series of pertinent arguments: glass inlays were used extensively in 'Phoenician' carved ivories and have been found in greater quantities at Nimrud than would be expected to result from their falling out of imported carved ivories (cf. Saldern 1966: 632-3; Barnett 1975: 240); a unique cut-glass bowl from Nimrud is inlaid with a comparable type of mosaic glass (Saldern 1970: nos. 29-30); at least one of the glass bowls from Nimrud has cut designs in a 'Phoenician' style (Lehrer 1974); there are glass plaques from Nimrud painted in the 'Phoenician' style (Orchard and Brill 1978); the 'Sargon Vase' is shaped like Egyptian rock crystal alabaster, more likely in a Phoenician than in an Assyrian craft tradition; the glass jug from Aliseda in Spain, a key artefact in this group of glass, is a typical 'Phoenician' shape, has a debased Egyptian hieroglyphic inscription, and is from an area of known Phoenician contact; and the industry persisted after the fall of Nineveh in 612 BC, when its products are better known from Cyprus and Italy than from Mesopotamia (Saldern 1970: 212).

To what extent the chemical change to clear glass may also be attributed to the Phoenicians or Syrians is at present an open question. In their study of Egyptian faience Kaczmarczyk and Hedges (1983) have argued that if one were to look for a time when antimony oxide might also have been added as a clarifier (bleaching agent) and not solely as a pigment, as was previously the case, it would be the XXVIth Dynasty (c. 664-525 BC). The clear glass from Nimrud was made before about 614 BC; but a moulded glass omphalos bowl placed in tumulus P at Gordion before about 700 BC indicates that this industry, wherever located, was already active in the later eighth century BC (Saldern 1959; Young 1981: 32). Both Young and Saldern believed the Gordion bowl to be of 'Assyrian' manufacture. It may, however, be Syro-Phoenician; possible predecessors may be identified at Sinjirli (Andrae 1943: pl. 56, fig. 165) and Megiddo (Lamon and Shipton 1939: pl. 30: 128, 137; 31: 144). No such glass has yet been reported from Egypt of this date. Although evidence for a local Neo-Assyrian faience industry is sparse, there was extensive production in Assyria of glazed pottery and bricks. This involved the use of lead antimonate to create yellow glazes or possibly (in combination with copper) green ones, so the existence of a local clear glass industry in Assyria by the reign of Sargon II (c. 721-705 BC), if not before, is plausible. Captured Syrian or Phoenician craftsmen might initially have brought the technical knowledge with them from the west and themselves, or their pupils, practised it at the Assyrian court.

The date of the reappearance of core-formed polychrome glass vessels in Mesopotamia has not yet been

established with any precision. Barag (1970: 194; 1985: 54–5) cites grave 119 in the *Merkes* at Babylon as a fixed point. It contained a pointed bottle and a globular bottle and was below the debris of a house said to have been destroyed by Sennacherib's sack of Babylon in 689 BC (Barag 1970: 159–60). Comparable vessels from such sites as Assur, Kish, and Nippur are not so firmly fixed in time and some may date as late as the fifth century BC (Barag 1970: 156 ff.; on a lower dating for the Kish vessels, Moorey 1978: 52). Barag (1970: 155) and Saldern (1966: 632) catalogued only a few sherds of core-formed glass from Nimrud. Two were from the shoulders of cylindrical alabaster, decorated with a wavy thread in white. Core-formed vessels are rarer in Neo-Assyrian palace excavations than in the private graves of this period so far excavated.

There are certain marked typological distinctions between the Late Bronze Age core-formed glass vessels, when the repertory of shapes was relatively limited, and their Iron Age successors. The early craftsmen had excelled particularly in the use of a variety of colours and in skilled treatment of thread decoration. The shapes of the later group show no direct links with the earlier; no open shapes occur and the vessels are smaller than before. The quality of the glass and the skill of the workmanship is also less impressive. The primary glass shapes, pointed bottles, globular jars, and relatives of the alabastron, are those most popular in other materials. Handles, unknown in the Late Bronze Age repertory, now followed the fashion of stone alabaster in being 'duck-shaped' vertical tabs or small loops. So far, outside their homeland, these distinctively 'Mesopotamian' shapes in glass are best known from examples found on the island of Rhodes in seventh-century archaeological contexts (Harden 1981: 52 ff., nos. 78–81; Barag 1985: nos. 48–51).

In the continuing absence of local evidence for Phoenician glass manufacture before the earliest reappearance of core-formed vessels in Mesopotamia, the source of the revived glass industry remains obscure. With a few isolated exceptions glass disappears in Egypt from late in the XX1st Dynasty (c. 1070–945 BC) until the XXVIth (c. 664–525 BC), when stray examples are again known. Even so, well-documented and securely dated glass of the Late Period is rare. The craft does not seem to have been revived locally on an extensive scale until the XXXth Dynasty (c. 380–343 BC) (Cooney 1976: XV–XVI). As there was a persistent tradition of glaze manufacture for baked clay objects in Assyria, as also probably in Babylonia, a local impetus is not wholly out of the question. This view would be strengthened if the glass fragments from Larsa really were of eleventh-century manufacture.

So long as the date of the earliest inlaid 'Phoenician' carved ivories is uncertain, evidence for glass and faience industries in either Syria or Phoenicia in the ninth

century remains oblique. Isolated imports of glass and faience in the Aegean world at this time have been taken to indicate the activity of Syro-Phoenician production centres. Conspicuous amongst such finds are a variegated glass bead, threaded with over 1,000 faience disk beads, in a rich female grave in the Areopagus at Athens (Smithson 1968: pl. 33: 78) and faience objects from Lefkandi in Euboea (Popham *et al.* 1982: 242 ff., pl. 20). The inlaid 'Syrian' carved ivories from Hasanlu IV may also indicate glass production in the ninth century in Syria (Muscarella 1980: 220).

Moulded glass in rich colours was of enduring popularity. Ivories inlaid with monochrome pieces of glass, in imitation of semi-precious stones, were already produced by craftsmen in Syrian workshops active during the ninth century (Barag 1983; Barnett 1982: 14, 44). In this case the glass inlays were secured in a distinctive way with a small depression drilled into the centre of the background, presumably to take an adhesive. Glass inlays are, however, much more intimately associated with carved ivories in the 'Phoenician' style (Barag 1983). These inlaid ivories and a series of small square polychrome mosaic glass tiles decorated with rosettes, have been found particularly at Nimrud (Saldern 1966: 623 ff.), at Arslan Tash (Thureau-Dangin *et al.*, 1931: 138), and at Samaria (Crowfoot and Crowfoot 1938: 56 ff.). As there is no hard evidence for dating any ivories in the 'Phoenician' style (or related glass) before about 800 BC, they are all at present dated after the end of Hasanlu IV, where none was found. Barag (1983) has argued that they may indeed be an innovation of the first half of the eighth century BC. Nor is it clear, once again, whether they were only manufactured in a series of closely associated workshops in Phoenicia, and exported thence to Syro-Palestine and Mesopotamia, or whether, as may well have been the case in Assyrian palace workshops, expatriate craftsmen produced them in foreign centres.

The blue mosaic-glass inlay-plaques decorated with rosettes in white fall into at least two distinct groups. In one case, probably made by the 'cane technique' (see below), the design is visible on both sides; in the other it is only visible from one side so the white petals were probably pressed into the blue matrix in a viscous state (cf. Barag 1985: nos. 53–4). The most elaborate 'Neo-Assyrian' glass vessels combined a multiplicity of techniques, to judge from a fragment found at Nimrud from a bowl made by the lost-wax process with mosaic-glass inlays, cut and painted decoration (Barag 1985: no. 40–40A). The remarkable royal tombs discovered at Nimrud in 1988–9 are reported to contain glass vessels of this quality and type in the early seventh century BC: 'ornate glass jar, inlaid with blue plaques and rows of tiny human figures' (*The Times Review (London)* (25 Nov. 1989), 31). As the designs are typically Assyrian, local manufacture seems probable. They also



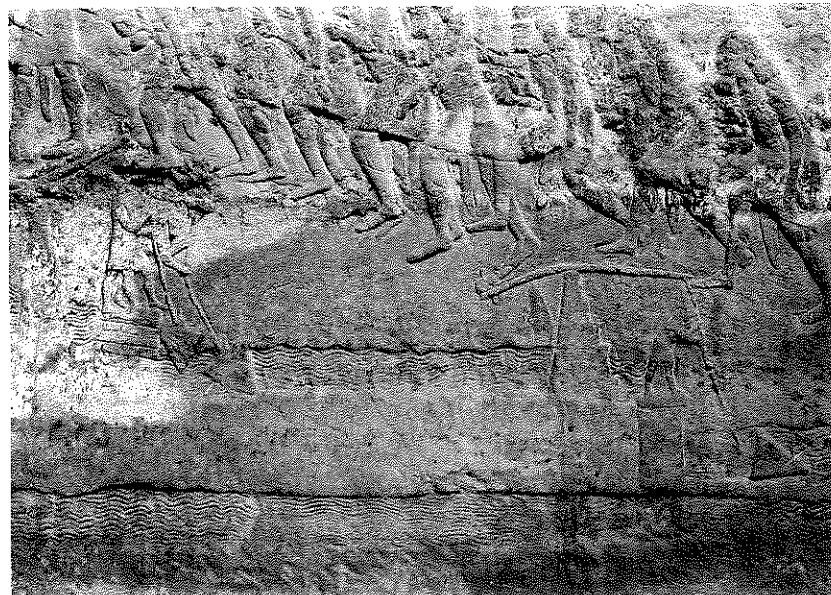
1. A. The ruler as master craftsman: headless diorite statue of Gudea of Lagash (c. 2100 BC) seated with a building plan on his lap; 93 cm. high.



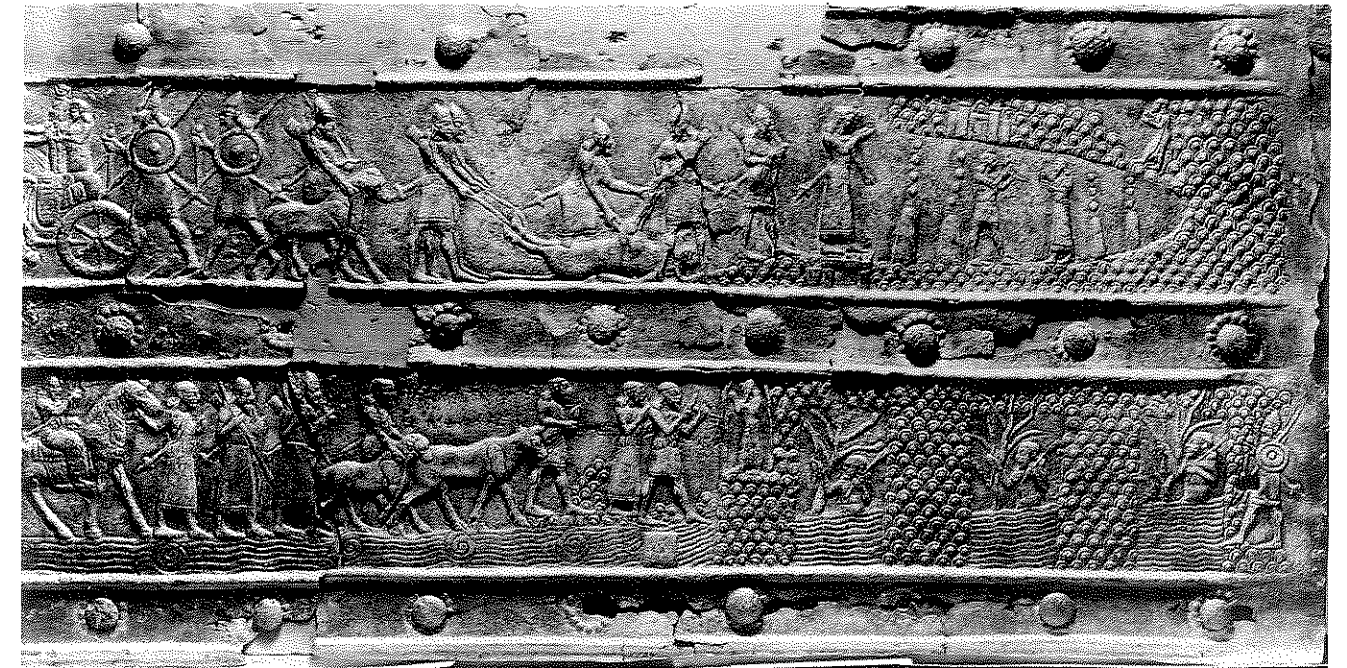
1. B. A carpenter at work using an adze to shape a chair leg; Babylonian terracotta plaque, c. 1900–1700 BC; such representations are extremely rare; 8 × 7.6 cm.



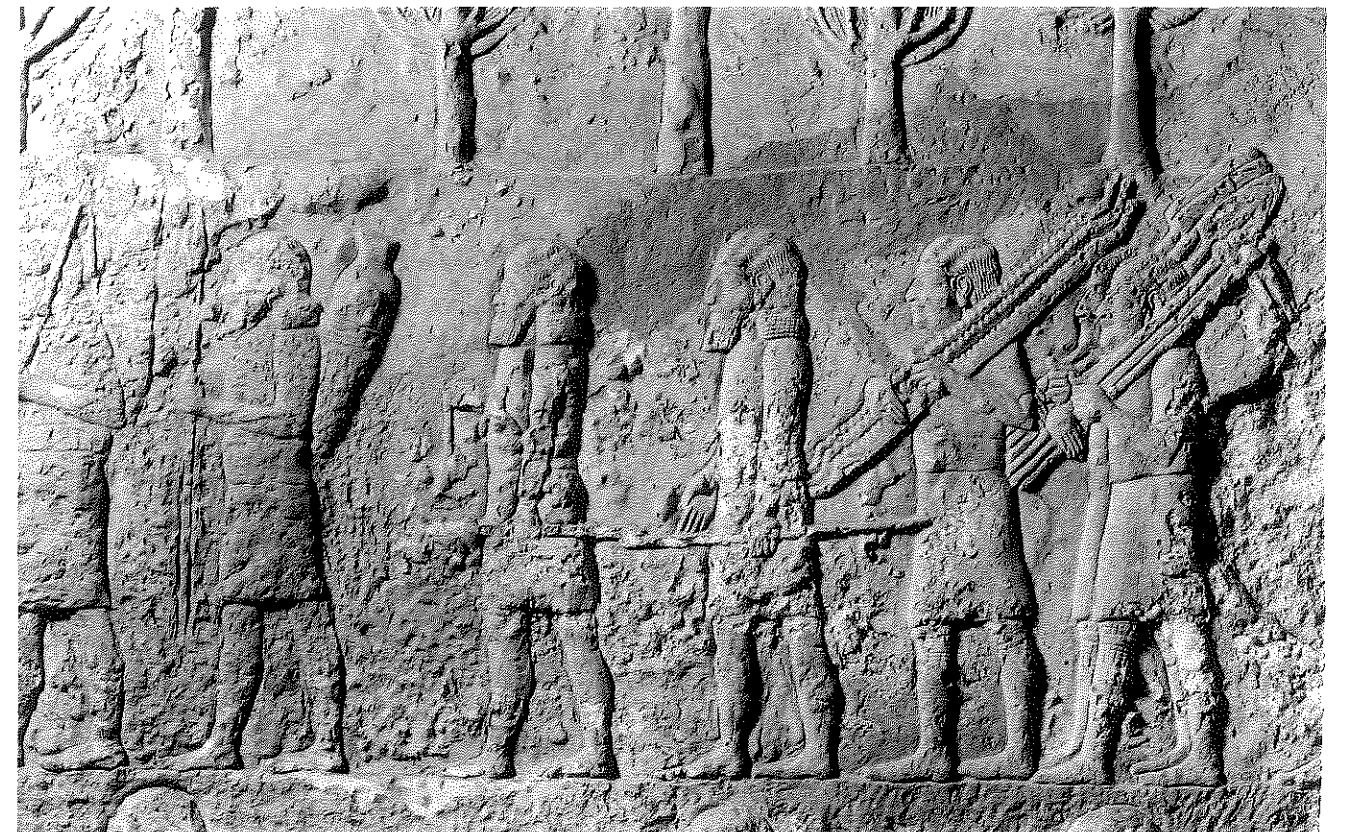
II. A. Mosul Marble relief fragment of the time of Assurnasirpal II (c. 883–859 BC) showing a besieged city; an enemy soldier cuts away the bucket from a wellhead serving the city; 10.4 cm. high; 9.3 cm. wide.



II. B. Mosul Marble relief fragment of the time of Sennacherib (c. 704–681 BC) showing an irrigation system with a shadoof; the men shown above (i.e. behind) are dragging an unfinished sculpture of a bull uphill.



III. A. Part of the bronze overlay on the Balawat Gates, showing an expedition by Shalmaneser III (858–824 BC) to the source of the Tigris. Above, animals are sacrificed and a mason appears to be carving an inscription on rock guided by a scribe with stylus and tablet; below, masons carve a relief of the king in rock overlooking the river; c. 28 cm. high.



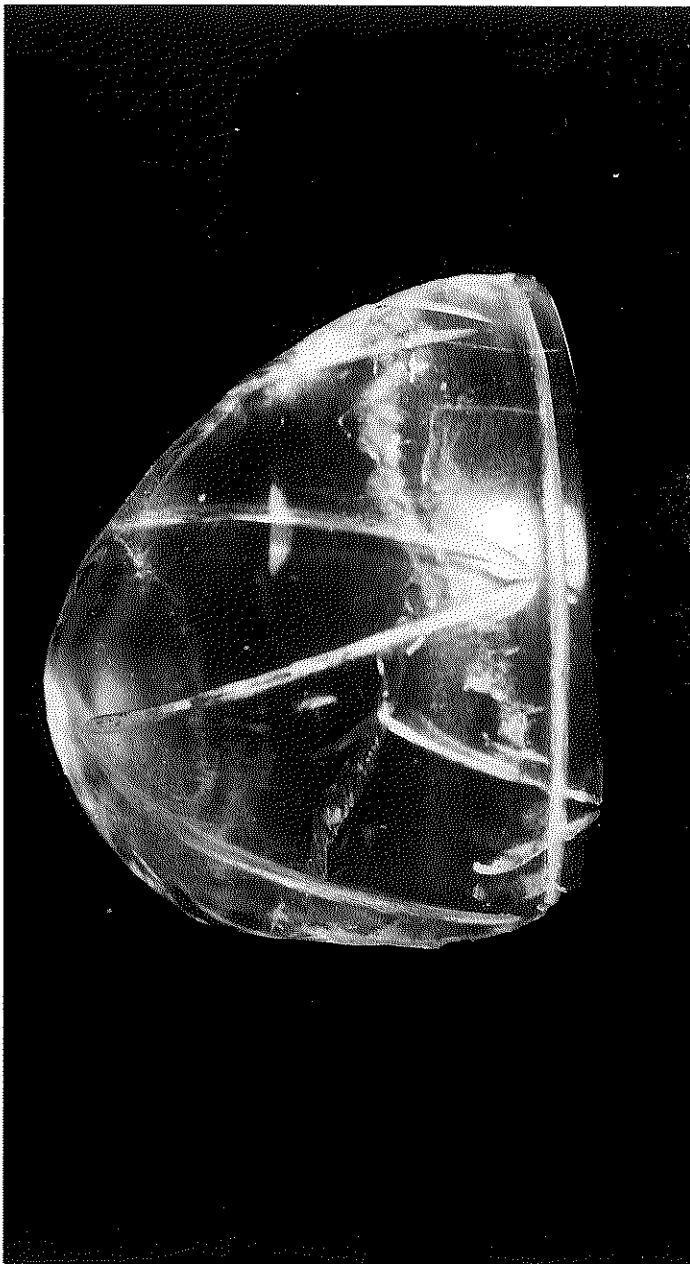
III. B. Fragment of a Mosul Marble relief of the time of Sennacherib showing workmen with iron(?) saws, shovels (or spades), and pickaxes; from a scene of quarrying.



IV. A. Baked clay mould for making a model terracotta chariot front depicting (above) a worshipper and a deity; (below) a man carrying a stool; Babylonian, c. 1900–1700 BC; 17 × 8.6 cm.



IV. B. Fragmentary baked clay Neo-Assyrian relief of a king spearing a lion; sometimes described as a 'sculptor's model'; 29.2 cm. high.



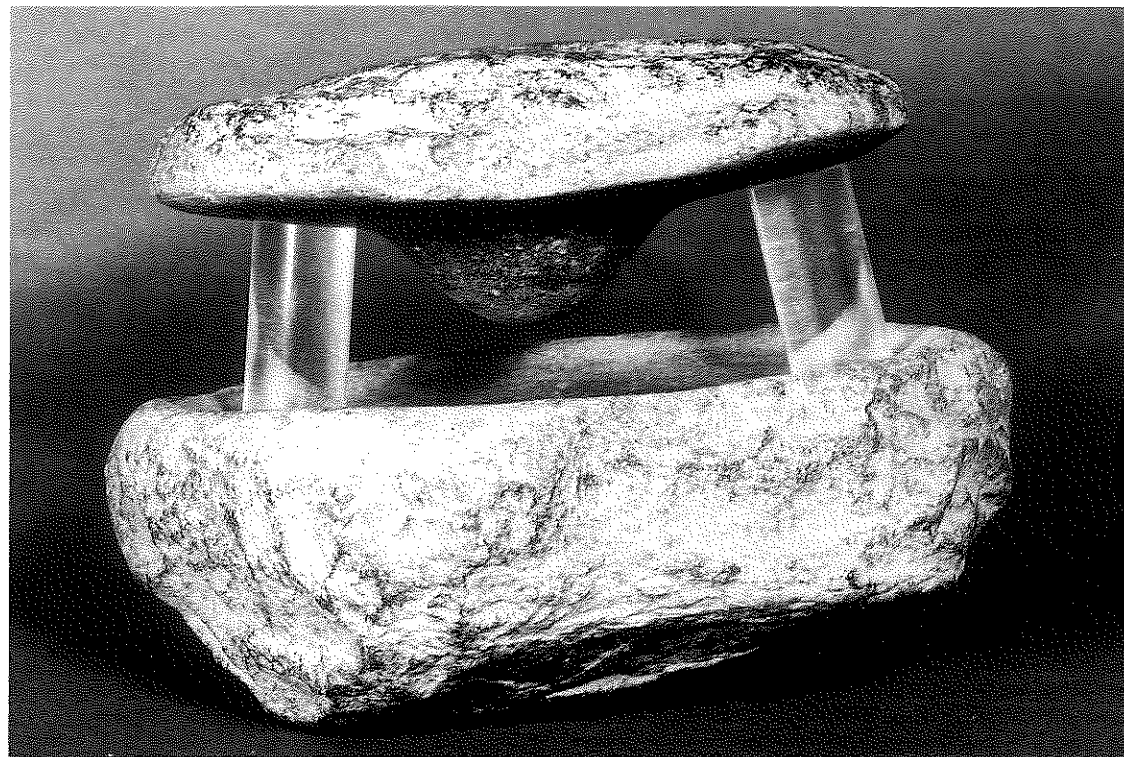
V. A. Fragment of a rock crystal bowl from Nimrud of the eighth or seventh century BC. Such bowls were directly initiated in some of the earliest clear cut-glass ever made; 6 × 7 cm.



V. B. Bowl of altered basaltic lava from Kish, c. 3000–2750 BC; repaired in antiquity with a stone patch held in place by lead rivets; 8 cm. high; 14.5 cm. diameter.



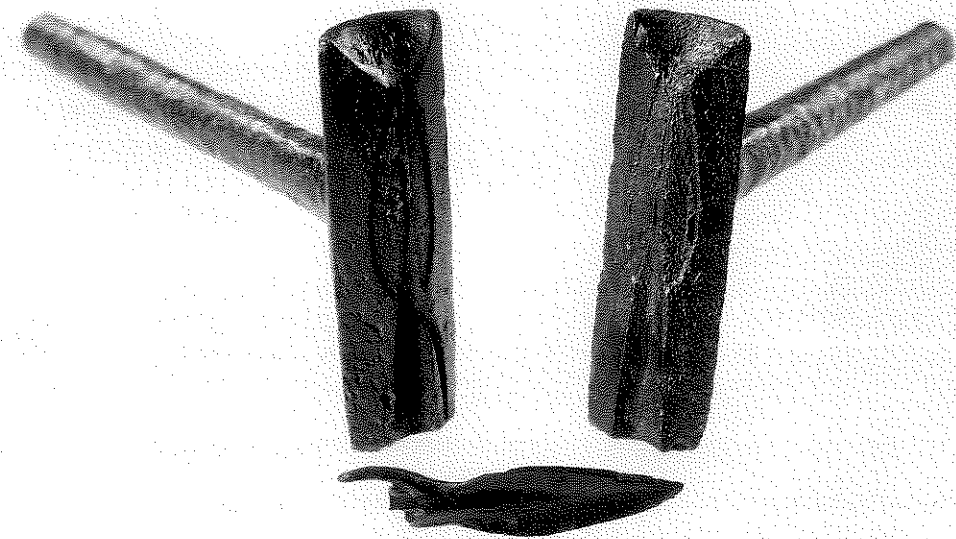
VI. A. Enigmatic schist objects ('The Blau Monuments'), c. 3500–3200 BC, perhaps imitating tools for pot-making or an eraser and a stylus for writing on the earliest type of tablet. It has been suggested that the squatting men are making stone vessels; they may simply be using pestles and mortars; 15.9 cm. and 17.8 cm. long.



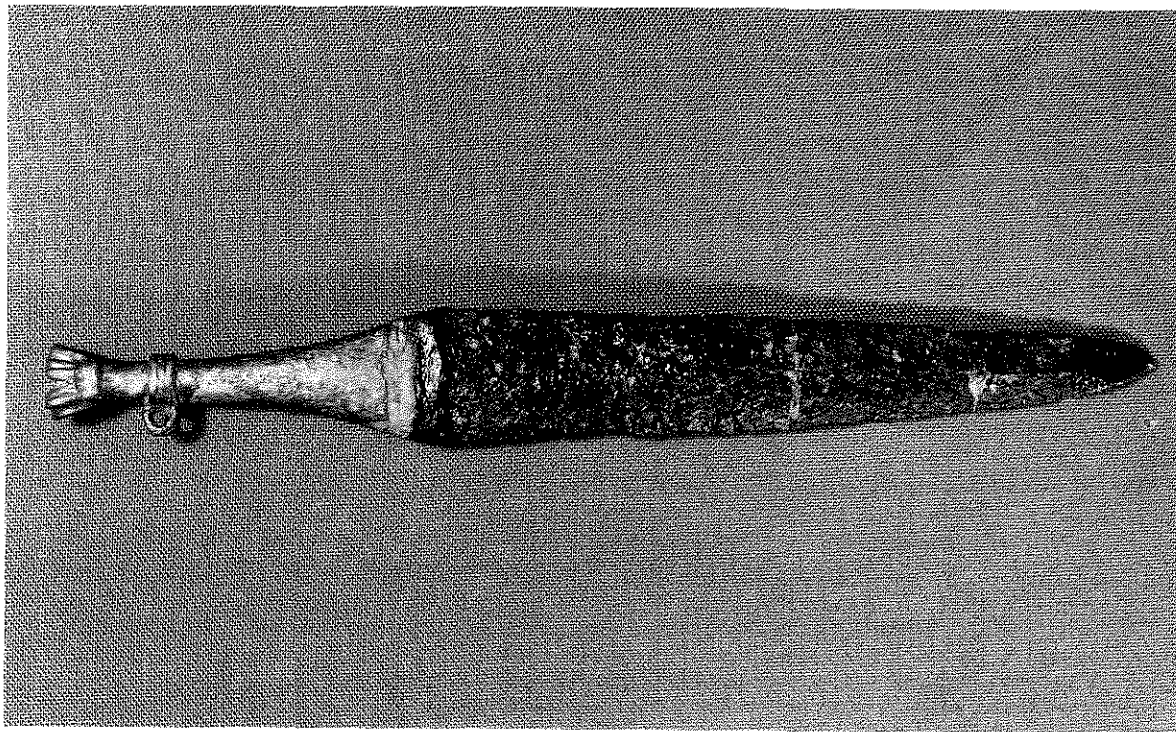
VI. B. Pair of pivoted stones (?granite) from Tell el-Amarna in Egypt, fourteenth century BC. Such stones occur widely in the Near East and were probably part of a turntable used by potters; 18 cm. diameter.



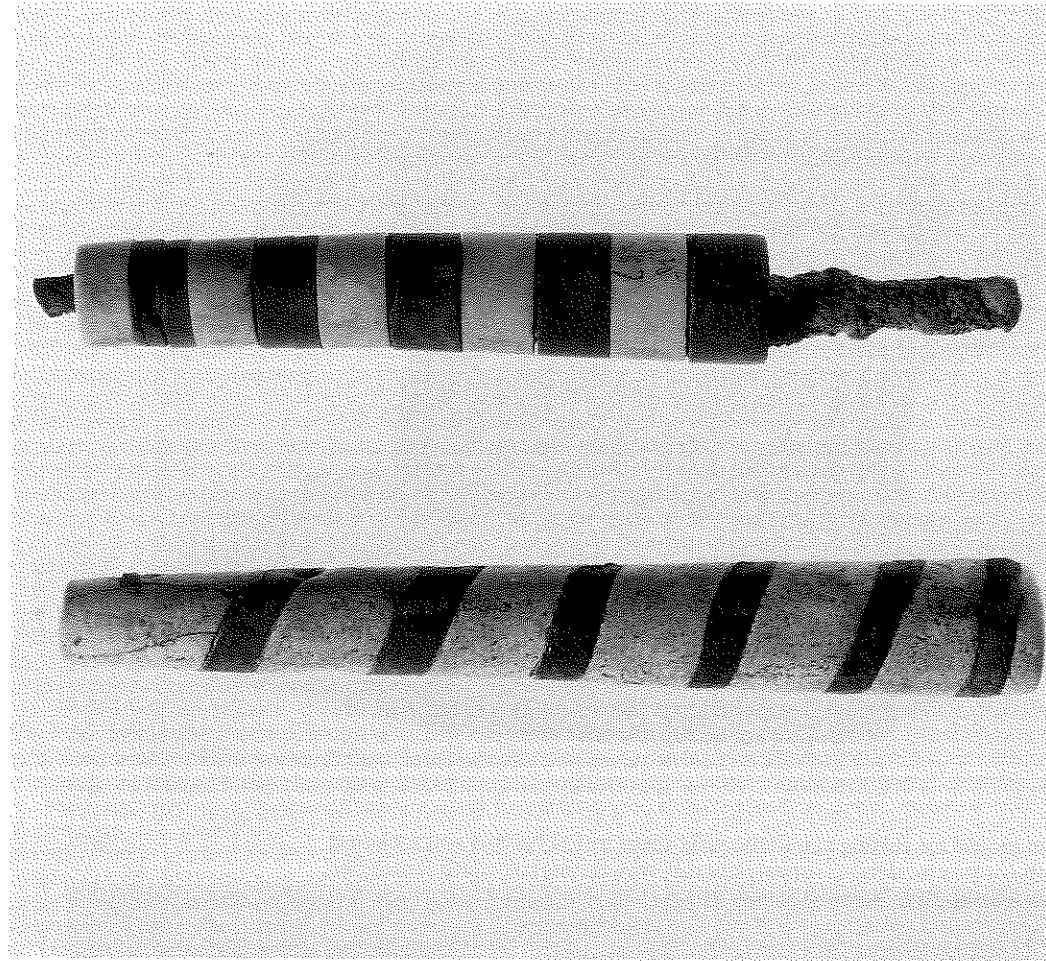
VII. A. Bronze mould for casting simultaneously three trefoil barbed and socketed arrowheads (or wax models for subsequent lost-wax casting); seventh century BC; acquired at Mosul, 8 cm. high. (see also fig. 18)



VII. B. Two of the three segments of a bronze mould for casting a trefoil barbed and socketed bronze arrowhead; from Carchemish, seventh or sixth century BC; 10 cm. long; 5.8 cm. high.



VIII. A. Dagger with a bronze hilt cast on to an iron blade from Nimrud, eighth or seventh century BC; 27.5 cm. long.



VIII. B. (left) 'Handle' of bluish-green faience spirally striped with black faience, from Kish c. 2500 BC; 13.2 cm. long. (right) 'Handle' of black and white stone rings on a copper or bronze rod, from Kish c. 2500 BC; perhaps the inspiration for the faience version.

contained gold jewellery inlaid with mosaic-glass plaques (Veenhof 1992: 22, colour plate).

Throughout the Neo-Assyrian period glass-makers were no less active in producing objects and fittings in opaque coloured glass in imitation of semi-precious stones than their predecessors in Mesopotamia had been. Indeed, it was this particular type of glass manufacture that most concerned the writers of the glass texts found in the library of Ashurbanipal at Nineveh (Oppenheim 1970; see below). Such objects include inlays for composite statuary, notably beard and hair fragments (Barag 1985: nos. 62–9), and attributes for deity statues like mace- or staff-heads, as at Nineveh (Barag 1985: no. 60), Nimrud (Saldern 1970: 224–5, no. 41a), Assur (Haevernick and Kühne 1982), and possibly Babylon (Barag 1985: no. 61). Some were made in moulds, some by the lost-wax process. A tiny translucent dark blue statuette (2.3 m. high) from Ur of a praying man is exceptional (Barag 1985: no. 76).

It is evident from excavations that luxury cast and cut glass, as well as core-formed glass, continued in use in Babylonia in the Neo-Babylonian period, though centres of production remain unknown. Grave 109 in the *Merkes* at Babylon contained a glass *phiale* in greenish glass, the neck of a bottle in translucent blue glass, and a core-formed jar in opaque white glass ornamented with blue circles with central reddish-brown dots (Reuther 1926: 209–11, pls. 65e, 66, fig. 107; Saldern 1970: 212, 226, no. 46, fig. 41). A cast, cut-glass bowl fragment from Ur (Woolley 1962: 110; U. 791; Barag 1985: no. 43) closely resembles a stone bowl. As the core-formed polychrome vessels of this period are typically Mesopotamian in shape and style, local manufacture is commonly assumed.

In Mesopotamia during the Achaemenid period (c. 550–320 BC) the isolated finds of clear or engraved glass (cf. Nippur: Barag 1968), still very much a luxury, are known to be a regular product of workshops serving the Achaemenid court and aristocracy. They were made in a standard repertory of forms, usually copying the shapes of tableware manufactured in precious metals (Oliver 1970). Finds from Persepolis illustrate the range of this internationally available glasswork (Schmidt 1957: pls. 66–7). Whether it was only produced in a few centres closely associated with royal residences, or more widely, is unknown.

Core-formed polychrome glass vessels (Barag 1970; 1985: 57–9) were probably still being made in Mesopotamia in the later sixth and fifth centuries BC. This is also the period when workshops somewhere in the East Mediterranean region emerged as producers of a distinctive range of core-formed polychrome vessels that were widely traded (Harden 1981: 52 ff.). Only one type of vessel made at this time appears likely to be from glass workshops in the eastern rather than the western Achaemenid Empire. This is a group of poly-

chrome glass, rod-formed, kohl-tubes, of a distinctive square-faced, tapering form (Barag 1975). Also in this period personal ornaments, amulets, and some seals, were made of glass to standard patterns. They are so widely distributed throughout the Achaemenid Empire, and beyond its frontiers, that it is impossible to isolate regional traditions. At this time distinctive 'eye-beads', produced in Western Asia, reached as far as China (cf. Taniichi 1983). Only in the case of cylinder seals and conoid stamp seals is it possible to define a concentration in Syro-Phoenicia and suggest that they were a local phenomenon (cf. Buchanan and Moorey 1988: 75; Barag 1985: nos. 92–106).

It is clear from the data assembled in this historical survey that glass was intentionally manufactured in Western Asia from at least about 1500 BC, in a number of shapes and by a variety of techniques, using various colours. A trend is broadly discernible, moving from opacity, in imitation of semi-precious stones in the later third and second millennia BC, to translucency and transparency, by the second quarter of the first millennium BC, though the earlier tradition also persisted for some time longer. Techniques, whether in core-formed or mosaic glass, in the earlier, polychrome stage, emphasized variegated colour effects, whilst it is only in the Neo-Assyrian period that the idea of clear, translucent glass, imitating cut stones like rock crystal, became the primary goal in the workshops of the Assyrian and Achaemenid courts. The colours included blue, notably a turquoise blue, red, yellow, green, brown, black, and white; the transparent colours were blue and purple. The early clear glass is, unintentionally, tinted green or yellow. The shapes of all glass vessels in the period covered here, that is before the invention of glass-blowing, derive from ceramic, stone, or metal prototypes. Beakers, goblets, and piriform bottles were the favourite shapes among the early core-formed, polychrome vessels, whilst various types of pointed bottle, of alabaster, of jars, and finally of juglets, emerged in the first millennium. In moulded glass the bowl became the most popular form in the first millennium BC.

Without direct evidence for places of manufacture, the sources of glass found in Mesopotamia remain controversial. The present pattern of distribution indicates that in the second half of the second millennium BC there were various glass production centres in northern Mesopotamia and in Khuzistan (Susiana); whether this was also true for Babylonia is not quite so clear, though evidence from Aqar Quf, Nippur, Ur, and Failaka suggest that it was. Evidence from cities like Assur, Aqar Quf, Nuzi, and Susa indicates that local glass workshops, within the orbit of major royal or temple building enterprises, served local needs. To what extent there was also an extensive commerce in glass vessels,

or more significantly in ingots of raw glass, from more minor factories is not yet established. If, as seems likely, Syria had its own very active glass industries, Mesopotamian export may only have been into western Iran. The mosaic glass vessels found at Hasanlu and Marlik may be examples of such an export trade. Archaeological finds of second-millennium BC glass in Mesopotamia are still bewilderingly sporadic and random: cane mosaics at Aqar Quf and Tell Rimah; opaque glass maceheads and axeheads at Nippur and Nuzi.

In the first millennium BC, to judge particularly from finds at Nimrud, royal palaces once again had their own glass workshops, employing craftsmen in some cases brought from the west not only to exercise their special skills, but also to train on the spot a new generation of artisans. There are numerous indications that, as in the second half of the second millennium BC, the innovative region in glass technology was to the west of Mesopotamia. But many key questions about innovation and diffusion remain wide open. Even if it is possible to suggest the possibility of two key glass-making traditions in the earlier first millennium BC, which might be distinguished crudely as 'Syrian' and 'Phoenician' (the former more closely linked to Babylonia by the Euphrates), it is still not possible to isolate with confidence their respective roles. The chronological distinction in the activity of ivory and metal workshops in these two regions, argued by Winter (1977), is in itself debatable. It is possible that glass manufacture revived earlier, and ceased sooner, in Syria than in Phoenicia; but hard evidence for such a conclusion is still awaited. Significant chemical changes in the composition of glass in the early first millennium BC are also likely to be of Syro-Phoenician origin (see below).

Although it falls outside the chronological range of this survey, evidence adduced by Adams (1981: 211–13) for glass production in the Sasanian period has implications for what might be expected in earlier periods when minor glass production centres are sought:

let me call attention to the series of sites specializing in glass manufacture along a newly dug Sasanian canal north-west and north of Uruk-Warka . . . The scale of what can only be described as industrial production there is suggested by mounds hundreds of metres long that apparently are composed mainly of glass slag. Numerous glass furnaces also can still be seen in place. To understand the resource base that led to such specialization, it is worth noting that in late Sasanian times the area south of this canal line probably had begun to include extensive swamps. Here would have been found large accumulations of snails as a source of calcium carbonate . . . Suitable water-laid sand might also have been supplied locally. Finally, naturally occurring plants in the same area are reported to be a source of sodium carbonate. There is little to suggest that these sites were extensively involved in fashioning glass vessels from the raw material they pro-

duced in such quantities. But the important point is that, in difficult terrain at a great distance from the main centres of administration and consumption, a large-scale industrial operation went on (probably into the Early Islamic period) that implies a fairly high degree of economic integration not merely in the cities, but extending throughout the countryside.

Even on a marginal site near Ur in this period there were 'glass sherds and glass cullet' (H. T. Wright, in Adams 1981: 335).

(ii) TECHNOLOGY AND COMPOSITION

(a) Workshops and furnaces

Evidence for local glass manufacture remains extremely rare in the archaeological record and, when found, is often of equivocal significance. In the area of Rooms 6 and 7 in the 'Mitannian Palace' at Tell Brak (Oates, D. 1987: 182; 199) the recovery of large and small ingots of glass as well as fragments of glass suggested to the excavators that this was an industrial area rather than the kitchen originally identified there. Fragments of segmental glass ingots, cast in concave crucibles, in dark blue glass, were found at Kar-Tukulti-Ninurta (Barag 1970: no. 171) and at Nuzi (Barag 1970: 140–1, no. 19, fig. 16), in contexts of the fourteenth to thirteenth centuries BC; but they do little more than indicate the wide currency of glass in this form. An enigmatic fragment of a vessel misfired in production was found at Ur; but its date is uncertain as the context was not reported. This piece of a polychrome pedestal glass vessel (5.7 × 4.3 cm.) from the 1930–1 season of excavation is now in the University Museum, Philadelphia (31–43–480; Ur no. not recorded). The 'cup' of the vessel is of blue glass with festoons of white and yellow; a bossed collar separates the cup from the pedestal, which has white lines on a dark ground.

Debris from a glass workshop was reported by Mallowan at Nimrud, where 'on the south side of room 47 [of the Burnt Palace] there were traces of kilns and a glassmaker's kit, including one specimen of sealing wax red glass, probably from a crucible' (Mallowan 1966: 209–10). In 1952 Mallowan deposited with the British Museum Laboratory 'ingots of opaque red glass then covered with a thin green weathered layer . . . Associated with the glass were runnels of bronze metal, fragments of magnetic iron oxide mixed with lead alloy and ferric oxide, a sintered cake of iron oxides and siliceous material and some charcoal' (Bimson 1987: 169). The revised British Museum Carbon-14 dating of the charcoal offers a most probable range of 860–740 BC (59 per cent probability) and 440–380 BC (16 per cent probability) (Freestone: personal communication, 1988). It seems then that Mallowan's original dating of this working debris to the Neo-Assyrian period, rather than later, is likely to be correct (cf. Mallowan 1954: 77,

82–3). This is to some extent reinforced by the strong similarity between the composition of the red glass and of comparable glass from Toprak Kale (cf. Barag 1985: no. 75; analysis in appendix 3).

There is other industrial debris from glass-making in the Neo-Assyrian levels of Mallowan's excavations at Nimrud; but none of it offers any coherent information on working methods. Two disks of opaque blue glass had probably been formed in rough moulds, whilst at least two pieces of blue cullet, or unshaped fused glass, to be used as raw material were also recovered (Saldern 1966: 633; 1970: 223, no. 37; cf. analysis in Turner 1955: 67).

The British Museum collection contains other glass ingots of first-millennium BC date. From Rassam's excavations at Dilbat (Dulaim) came fragments of dark red to orange glass ingots (Barag 1985: nos. 168–70). They are parts of large, heavy disks with straight edges, probably cast in dish-like crucibles some time between the eighth and fourth centuries BC. A translucent dark blue rectangular glass ingot from Kuyunjik, likely to be Neo-Assyrian, is comparable to an example from Persepolis (Barag 1985: no. 172). Other lumps of glass from Kuyunjik and Abu Shahrein (Eridu) may be pieces of ingots or at least debris from local glass-working (Barag 1985: nos. 182–5). Glass canes are reported from Ur (Woolley 1965: 105; Barag 1985: no. 177) and Babylon (Barag 1985: nos. 173–6).

In the absence of the evidence of early glass factories, it is generally assumed, as at Tell el-Amarna in Egypt, that an open-hearth system was used, with shallow crucibles supported on heat-resistant drums. As no really high temperatures would thus have been possible, the glass would generally have been worked in a pasty state (Petrie 1894: 25 ff.; Vandiver 1982a: 77). But in the glass texts (see below) studied by Oppenheim (1970: 69 ff.), of the later Neo-Assyrian period (though probably incorporating sources going back at least to the Middle Assyrian period), three types of kiln-like structures are mentioned. They are never explicitly described. The *kūru*-kiln, with four fire openings ('eyes'), was used for fritting and sintering. It had a lower part or 'fireplace', possibly constructed so that flames might rise through a pierced floor to the main furnace. This seems to be a special type of kiln, because the introduction to the texts refers to 'kiln for glass (making)'; its Sumerian designation indicates that it was provided with bellows to obtain the required high temperatures with a wood fire. There was an alternative type of *kūru*-kiln 'with a chamber', which could be closed with a 'door'. Such kilns were evidently used as melting furnaces, for founding glass, perhaps a reverberatory furnace in which the flame is forced back upon the material exposed to it. The *atūnu*-kiln was brought into use for prolonged firings of up to a week and involved use of 'moulds' rather than the standard 'cruc-

cibles'. The texts speak of 'stands' within the kilns and slabs of baked clay upon which primary glass was cooled and then ground up for further processing. Tongs ('lifters'), rakes ('turners'), and tools for handling the hot crucible are listed. Mention is made of different types of crucible and a mould in which glass was heated and reheated in successive stages from fritting to final colouring.

The texts mention consistently high temperatures to be held over long periods; they indicate how the boiling glass should be tested for viscosity; and the complex stages of grinding and firing required to produce the desired opaque, coloured glass. In common with glass-makers until modern times, when chemical reactions could finally be analysed and controlled, they appear to use redundant materials and excessive care, simply because they could not distinguish precisely the effective from the ineffective.

(b) Mixing and melting

There is no ancient textual evidence from Mesopotamia describing the manufacture of glass artefacts. Artists (Labino 1966), scientists (Schuler 1959, 1959^a, 1962) and, regrettably, forgers (cf. Goldstein 1977), have attempted to reproduce ancient forms and techniques, sometimes just for the end-product itself, sometimes as a means of elucidating ancient technology. The comparative study of contemporary primitive glass-making has also made significant contributions in the hands of Wulff (1966) and Charlesworth (1967) to modern study of ancient glass production methods.

The mineral raw materials used in glass-making are generally in the form of oxides. The 'batch', from which the manufacturing process begins, normally contains a glass former (the sand), a modifier (soda or potash), and a stabilizer (lime). In many industries it may also contain 'cullet', i.e. excess glass from previous production. Then, as required, other ingredients are added: colourants; opacifiers; decolourants. The ingredients are mixed together and heated in a furnace (see above). At about 1400°C the entire mixture fuses into a viscous liquid. The temperature is then held steady for some hours; it is lowered (to 1100–1300°C) towards the end of the operation to raise the viscosity of the batch so that it is ready for manufacture into artefacts. This has to be a relatively quick process, at most a matter of minutes, as the cooling glass changes rapidly from a highly viscous liquid to a solid.

(c) Forming processes

Free-modelling. This, the simplest of techniques, does not appear to have been used very much in the ancient Near East, as free-modelled and tooled objects are rarely encountered in Mesopotamian excavations. Small birds from Nuzi stratum II (Vandiver 1982a: 77 ff., fig. 4) are good examples of the technique.

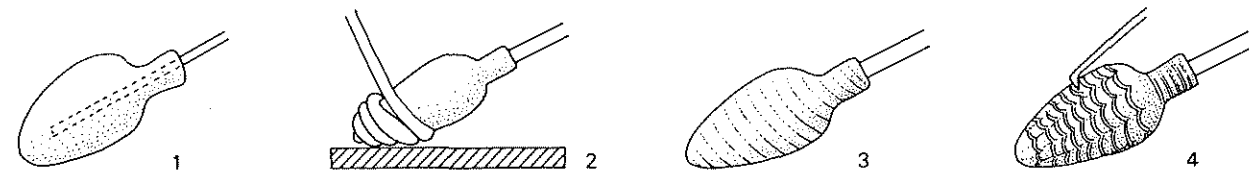


Fig. 13. Stages in the manufacture of a core-formed glass vessel of the later second millennium BC.

Core-formed. So far as present evidence goes, core-forming was the earliest method for the manufacture of glass vessels (Barag 1970) and remained until the Parthian period the most common for small bottles and other glass containers. It may have derived directly either from techniques for forming sintered quartz vessels on a core or simply from glazing pottery vessels, though the priority of that technique over glass vessel-making has yet to be firmly established. With the discovery that sand had not been a major constituent for the core, the traditional term 'sand-core' was dropped (Bimson and Werner 1969). A core of clay and dung was made first and round this the craftsman trailed the glass (cf. Goldstein 1979: figs. 1–4), again perhaps following, if only broadly, techniques by then standard in faience vessel-making. As the ancient craftsman was probably working with temperatures lower than those available under modern conditions, the viscosity of the glass would have been higher and he is unlikely to have dipped his core into a pot of glass as has often been suggested. However, any modern reconstruction of ancient work-procedures must allow for many variations. The need for constant reheating would have required many stages in the production (Harden 1969: 50; Goldstein 1979: 27–9). Wall thickness and the smoothness of the vessel's surface were controlled by rolling the glass-covered core across a flat surface (marvering). Various techniques were used in decoration. The most common was the application of different coloured trails, usually marvered into the surface, but sometimes left in relief. Handles and foot-rings were then added; if appropriate, rims were trailed on and then fashioned to shape. Preformed rods or canes of glass were also applied to core-formed objects.

Rod-formed. Beads were formed on a rod, at times coated with a clay core, trail-decorated, if required, and then tooled. This is well illustrated by finds at Nuzi (Vandiver 1983: fig. 3). The glass tubes for architectural inlays from Tchoga Zanbil in Khuzistan in the thirteenth century BC were also made in this way. One still retains the metal rod, presumably because the maker was unable to extract it (Ghirshman 1968: pl. L: 2). Some kind of separating agent would have been needed on the metal rod. Goldstein discounts the suggestion that it was lime (Goldstein 1979: 28); Vandiver has proposed a 'parting layer of calcite and clay' (Vandiver 1983: 242). A series of rod-formed kohl-tubes was

manufactured in the eastern Achaemenid Empire (Barag 1975).

Mosaic glass. It has been suggested that the mosaic glass technique was evolved some time in the middle of the second millennium BC from experiments with the rods and trails used by contemporary core-glass makers. In so far as the chronology of the process is at present understood, the earliest vessels were made from sections of monochrome cane, though a fragment from Aqar Quf, which may be older than the Tell Rimah vessels, is made of a cane consisting of three concentric colours: a blue centre with red surround in a white border (Harden 1969: 50, fig. 2). Goldstein (1979: 30–1, figs. 5–7) admirably summarizes and illustrates the probable procedures of manufacture. He explains how preformed canes of glass would be cut into the required lengths for the mosaic pattern. The cane-sections would then be assembled over a solid core, presumably with a binder or adhesive, and then enveloped in an outer mould (cf. Saldern 1966^a). The mould would then have been heated slowly to fuse the canes without allowing them to become so hot that the design was lost. This would have required a sophisticated knowledge of the properties of various glasses. Once the canes had been fused, the mould would be removed, the glass surface cleaned and maybe polished. There was much scope for damage and error; but only the excavation of a glass factory will reveal the details of this procedure with which it was possible to achieve remarkable designs incorporating geometric and floral devices, animals and figures. Occasional marbled patterns evoke veined stone vessels (fig. 14).

Moulding and casting glass. Moulding techniques had been developed over centuries for the production of small faience objects and the same methods were used for glass pendants and amulets from early in their history. Pendants and inlays were cast in simple open moulds; ground and polished after removal from the mould, which would have been put into the kiln for the glass to be fired in it. Casting in piece-moulds would have been a much more complex process, for which analogies with metal-casting are misleading. At the temperatures used in antiquity the glass would not have flowed into a complex mould as did molten metal. Schuler (1959) has proposed methods for mould-casting glass that would have overcome this problem. In his reconstruction the mould, as it was heated in a furnace,

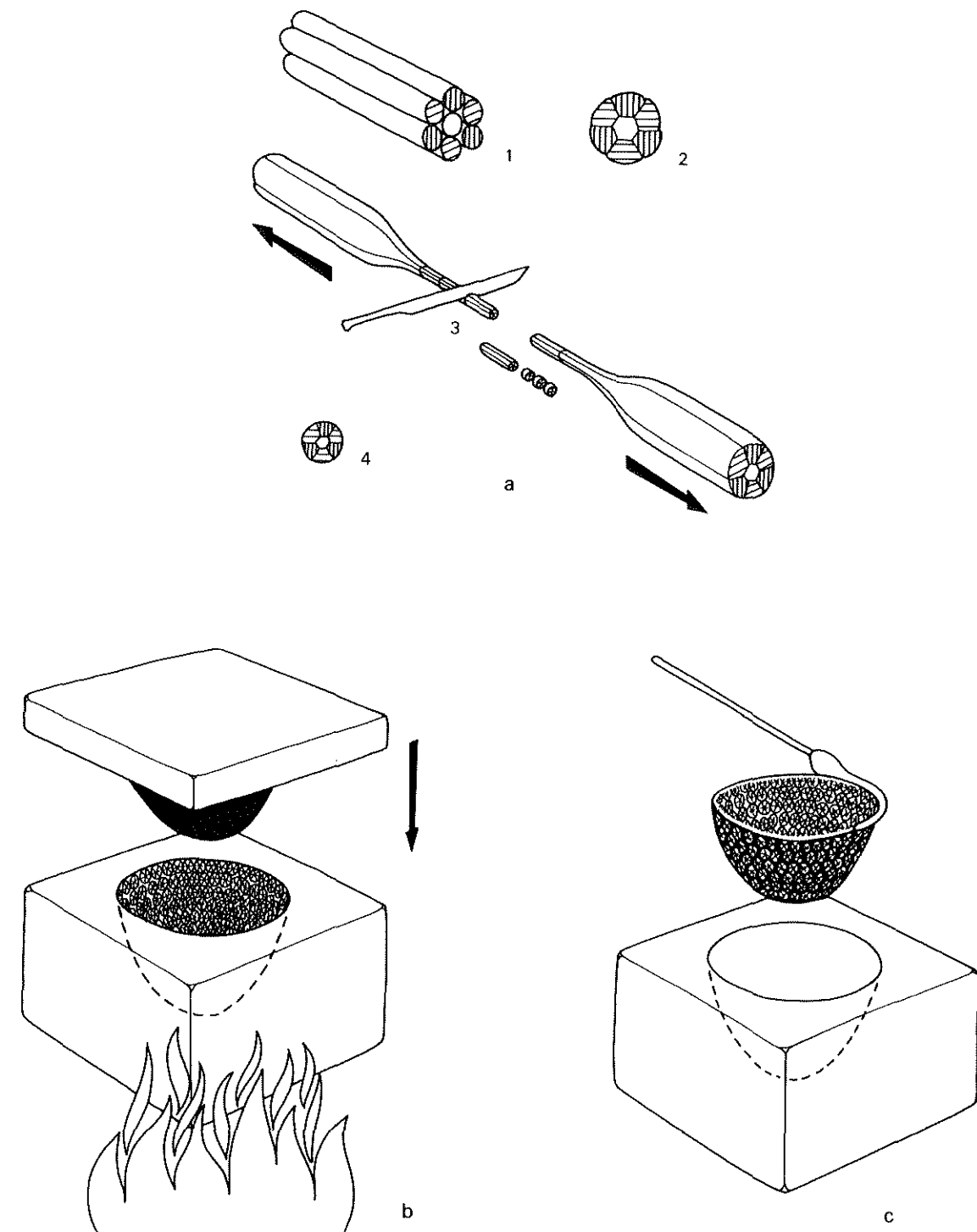


Fig. 14. Diagrams to illustrate the manufacture of a mosaic-glass vessel; later second millennium BC (after drawings by Paul Seiz, in Goldstein 1979: figs. 5–7):
(a) Fusing, drawing, and cutting canes.
(b) Arranging canes in a mould and heating.
(c) Removing a bowl from the mould, trailing on the rim, and reheating before final grinding and polishing.

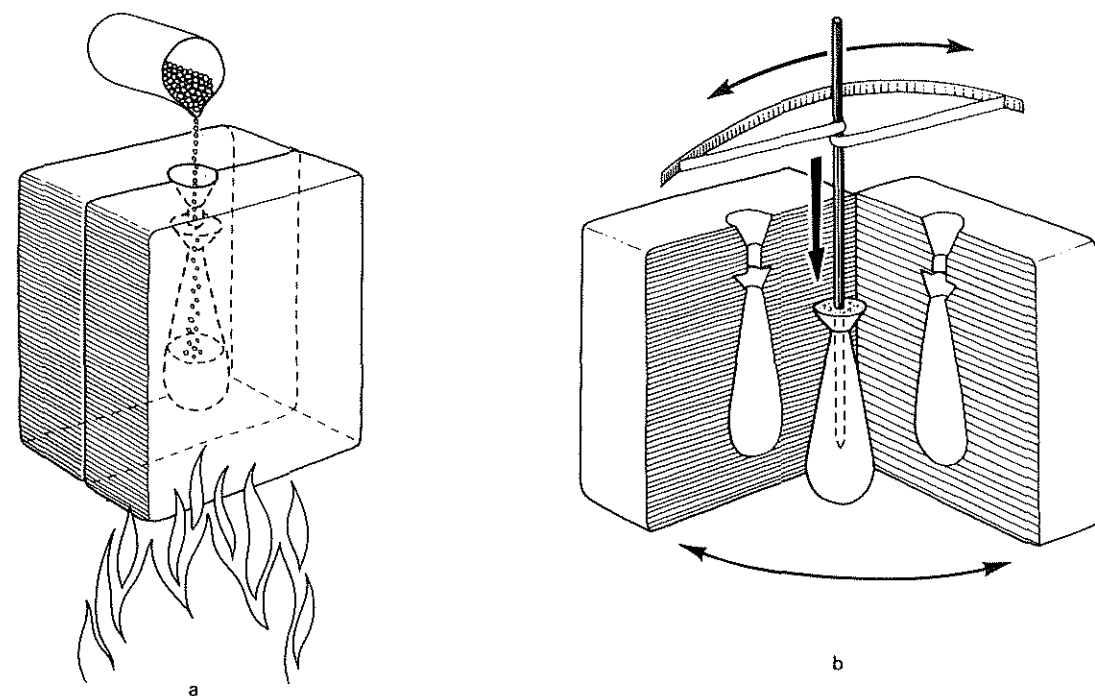


Fig. 15. Diagram to illustrate the technique for casting the blank of a glass vessel to be worked as if it was of stone (earlier first millennium BC) (after drawings by Paul Seiz, in Goldstein 1979: figs. 9–10): (a) Casting: heating mould and continuously adding crushed or powdered glass. (b) Blank removed; ready for drilling and polishing.

was continually filled with ground or powdered glass.

For more complex vessel shapes and for elaborately decorated inlays, such as beards and wigs, the lost-wax technique was probably used to make the moulds (cf. Schuler 1959: 49–50).

Cold-cutting. This was a technique in which glass was treated in the same manner as stone had been for millennia. As glass is slightly softer than the harder stones like quartz or flint, cold-cutting or grinding was possible both for finishing glass objects, first roughed out by casting, or for working a vessel from a block of glass just as a stone vessel would have been made. Examples of the first process are known in Mesopotamia from the later second millennium BC; but the latter is not evident until the next millennium in Assyria. It has been suggested that the famous 'Sargon Vase', of the late eighth century BC, was produced by cutting, grinding, and polishing. A lump of glass, approximately 10 cm. high by 7 cm. in diameter, was first prepared. The block was of reasonable uniformity, obtained from well-melted glass and subsequently slow-cooled to avoid shattering. It was then worked exactly as a stone alabastron would have been (Saldern 1970: no. 17, fig. 17; Barag 1985: no. 26). However, it has also been argued that a lost-wax method could have been used for the basic shaping and only the finishing done by grinding and polishing.

None of the excavated examples of Neo-Assyrian cast, cut, and polished glass has yet been the subject

of a thorough technological examination; but Gwinnett and Gorelick (1983; Gorelick and Gwinnett 1988) have published their investigation of an unprovenanced vessel of this type in the Corning Museum of Glass. This vessel is at present attributed to a workshop in Syria or Assyria in the eighth or seventh century BC, though it might be of the Achaemenid period. They demonstrated that the drill holes in the two lug-handles were probably made with a copper drill pre-bonded with an abrasive; an instrument evident considerably earlier in the manufacture of cylinder seals. No evidence survived to show whether a solid core drill or a hollow core bit had been used. The inner surface showed that original horizontal ribs produced by drilling had been polished in a vertical direction, perhaps with an abrasive used with cloth or leather. There was no trace of the use of a lathe; the regular grooves were probably made with abrasives manipulated by hand.

(d) Composition

Today the commonest commercial glass is made by heating together a mixture of such materials as sand (c.75 per cent), limestone (c.10 per cent) and soda (c.15 per cent), at a very high temperature, to form a liquid. When this liquid is taken from the furnace, it stiffens rapidly as it cools, until at about 500°C it resembles glass as generally understood. The soda acts as a flux and the limestone as a stabilizing agent to give

a durable glass. Other oxides, such as aluminium and magnesium, are also usually present; the former improves the chemical durability and reduces the tendency of the mix to crystallize, whilst the latter decreases the solubility of the glass. Soda-lime-silica (SLS) with a relatively high proportion of magnesium (MgO), known as HMG glass, was that most widely used in the Near East. The other common composition has potash replacing soda as the fluxing agent. Potash (K_2O) assists in making a glass that hardens more rapidly and at a higher temperature; but is less suitable for the moulding techniques used in antiquity. Lead oxide (PbO) is also a good modifier, providing glass of low softening temperature and high density.

There are two sources of information on the composition of the glass excavated from ancient sites in Mesopotamia: that provided by modern methods of scientific analysis, which is still meagre, and that derived from the cuneiform records, assembled and critically studied by Oppenheim (1970), which are full of obscure terminology. All the analyses of ancient glass undertaken between 1790 and 1957 have been assembled and critically assessed by Caley (1962). He pointed out a number of general conclusions emerging from the narrow data base available to him for Mesopotamian glasses: the magnesia content was so high that these may properly be called soda-lime-magnesia glasses; differences in the ratio of alumina to silica might be due to a contrast between the quality of quartz sand used in Assyria and Babylonia; the ratios of magnesia to lime were decidedly higher than in contemporary Egyptian glass; generally the same colouring agents appear in Mesopotamian as in Egyptian glass; a mixed soda-lime-lead type of glass had appeared in Mesopotamia by at least the eighth century BC. Caution is necessary with some early (and current) analyses, since weathered specimens were analysed, *faute de mieux*, and errors thereby introduced.

The flow of information in recent years has much increased; but not as significantly as in other aspects of glass studies, since suitable samples of Mesopotamian glass are not readily accessible to scientists for analysis. Garner's (1956) analysis of the early Eridu fragment (see above) was an isolated piece of research. In 1969 Brill, in reviewing scientific investigations of ancient glasses, brought forward his own work on glass from Tell Rimah and from Nimrud as part of the survey. He pointed out the potential of such techniques as lead and oxygen isotope analysis for characterizing early glasses and, more particularly, for grouping glasses. This had been the intention of the pioneers using chemical analysis; but for the moment the available information is too meagre, uneven, and scattered to make any real and reliable contribution to source studies.

Most progress has been made in the study of composition, notably in establishing the identity of colourants,

opacifiers, and clarifiers. In 1963 Sayre published a major study demonstrating that both antimony and manganese had been used intentionally as colourants or opacifying agents in glass manufacture long before they were used as decolorants. He produced the first indication that in the time of the Neo-Assyrian Empire, by at least the seventh century BC, the role of antimony as an oxidizing agent was well appreciated (Sayre 1963: table III). Antimony changes the state of oxidization of the iron in the glass mix from the ferrous state (a pale green tint) to the ferric state in which iron causes only a pale yellow shade and yields an apparently colour-free glass. More recently Vandiver (1982^a, 1983) has published analyses of glass from Nuzi; Brill (1969) and Pollard (1982) of that from Rimah; Pollard (and Højlund 1983) of that from Failaka; and Brill (1969; 1970; 1978) has contributed particularly to studies of glass from the Neo-Assyrian levels at Nimrud. In 1970, when contributing to Oppenheim's philological study of glass, Brill assembled the analyses of Mesopotamian glasses, by then about twenty of them; but their variety was such that in a comparative table he sought only to describe 'a hypothetical base glass to which additional colorants and colorant-opacifiers as listed separately in the table, would have been added' (see tables on pp. 208).

Vandiver (1983) has published a technical study of the Nuzi glass. Her representative compositions (see p. 209) fall within the second-millennium BC category of relatively high K_2O and MgO established by Sayre and Brill; a tendency to higher $MgO : Ca$ ratios (0.3–0.8) may be explained by the dolomitic lime in local Nuzi clays. The glazes on clay vessels at Nuzi have the same characteristic ($MgO : Ca$: 0.5–0.8). Vandiver (1983: 240) identified three mechanisms for colour formation at Nuzi. In one, solution of ions into the base glass applied: translucent turquoise blue was formed by absorption of colours other than blue by copper ions, requiring melting in an oxidizing atmosphere. In another, precipitation processes operated: red formed by the scattering of light from submicron-size, droplet-shaped particles of cuprite, which precipitate in the glass melt in a reducing atmosphere over a range of temperature. Finally, there was the inclusion of unmelted particles: lead and calcium antimonates for yellow and white which require oxidization and relatively low-temperature melting. Vandiver (1983: 245) suggested that the black and amber glasses were coloured by the sulphur-iron chromophore used today to colour beer-bottles brown.

Kaczmarczyk and Hedges (1983: 287) cited Sayre's complete analyses of five thirteenth-century BC glass samples (2 white; 2 black; 1 blue) and a glazed brick, from Tchoga Zanbil. The white glass was a very pure soda-lime-silicate material without any identifiable opacifier. As the blue glass contained less than 0.02 per

Compositions of Mesopotamian Glasses

	Typical values (and ranges) found upon analysis ^a			Hypothetical 'base glasses' ^b			Calculated composition for zukû per cent ^c	Calculated semi-quantitative composition of a red opaque glass (per cent)	
	per cent			per cent					
SiO ₂	55	64	68	56	66	70	56.0	SiO ₂	40
Na ₂ O	13	16	19	14	17	20	23.8	Na ₂ O	18
CaO	4	6.5	8	4	7	10	6.6	CaO	5
K ₂ O	1	1.5	3	1	1.5	3	3.8	Cu ₂ O	13
MgO	3	4.5	6	3	4.5	6	5.6	PbO	12
Al ₂ O ₃	1.5	2	3	1.5	2	3	2.2	Sb ₂ O ₅	1
Fe ₂ O ₃	0.5	1	1.5	0.5	1	1.5	0.7		
TiO ₂		0.1			0.1		0.05	'anzahhu'	1
MnO		var.			0.02		0.05	Other ^d	10
Sb ₂ O ₅		var.			0.00X(?)		nil		
PbO		var.			0.000X(?)		nil		
BaO		~0.1			~0.1		~0.1		
SrO		~0.1			~0.1		~0.1		
P ₂ O ₅		~0.3			~0.3		1.0		
SO ₃		~0.3			~0.3		~0.5 (?)		
Cl		~0.3			~0.3		~0.5 (?)		

Other elements sometimes found in the range of 0.000X–0.2 in ancient glasses from various sources: B₂O₃, Li₂O, Rb₂O, V₂O₅, Cr₂O₃, ZrO₂, NiO, ZnO, Ag₂O, SnO₂, Bi₂O₃.

^a Excluding red opaques with high PbO contents. Values to left and right of main percentage show approximate maxima and minima.

^b To be modified substitutionally by colourants and colorant-opacifiers.

^c SO₃ and Cl uncertain due to unknown extent of retention.

^d Includes K₂O, MgO, Al₂O₃, Fe₂O₃, etc.

Var. = variables, depending upon colour of glass.

Colourants and Colourant-opacifiers

CuO	1–2 per cent	blue transparent
CoO	0.05–0.2 per cent	blue transparent
MnO	1.5 per cent	purple transparent
Fe ₂ O ₃	2–3 per cent	green transparent
Fe(S) _x	2–3 per cent	amber transparent
Mixture of above	5 per cent	black 'transparent'
Cu ₂ O	~5, ~10, ~15 per cent	red opaque
PbO	0.0X, ~3, ~10, ~20 per cent	
SnO	nil, .X per cent	
Sb ₂ O ₅	.X, 2 per cent	
Ca ₂ Sb ₂ O ₇	(2–5 per cent Sb ₂ O ₅)	white opaque
Pb ₂ Sb ₂ O ₇	(2–5 per cent Sb ₂ O ₅)	yellow opaque
Ca ₂ Sb ₂ O ₇ + CuO/CoO		light blue opaque (turquoise)
Pb ₂ Sb ₂ O ₇ + CuO/CoO		green opaque

Source: After Brill 1970: 122.

cent CoO and less than 0.04 per cent MnO, the colour was produced by copper and iron. Both of the black glasses were coloured with reduced iron and not manganese, as their iron oxide contents were far in excess of the trace amounts of manganese. None of the glasses contained much lead; 0.07 per cent PbO in the blue glaze was the highest. Only one, the blue glass, had a detectable opacifier, 2.2 per cent Sb₂O₅ (cf. Brill 1970: 116 ff.). Neumann (B. 1927; cf. Caley 1962) analysed two specimens of blue glass from Kassite Nippur. One was turquoise-coloured and contained no lead or

cobalt; but its copper was accompanied by some tin (2.6 per cent CuO; 0.32 per cent SnO₂). The darker blue piece was coloured by cobalt, which was accompanied by some manganese (0.93 per cent CoO; 0.65 per cent MnO). As no nickel or zinc was reported, and cobalt exceeded manganese, this was probably Iranian cobalt comparable with that in the Eridu glass fragment.

Pollard (Pollard and Moorey 1982) has analysed some of the Mitannian/Middle Assyrian glasses from Tell Rimah. These samples showed calcium concen-

Representative Nuzi glass compositions determined by microprobe analysis

Oxide	Corning Glass Standard A	Average and range of five analyses	Black glass 30–2–195	Blue opaque glass 30–2–7–1	Blue translucent glass M79/1
SiO ₂	66.40	67.23 (64.97–70.55)	69.71 (68.71–72.10)	71.41 (70.27–72.47)	69.95 (67.51–70.95)
Al ₂ O ₃	1.14	2.21 (1.81–2.93)	1.45 (1.51–1.65)	.58 (0.51–0.65)	.62 (0.53–0.72)
Na ₂ O	14.40	12.53 (11.67–13.01)	15.50 (15.49–15.99)	10.40 (7.74–12.08)	15.08 (14.03–15.28)
K ₂ O	2.88	2.75 (2.30–2.92)	2.34 (2.0–2.59)	1.31 (1.16–1.60)	2.32 (2.34–2.46)
CaO	5.29	5.35 (4.92–5.96)	3.42 (2.92–3.76)	4.82 (4.56–5.29)	3.22 (3.13–3.40)
MgO	2.75	2.65 (2.57–2.75)	3.82 (3.71–3.76)	2.90 (2.82–2.97)	6.11 (6.09–6.22)
Cu ₂ O					
CuO	1.22	1.75 (1.74–1.76)	.01 (0.00–0.05)	2.13 (2.05–2.20)	1.63 (1.51–1.72)
TiO ₂	.80	1.00 (0.82–1.67)	.38 (0.12–0.83)	.00 (0.00)	.00 (0.00)
Fe ₂ O ₃	1.07	1.17 (1.09–1.23)	.88 (0.82–0.94)	.33 (0.30–0.36)	.35 (0.30–0.37)
Sb ₂ O ₅	1.76	1.74 (1.59–1.86)	.00 (0.00)	1.55 (0.56–2.73)	.00 (0.00)
PbO	.05	.06 (0.00–0.11)	.02 (0.01–0.03)	.05 (0.00–0.03)	.00 (0.00–0.01)
TOTAL	97.76	98.44 (97.32–100.11)	97.62 (97.13–98.85)	96.12 (95.39–97.43)	99.28 (97.99–99.57)
Other elements			S and Cl present, could not detect Cu, Mn, Co, or Zn in excess of 0.01%.	Cl present, Ca-Sb inclusions, 0.01–1.0 micron	Cl present.

By emission spectroscopy, the following elements were found in quantities of less than 0.1%: Ag, B, Cr, Mn, Ni, Pb, Sn, Sr, and Ti.

Source: After Vandiver 1983: 243

Representative Nuzi glass compositions determined by microprobe analysis

Oxide	Red opaque glass 30–2–414	Yellow opaque glass 30–2–414	White opaque glass H 12–13	Blue translucent glaze on clay body 31–1–162
SiO ₂	63.50 (62.20–67.62)	63.60 (62.33–64.51)	68.36 (68.26–69.66)	51.46 (49.00–53.36)
Al ₂ O ₃	1.63 (1.38–1.82)	1.35 (1.25–1.45)	.55 (0.53–0.58)	10.10 (9.27–10.90)
Na ₂ O	15.04 (14.79–15.14)	14.55 (14.38–14.95)	13.21 (12.64–13.75)	12.37 (11.67–13.34)
K ₂ O	4.15 (4.07–4.19)	4.17 (4.15–4.19)	2.75 (2.66–2.92)	3.31 (3.18–3.62)
CaO	5.60 (5.68–5.72)	5.48 (5.44–5.50)	8.42 (7.79–8.56)	8.93 (8.20–9.91)
MgO	3.61 (3.57–3.63)	3.48 (3.41–3.56)	4.55 (4.38–4.92)	4.23 (4.08–4.36)
Cu ₂ O	3.58 (3.37–3.82)			
CuO		.09 (0.08–0.10)	.14 (0.11–0.17)	1.37 (1.24–1.47)
TiO ₂	.16 (0.15–0.17)	.00 (0.00)	.00 (0.00)	.80 (0.70–1.01)
Fe ₂ O ₃	3.32 (3.37–3.82)	.96 (0.80–1.04)	.22 (0.20–0.25)	4.35 (4.17–4.38)
Sb ₂ O ₅	.00 (0.00)	1.95 (1.75–2.06)	2.05 (1.90–2.68)	Not measured
PbO	.40 (0.40–0.45)	4.35 (4.20–4.53)	.00 (0.00–0.02)	.15 (0.11–0.20)
TOTAL	100.99 (99.32–101.59)	99.98 (97.83–100.70)	100.25 (99.46–100.88)	97.07 (95.21–99.98)
Other elements	S and Cl present, Cu rich inclusions.	Cl and Mn present, Pb-Sb inclusions.	Cl present, Ca-Sb inclusions.	

Source: After Vandiver 1983: 244

trations in the range 2–10 per cent, slightly higher than the 4–8 per cent previously reported for Mesopotamian glass (Brill 1970: 122); but this might be explained by corrosion products on the surface. Antimony was present in all objects tested. In the fragment of a mosaic glass vessel it was present in all colours, with copper in

the opaque green areas, manganese and copper in the black. This does not support Dayton's view (1978) that the copper was associated with black glass, antimony with white. The black areas of the mosaic glass had relatively less Mn and more Fe and Cu than the colouring of black faience.

The use of *cobalt* in blue glass in Mesopotamia is fully documented as early as the Ur III period at Eridu (Garner 1956). In published analyses of Mesopotamian glasses cobalt is uncorrelated with MnO or Fe₂O₃ and is seldom accompanied by more than trace amounts of nickel or zinc. This is in marked contrast to the cobalt used in Egyptian faience, glass, and pottery pigments in the New Kingdom. Kaczmarczyk (personal communication) believes that cobalt in the alum from the Dakhla Oasis is invariably accompanied by all of these elements and is the likely source for Egyptian glass-makers in the New Kingdom. Mesopotamia (and (?)Egypt in the first millennium) is likely to have drawn on the rich deposits of high-grade cobalt in Iran. When manganese appears with the cobalt in Mesopotamian glass it is likely to have been introduced independently as a clarifier (cf. Sayre 1963). On Failaka in the Kassite period two types of blue glass were current, one coloured only by copper, the other with 0.10 per cent cobalt in addition, to develop a deeper blue colour (Pollard 1987).

Brill has studied (1970; 1978) the composition of the colourless glass from Neo-Assyrian levels at Nimrud, both that used for vessels, whose origin is uncertain, and that for the miniature painted glass plaques, whose patterns are 'Phoenician'. They are the usual soda-lime-silica type of glass. The levels of potassium and magnesium are high enough to place them in the high-potassium high-magnesium category defined by Sayre (1963), as would be anticipated for 'Mesopotamian' glass. They also contain antimony as a decolourizer, perhaps also as a fining agent to remove some of the bubbles from the glass (Brill 1970: 116 ff.). A 'Phoenician' glass plaque, which Brill examined, was unusual in having 2.6 per cent lead oxide. This would be explicable in a coloured glass, but its role in colourless glass is less easily explained (Brill 1978: 29-30). On the painted plaques the outline was done with a black paint (some bituminous substance), whilst a finely ground Egyptian blue frit was used to colour certain selected details of the paintings (Orchard 1978: 6). It is just possible, though this was by no means certain, that the plaques had originally been painted with white lead to provide a background for the designs. Much attention has also been paid to the opaque red glass from Nimrud (see below).

Kühne (Haevernick and Kühne 1982) has published an analysis of a sky-blue glass mace- or staff-head from Assur.

	%		%
H ₂ O	6.2	CaO	10.9
SiO ₂	59	MgO	4.6
Al ₂ O ₃	0.75	Na ₂ O	16.5
TiO ₂	0.13	CuO	0.6
Fe ₂ O ₃	0.55	Mn ₂ O ₃	0.04

A glass seal, from level II at Tell Taya (Neo-Assyrian), which may not have been of local manufacture, had copper not cobalt as the blue colourant (Bimson 1973).

In view of the wide distribution of standard types of fine glassware throughout the Persian Empire (Oliver 1970), Matson's report (1957) on two fragments of colourless glass vessels from Persepolis has a wider relevance than might at first be apparent. They were of the normal soda-lime-silica composition with low magnesium and with antimony added as a clarifier. Matson examined a bead, a slab, and a lump of opaque red glass from Persepolis. They had a complex composition in which several ingredients, including copper, iron, and antimony, contributed to the development of the colour (Matson 1957: 131-2; cf. below for more recent work on the manufacture of red glass).

(e) Provenance studies

Although Egyptian glasses often have a high magnesia content and thus a high magnesia:lime ratio (MgO:CaO), this ratio is much higher in Mesopotamian than in Egyptian glass. It is on this fact that Matson based his claim that the colourless glass he analysed from Persepolis (see above) was 'made in Egypt in the vicinity of Cairo or in the Delta, since its MgO content is very low' (Matson 1957: 129). With the present restricted database such statements must necessarily be conjectural.

(iii) ANCIENT TEXTUAL TRADITION

The most important collaborative study of ancient Mesopotamian technology is *Glass and Glassmaking in Ancient Mesopotamia* (Corning, 1970), initiated by the philologist Oppenheim, whose edition of a series of cuneiform glass texts inaugurated the volume. To this Brill contributed a scientific commentary. Two historical and typological studies of glass vessels and other objects, by Barag and Saldern, completed the volume. Each of the four sections is an important independent essay; but, significantly, they are not complementary. 'The glass objects do not "illustrate" the history of this particular class of cuneiform literature and the texts are useless in helping us trace the typological history of early Mesopotamian glass vessels' (Barag 1970: 134). Nor, he might have added, do they offer information on techniques of artefact manufacture or on workshop organization. Nor, even do they offer a very satisfactory guide to glass composition, as Brill's scrupulous but inevitably faltering attempts to replicate the materials they describe vividly demonstrates. This is a particularly clear illustration of a recurrent disjunction in the history of early technology: ancient texts served administrative or literary purposes, they did not represent a body of technical or scientific literature. They were far removed from practical knowledge, and chem-

ists interested in ancient glass technology have been heard to describe them as 'useless' for reconstructing ancient methods and recipes. This may be an extreme view; but it highlights the problem.

The difficulties run deep, as Oppenheim clearly pointed out. Current understanding of these texts is, at the most basic level, faulty and incomplete. They employ a large number of rare or unique words, refer obscurely to chemical procedures, and lack a scientific mode of presentation. The current status of the texts is not assisted by their complicated historical development, which has to be unravelled from internal evidence. Oppenheim believed them to be predominantly the work of seventh-century scribes, copying earlier records, some of which might be over a millennium older. A preliminary critical review of Oppenheim's approach was provided by Muhly (1972; cf. Moorey 1989). Foster (K. P. 1979: 15 ff.), presumably with the specialist philological assistance of her husband, B. R. Foster (Foster, K. P. 1979: XVIII), offered a critical summary of Oppenheim's interpretation of the glass texts. This included significant modifications in his translation of key words (Foster, K. P. 1979: 21) that had themselves often differed from the definitions given in volumes of the *Chicago Assyrian Dictionary*, published before 1970, with which Oppenheim was associated.

The main corpus of these glass texts came from the Library of Ashurbanipal (c.668-627 BC) at Kuyunjik (Nineveh). Oppenheim argued that they had belonged to a larger body of texts offering 'procedural instructions' in mathematics and astronomy, in ritual and in medicine, in chemistry (glass and perfumes), and in horsemanship. The original chemical and equestrian texts he attributed to scribes working in Assur in the last third of the second millennium BC at the height of the Middle Assyrian Empire. The glass texts seemed to him to represent an Assyrian tradition, though references to past masters of the craft may imply a history extending back into at least the early Middle Babylonian period, in the middle of the second millennium BC or soon after, and to a complex geographical origin for some of the techniques involved (Oppenheim 1970: 51-3). The surviving Middle Babylonian glass texts represent the same technical tradition, but date only between the fourteenth and twelfth centuries BC. Oppenheim demonstrated that they cannot confidently be taken back to the later Old Babylonian period, as had previously been assumed.

Great caution is still necessary in explaining the precise nature of the materials whose composition is described in these texts. Brill (1970: 108) puts the problem succinctly: 'there is sufficient ambiguity in the translations of the texts to leave room for the possibility that the materials being prepared were glassy faience, Egyptian blue, or some related but not yet clearly

defined material'. But he favoured the opinion that the materials being prepared actually were true glasses (i.e. fused, not sintered, compositions). The proportions of the major ingredients called for and the presence of antimony, copper, and lead relate well to the known chemistry of Mesopotamian glass. As far as translation permits, there is no sign of inappropriate materials among the major constituents. Muhly (1972: 181-2) was more sceptical, whilst Foster (K. P. 1979: 16 ff.), although she believed that the majority of texts referred to true glass manufacture, assumed that many of Oppenheim's 'primary, alkali-silicate glasses' were in fact faience; on the terminology used in this volume (and generally in her book) this is imprecise. The alternatives, as Brill appreciated, are frits or Egyptian Blue. These substances are manufactured chemical intermediaries, to be used as starting points in complex processes leading to the production of coloured materials imitating semi-precious stones; but whether for manufacture, as glass artefacts, or to glaze terracotta or sintered quartz was information not appropriate to the scribe's purpose and therefore not explicitly stated (cf. Muhly 1972: 181-2).

These texts are part of a traditional Mesopotamian literary enterprise: the compilation of lexical lists. These had always included terms for natural stones, so the artificial manufacture of such stones (once it became a regular industrial activity) was of interest. Thus the glass texts, in accord with this long-standing purpose, concern themselves with little more than the appropriate technical vocabulary. As the technical procedures themselves were of little interest, and probably unknown, to the scribes, their descriptions are rudimentary: sufficient for the purpose of lexicography, but inadequate as descriptions of an actual technology. Literary tradition is a notoriously inadequate source for the history of technology. Despite Oppenheim's (1970: 83 ff.) attempt to see a historical development in what his texts describe (complementary to his analysis of the historical evolution of the textual tradition itself), it seems they deal with methods for the manufacture of imitation coloured stones that changed little between about 1850 and 700 BC. For centuries before the emergence of a fully fledged glass industry (c. 1600-1500 BC) this had been done either by glazing dark-coloured stones or by making replicas in faience. This craft tradition continued, even after the growing mastery of glass in the middle of the second millennium BC, though the new material permitted closer imitation of the original stones. Since faience and glass workshops were closely associated, as at Nuzi and Assur, both materials came to be used to imitate stones.

Modern scientific examination has only just begun to reveal the complex history of glass and glassy materials in antiquity. There were certainly more categories, particularly after about 1500 BC, than the modern descrip-

tive terms faience, frit, glass paste, glassy faience, and glass can adequately describe. The only practical application referred to in the Oppenheim corpus of texts is the glazing of bricks.

Oppenheim, using the lexical lists of the Old Babylonian period (c. 1850–1600 BC), isolated various terms for what he described as 'primary glasses', though their characters differ, almost to the point of confusion:

I propose to call the glasslike substances which appear in Akkadian as *anzahhu*, *kutpû*, *huluhhu*, *huhu* as well as *bûsu* and *tuzkû*, primary glasses, each specific product being apparently endowed with definite chemical properties. Some of them—such as *anzahhu* and *bûsu*—can be used to produce glass objects, from simple beads to vessels in the core technique, others such as *zukû* and *tuzkû*—are attested only as intermediary products used to manufacture opaque colored glasses meant to imitate precious stones. In contradistinction to *anzahhu* and *kutpû*, the composition called *huluhhu* and *hahu* (also *huhu*) do not occur in glass texts—the latter is once explained as slag from the potter's kiln.

(Oppenheim 1970: 19)

Two points are important in considering this paragraph. None of these materials may yet be reliably identified in the surviving material culture, and the evidence for a glass industry in Mesopotamia before 1500 BC is meagre. At the earliest stage such a vocabulary is likely to refer either to aspects of frit production, to glaze manufacture for application to sintered quartz (not yet to terracotta), or to small-scale production of glass beads.

The given recipes for the manufacture of Oppenheim's 'primary glasses' involve grinding, combining, and firing several sets of named ingredients. The two major constituents are:

Immanakku: 'like river silt dotted with pebbles' was taken by Oppenheim (1970; 1974) as general term for a hard, conglomerate (silicate stones or coarse sand); Brill (1970: 109 ff.) identified it as 'quartzite pebbles'; Foster (K. P. 1979: 21) as 'quartzite, perhaps sand.'

NAGA (*ahussu*): a plant used in bleaching linen and in soap production; this, or rather its ashes, provided the necessary alkali.

Together these produced *zukû* in which U. BABBAR (literally 'white plant') was also mixed. This word is found in medical texts referring to what may be the sap of the poplar tree, readily made into a paste or adhesive to be used as a binding agent (Foster, K. P. 1979: 16).

Brill (1970: 111) attempted a laboratory synthesis of *zukû* (without U. BABBAR): 'The product that resulted was not only a glass, but a glass of unexpectedly high quality . . . It was entirely transparent, but had an amber color . . .' (Brill 1970: 113). Further experiment, in an oxidizing atmosphere or using an oxidizing agent, removed the amber, leaving a pale blue colour.

The texts describe the heating of the basic ingredients

in a kiln until sintering occurs; both the mineral and the alkali had been ground before the first sintering, and it was ground again before reheating. The finished product was poured on to a kiln-fired clay slab to cool off. *Zukû* was only a basis. Its principal derived product was *tersûtu* made by grinding *zukû* and throwing it upon a previously heated mass of the unidentified URUDU.HI.A. *nêhu* (literally 'slow copper') to introduce a blue colour. This copper colouring compound might have been a blue frit, perhaps Egyptian Blue (Oppenheim 1970: 77), or a metallic alloy (Brill 1970: 123). The term 'fast copper' or 'fast bronze' is also used to describe it. *Tersûtu* was in turn an intermediary, for the manufacture of opaque imitation lapis lazuli (*zagin-durû*); this transformation was made by combining *tersûtu* with *bûsu*, *anzahhu*, and *namrûtu*. *Bûsu* was another of Oppenheim's 'primary glasses', made in a similar manner to *zukû*. It was used in the later second millennium BC for tableware, inlaid statuettes, and oil containers (CAD, s.v.). As *anzahhu*, yet another of Oppenheim's (1970: 19) primary glasses, has a close, at times synonymous, relationship to the mineral *immanakku*, it might be a mineral, a type of quartzite (cf. Foster, K. P. 1979: 17), rather than a manufactured material. It can be 'washed' or 'unwashed' and more enigmatically 'male' or 'female', perhaps (on classical analogies) distinguishing a lighter from a darker colour. *Namrûtu* was white calcinated material made from red coral.

(iv) OPAQUE RED GLASS: THE ANCIENT TEXTS AND MODERN ANALYSES

Zukû was equally an important intermediary stage in the production of red glass, distinguished as 'Assyrian' and 'Elamite'; the former requiring that it be mixed with lead, antimony, copper, and *anzahhu*; the latter involving combination with *tuzkû*, lead, antimony, and *anzahhu*. *Tuzkû*, another 'primary glass' in Oppenheim's terminology, consisted of *mekku*, for Oppenheim a 'glass', for others a mineral (perhaps 'powdered quartzite', cf. Foster, K. P. 1979: 21), to which was added minute quantities of *kalû/kalgûgu* ('red earth') as the colourant to be fused with small additions of sand and alkali. Foster (K. P. 1979: 21) renders these as 'cobalt compounds' and 'potash' respectively.

Production of red glass is described in the best-preserved of the known glass texts (British Museum: 120960), dated by Oppenheim (1970: 59 ff.) to the Middle Babylonian period. This text has been well known since its first publication by Gadd and Campbell Thompson in 1936. It has attracted wide attention in non-Assyriological literature on account of its supposed cryptographic style said to protect craft secrets. Oppenheim (1970: 59 ff.) cogently rejected 'such facile

and unfounded assumptions' and provided a new edition. Only a few words remain unintelligible and, though the syllabary used by the scribe is often atypical, this is probably a display of erudition (for only fellow scribes could have read it anyway), not a device for ensuring secrecy. A more relevant problem is provided by the scribe's dating of his text to the 'year (after that in which) Gulkishar became king'. This obscure ruler was the sixth in the First Dynasty of the Sealand in the sixteenth century BC. Oppenheim argued that the reference was an anachronism, arising from a desire to have the tablet accepted as older than it was; but still 'the question is not whether the date of the tablet is correct or not, but rather whether the dating and the entire subscript refers to the original of the text copied or whether it dates the copy' (Oppenheim 1970: 61). Oppenheim answered this question rather obliquely by assuming that the scribe of this tablet, writing it, perhaps in Babylon, in the fourteenth to twelfth centuries BC, used the name of an old and famous scribe who had lived in the time of Gulkishar. It is then a Middle Babylonian text, which might well describe earlier craft practices.

The first two sections give the materials and quantities needed for two types of *red glass*; in the largest section the constituents are combined. At the end, in an intriguing indication of the complex realities of such work, the craftsman is told not to worry if 'inside the cover' the described result is not achieved. A remedy is offered. In 1948 Moore published his attempt to repeat this recipe (following the old translation) in a modern laboratory; he believed it to be for a glaze to be applied to a clay body. In Oppenheim's revised rendering of lines 7–11 they refer to melting the batches in crucibles and the kiln procedures for this, not to the preparation of clay bodies for glazing, as had earlier been supposed. Indeed, the recipe as now translated gives no indication of the purpose for which the red glass/glaze was being made. Although the stages proposed seem unnecessarily complicated to a modern craftsman, insecure temperature controls would have required them in antiquity. 'Fine grinding, followed by remelting, would assist in ensuring the complete solution of any material left unincorporated after the first melting, and would also give a melt containing much less bubble, besides ensuring greater uniformity of colour' (Moore, H. 1948: 27).

Brill (1970), following Oppenheim's new edition, attempted to repeat the instructions for making red opaque glass: 'the ingredients include both those which are essential for making a red opaque glass and those which are beneficial in making them; and the chemical treatments such as the heating procedures are appropriate for making red glasses. Moreover, the chemical composition of the product prepared is consistent, in a semi-quantitative sense, with analyses of some exca-

vated specimens of red glasses' (Brill 1970: 121; cf. Brill and Cahill 1988: 19).

Recent research has established that two main types of opaque red glass were manufactured in the Near East in antiquity. Colour and opacity in both are owed to copper, but they may be separated by their lead content. They may also be distinguished to some extent by eye. Lead-free opaque red glass tends to be a rather dull or liverish dark red colour, whilst the high-lead glasses are a much more brilliant red on account of the well-developed dendritic crystals suspended in an almost colourless matrix (cf. Freestone 1987).

Opaque red glass with negligible lead first appears in the third quarter of the second millennium BC as inlays set in jewellery, perhaps as a substitute for cornelian. Analyses have shown the second millennium opaque reds to be soda-lime-silica compositions with moderately high copper (3–12 per cent Cu₂O) and negligible lead, with relatively high magnesium and potassium, generally taken to indicate plant ash or evaporated river-water as a source of alkali. Several samples registered high antimony. The high-lead (up to 25 per cent) opaque red glasses of the first millennium BC have 'concentrations of SiO₂, CaO and Na₂O . . . depressed relative to the second millennium glasses; MgO and K₂O are again present at concentrations which suggest an alkali source other than natron. At around 10 per cent Cu₂O, copper is similar to that in the more copper-rich of the low-lead glasses and antimony is higher, at 4 per cent Sb₂O₃' (Freestone 1987: 174).

Antimony might have been a deliberated additive, as iron may sometimes have been, not as colourants or opacifiers, but as aids to the reduction of copper oxides and the striking of cuprite (Freestone 1987: 184). However, if copper was added to glass as an oxide scale made from scrap bronze, such impurities, as well as zinc and tin, may well have arrived this way. There is no reason to believe that tin was any assistance in developing opaque red colours (cf. Brill and Cahill 1988: 22–3).

The introduction of substantial quantities of lead at some point early in the first millennium had various advantages. It increased the solubility of cuprous and cupric oxides in the glass. The glass was more brilliant as high-lead glasses have a higher refractive index and a higher dispersion or 'play of colours'. Such glasses were also much less likely to devitrify to sodium and calcium silicates. The lead may have softened the glass, making it easier to cut.

At present the earliest high-lead opaque red glasses recognized by analysis are those from Hasanlu IVB (Brill and Cahill 1988) in the earlier first millennium BC. Dull opaque red glass also continued to be manufactured, indicating a degree of continuity with late Bronze Age glass-working traditions; but it differs from the earlier variety in usually having low

Analyses of opaque red glasses

1. Details of analysed objects (after Freestone 1987)														
Analysis No.	Registration No.	Date (century BC)			Provenance					Description				
1	EA 1894.8-16.241	14th			Amarna					Flat strip				
2	EA 1924.10-11.124	14th			Amarna					Curved strip				
3	EA 1984.8-16.193	14th			Amarna					Trailing rod				
4	WAA 1951.1-2.115	15th			Alalakh					Core of Fragment				
5	WAA 1951.1-2.115	15th			Alalakh					"				
6	WAA 1957.2-9.10	8th			Nimrud					Crucible blank				
7	WAA 118049	8th-7th			Toprak Kale					Circular inlay				
2. Electron microprobe analyses of opaque red glasses (after Freestone 1987)														
Analyses	SiO ₂	Al ₂ O ₃	FeO	MgO	CaO	Na ₂ O	K ₂ O	Cu ₂ O	PbO	Sb ₂ O ₃	S	Cl	Total	
1.	57.79 (0.10)	1.09 (0.12)	0.62 (0.07)	4.10 (0.07)	7.84 (0.53)	14.31 (0.42)	1.70 (0.05)	9.85 (0.46)	b.d —	0.89 (0.15)	0.21 (0.03)	0.58 (0.03)	98.98	
2.	54.36 (0.05)	0.76 (0.15)	0.58 (0.12)	3.85 (0.32)	9.12 (0.05)	16.61 (0.04)	1.65 (0.09)	9.06 (0.40)	b.d —	1.51 (0.31)	0.18 (0.07)	0.80 (0.04)	98.48	
3.	59.58 (0.09)	0.47 (0.03)	0.36 (0.11)	3.32 (0.16)	8.87 (0.66)	17.15 (0.30)	1.74 (0.08)	5.18 (0.28)	b.d —	b.d —	0.17 (0.04)	1.10 (0.09)	97.94	
4.	53.95 (0.57)	0.37 (0.12)	2.93 (0.12)	4.98 (0.18)	7.30 (0.23)	16.83 (0.44)	2.65 (0.09)	5.65 (0.77)	0.13* —	2.44 (0.34)	0.33 (0.06)	0.90 —	98.46	
5.	52.61 (0.41)	0.49 (0.08)	2.73 (0.10)	4.77 (0.12)	7.04 (0.06)	16.50 (0.18)	2.44 (0.05)	7.59 (0.25)	b.d —	2.56 (0.24)	0.21 (0.06)	0.91 (0.05)	97.85	
6.	42.28 (0.95)	0.68 (0.07)	0.43 (0.03)	2.84 (0.27)	3.82 (0.27)	9.46 (0.25)	1.43 (0.07)	8.58 (1.25)	24.96 (2.12)	4.19 (0.11)	b.d —	0.45 (0.08)	99.12	
7.	41.13 (1.05)	0.56 (0.07)	0.48 (0.09)	2.18 (0.06)	3.00 (0.19)	9.10 (0.70)	2.15 (0.05)	11.00 (2.17)	23.54 (1.70)	3.89 (0.24)	b.d —	0.55 (0.02)	97.58	

Notes:
Number in brackets is one standard deviation of the value given, typically a mean of three analyses.
TiO₂ and MnO analysed but below detection limits.
P₂O₅ analysed and below 0.5 per cent.
* PbO in sample 4 analysed by wavelength dispersive spectrometry.

copper and small amounts of lead. When and where the change in formula took place is unknown. Low-copper, low-lead dull red opaque glasses may have been made because their manufacture was easier and cheaper than that of the copper-rich glasses of the previous millen-nium. Freestone (1987: 185, fig. 9) has distinguished the two later groups of red opaque glass as 'a high-lead, high-copper group with PbO typically above 15 per cent and Cu₂O typically above 5 per cent, and a low-lead, low-copper group with PbO typically less than 15 per cent and Cu₂ typically less than 5 per cent'.

Replication exercises have shown the production of ancient Mesopotamian red opaque glass to be a strenu-ous test of the glass-maker's skill. By its first appearance in the second millennium BC, craftsmen had mastered the art of establishing and maintaining a strong reduc-ing atmosphere. Their control of the oxidation state in high-lead glass half a millennium later was an even greater achievement. Cable and Smedley (1987: 163), after their attempt to reproduce high-lead opaque red glass of the type found at Nimrud, summed up the

abilities of its makers as follows: '(1) to achieve a suf-ficiently high volume fraction of cuprous oxide crystals to produce visually uniform opacity, (2) to produce an almost colourless glass matrix containing very few cupric ions, thus avoiding degradation of the red colour, but (3) to do so without, apparently, reducing large proportions of the dissolved metal oxides to glob-ules of metal, and (4) to avoid serious melting segre-gation'.

(v) THE PROBLEM OF ENAMEL

A long-standing controversy over whether or not true enamel (powdered glass fused *in situ*) was produced in Egypt during the New Kingdom has highlighted the complexities of attempting to identify enamel by eye, particularly through the glass of showcases in museums (Teeter 1981). Various types of stone or glass inlay, and the manipulation of pliable glass secured by adhesives, may all too easily appear to be true enamel. As it is relatively easy to place powdered glass in the

areas to be decorated on a piece of goldwork and then fire it in a furnace or over a charcoal fire, students of ancient technology have been surprised by the apparent absence of true enamel in areas where glass technology was innovative and where jewellers were skilled in the production of fine jewellery inlaid with coloured stones or pieces of glass or faience. But the presence of true enamel in jewellery of the New Kingdom in Egypt remains an open question; earlier occurrences are even less probable. It is more generally agreed that towards the end of the local Late Bronze Age in Cyprus, in the thirteenth century BC, true enamelling was practised on the island for the decoration of gold earrings and a sceptre (cf. Åström 1967: 102). In the continuing absence of certain use of the technique in contemporary Egypt and Syro-Palestine, the source of the expertise is usually thought to have been Mycenaean (cf. Higgins 1980: 24 ff.).

The history of true enamel in ancient Mesopotamia is wholly obscure for want of well-authenticated examples. Indeed, in the whole of Western Asia only one object is commonly said to be decorated with enamel before the Hellenistic period. This is a gold diadem, with petals enamelled in yellow and green, associated with the hoard from Ziwiye in Kurdistan, usually dated to the later eighth or early seventh cen-tury BC (cf. Maxwell-Hyslop 1971: 214-5). Even in this case the identification is not scientifically documented and the integrity of this hoard is suspect (Muscarella 1977). The whole question has been reopened by finds in the royal tombs at Nimrud in 1988-9 (see p. 222 here), which included elaborate gold bracelets decor-ated with polychrome *cloisonné* work. Although some parts of it are clearly inlaid with semi-precious stones, some parts might be true enamel (cf. Roaf 1990: 165, in colour).

5

✠ METALWORKING

THE MAIN METALS USED IN MESOPOTAMIA IN antiquity were *copper*, *iron*, *lead*, *gold*, and *silver*; *tin* was alloyed, more rarely used alone. Occasional instances of metal *antimony* have been reported. *Bronze* (copper and tin) was an important alloy; before the mid- or later second millennium BC it may not have been as common as has been assumed. Arsenic as a metal was apparently not known, but *arsenical coppers* were a significant feature of the copper industry for centuries. *Brass*, an alloy of copper and zinc, appeared in Anatolia in the eighth century BC, but its manufacture in Mesopotamia has yet to be established. *Electrum*, both natural and artificial, was employed and may well have been far more common than present identifications of 'gold' and 'silver' might suggest. *Nickel* and *zinc* as metals were not known. Salonen (E. 1970: 97–148) has analysed the terminology for metalworkers and their craft skills.

1. Specialist Terminology

The following section inevitably introduces the archaeologist and art historian to a new vocabulary. The following concise glossary includes only the most recurrent terms:

(a) *With particular reference to precious metals, copper and copper alloys* (cf. particularly Coghlan 1975; Maryon 1949):

Annealing: the process of heating to red heat to remedy brittleness caused by hammering (see pp. 269 ff. here).

Brazing (Hard-Soldering) and Soft-Soldering: joining techniques involving an agent (filler metal). Conventionally soldering refers to processes below 450 °C; brazing to processes above 450 °C.

Casting: see pp. 269 ff. below.

Casting-on a method employed not only in repairing broken or damaged objects, but also in manufacture, to form joins between elements in copper/copper alloys, or between elements in copper/copper alloys and iron (see p. 285 in main text).

Chasing: hammering the metal down from the front to produce a low-relief design with linear margins.

Engraving: linear designs made on the surface with a

sharp tool which removes the metal from the groove it cuts. It is not certain how much this was done before steel came widely into use for working tools (cf. Lowery *et al.* 1971).

Forging: the process by which a piece of metal is shaped through hammering either at its normal temperature (cold-working) or when heated.

Punching: shape or decoration achieved with a patterned tool (or die) hammered into the surface of a piece of metal (cf. also *Stamping*).

Raising: production of a sheet-metal vessel by hammering from the outside. A disk of metal is worked over a special anvil (*stake*) with unusually long arms which can enter the vessel being made.

Repoussé: hammering the design up from the back of a piece of sheet-metal so that it appears in relief on the front; normally done with a blunt tool against a yielding surface.

Sinking: making a sheet-metal vessel by hammering the metal down into a suitably shaped depression cut into wood or a similar material.

Soldering: see *Brazing* above.

Stamping: producing a design by using a patterned tool (or die) from the back of piece of sheet-metal (cf. also *Punching*).

Tracing: linear designs on the surface made with a slightly blunt tool which displaces and compresses, but does not remove the metal from the groove it makes (contrast *Engraving*).

(b) *With particular reference to iron technology* (cf. particularly Wheeler *et al.* 1976: 108 ff.; Waldbaum 1983: 177 ff.).

Austenite: a solid phase of carbon in iron, at temperatures over 710 °C.

Bloomery iron: in antiquity the first product of smelting iron ore in charcoal. It is a relatively pure iron with small amounts of slag.

Carburization: the process of heating bloomery iron in direct contact with charcoal. Carbon is absorbed into the iron converting the areas in which they combine into steel.

Decarburization: the process for depleting surface layers of carbon. Carburized iron is heated in an oxidizing atmosphere so that the carbon in the surface layers combines with oxygen and is given off as gas.

Eutectoid steel: an alloy of iron with 0.8 per cent carbon.

Martensite: the product arising when austenite is sharply cooled, as by plunging an object into cold water. It is hard and brittle.

Pearlite: the product arising when austenite is cooled more slowly. The name derives from the decomposed appearance of the austenite: alternate lamellae of *ferrite* (pure iron) and *cementite* (a compound of iron and carbon) with a 'pearly' appearance under the optical microscope.

Quenching: plunging a hot metal into water or some other cooling medium; most commonly used for hot steel (austenite).

Tempering: the process for relieving the brittleness of martensite, accomplished by heating to a temperature in excess of 150 °C.

Welding: heating two pieces of metal to be joined, almost to melting point, and then hammering them together. In antiquity it could not have been used to join copper or copper alloys, only iron.

Widmanstätten structure: a microstructure characterized by a tendency of *ferrite* (pure iron) to form plates, during cooling from above 710 °C, along certain crystallographic planes of the parent *austenite*.

2. Precious Metals

(i) ELECTRUM

Electrum, which derives its name from the Greek word for amber, describes a mixture of gold and silver, pale yellow in colour. In mineralogy it is applied to native argentiferous gold containing 20–50 per cent of silver; its definition when artificial is arbitrary. Pliny used the term to describe alloys of gold and silver with one part of silver to four of gold. Laboratory research has not proceeded far enough with ancient objects of precious metal from Mesopotamia to make separate treatment of this metal possible, since the distinction between natural and artificial electrum may not be confidently drawn. Many of the rare analyses of Mesopotamian 'gold' show that it is in fact electrum, but whether a natural or a deliberate alloy is not invariably clear. As its history involves both that of gold and silver, electrum is, for the moment, best treated with them as and when the question arises. An alloy of gold with silver is harder than pure gold and will consequently stand wear better. Silver may only be separated from gold by a complicated process (see p. 218); but base metals may be slagged off by repeated meltings of native gold in an oxidizing atmosphere, routine in many goldsmithing techniques. Natural electrum can have a substantial copper content (cf. Primas 1991 on electrum weapons in general).

(ii) GOLD

Gold (Au), whose distribution is almost universal, occurs either in veins of quartz rock (*reef gold*) or in alluvial sands and gravel (*placer gold*); a distinction found in the textual sources (*ḫurāšum ša abnīsu*; *ḫurāšum ša ma'ēšu*). As it combines chemically with neither oxygen nor sulphur, it is present predominantly in the metallic state (Patterson 1971). In its native state gold is always alloyed with silver in proportions that vary greatly; sometimes also with copper and traces of iron and other metals. A gold with only a trace of silver, or no silver at all, has been deliberately refined.

(a) Recovery

As there are no gold deposits in Mesopotamia, the processes of recovery would have been remote from the experience of her craftsmen. They received the metal either in nuggets, or prepared or partially prepared as powder, or as ingots, taking that term to embrace both block and ring shapes (Limet 1960: *passim*; Leemans 1967–71: 505; for early ring-ingots see now Gopher *et al.* 1990). Methods of recovery are rapidly reviewed here as a brief preliminary to understanding the manipulation of this metal.

Reef gold occurs as irregular masses in quartz veins or lodes. The mining process consists first of freeing the gold particles by crushing and sifting the ore, then of separating the gold by making use of the metal's higher density. The classic description of gold-mining in antiquity is that by Agatharcides, preserved by Diodorus Siculus (iii. 12–14) who, in the second century BC, visited and graphically described the rigours of gold-mining in Egypt (cf. Lucas 1962: 224 ff.).

Placer gold is produced through the action of weathering, or other agents, by which gold deposits are broken down and carried into river-beds as secondary, alluvial gold. As gold has a high specific gravity (19.3), it does not move as easily with the current as lighter matter, and so collects in pockets, commonly found concentrated in the middle of a river. To recover it the sand and gravel of the river-bed are agitated with water in pans, troughs, or cradles, so that the rocky matter floats off and the gold particles collect in the bottom as gold dust or nuggets. Maxwell-Hyslop (1970) sought to identify a type of metal pan found at Troy and in a grave at Assur as an instrument for panning alluvial gold. Further study of these vessels has indicated that a domestic role is more likely; such a pan was found at Sippar (Calmeyer 1977).

(b) Colour variation

Ancient terminology for gold (Leemans 1957–71: 540 ff.; Limet 1960: 43–4; Waetzoldt 1985; for Egypt: Harris 1961: 32 ff.) is notoriously complicated, probably arising from the different sets of circumstances in

which it was employed (Ungnad 1935; cf. also Eilers 1954–9). There was first the technical terminology conveying, for the specialist administrator and craftsman, important information on source, appearance, and degrees of purity; then a poetic or symbolic vocabulary; and finally what may best be termed the craftsman's slang or demotic phraseology. At present it is impossible to relate these terms directly to the material evidence in any meaningful or useful way. The quality of the gold from the Royal Cemetery at Ur, for instance, could not be assessed by eye from the colour alone, as some specimens of different colour had practically the same composition, whilst one example, with 10 per cent copper, had the rich yellow colour of a purer metal (Plenderleith, in Woolley 1934: 292–3). Significant colour changes in native gold require a fairly substantial modification in the alloy and insufficient laboratory work has been done to allow for detailed comments on this phenomenon in Mesopotamia, where much of the little 'gold' so far sampled is, in fact, 'electrum' (Plenderleith, in Woolley 1934: 294; Partington 1935: 232). Substantial additions of copper would tend to turn the gold red, perhaps illustrated by a text from Ur in which copper is alloyed with gold in the making of earrings (Limet 1960: 43–5; Legrain 1947: no. 452). Substantial additions of silver would make it green or grey in tone. It is not only the composition of the alloy which modifies the colour; since surface colour may also be changed. If the surface treatment of the metal were varied, the surface would reflect light differently and give the impression of different colours, even in the same alloy. Surface colour may as easily be modified accidentally, for instance, when organic matter stains it, or when a film of iron oxide, natural or contrived, turns it rose-pink in colour (cf. Lucas 1962: 233–4), or when there is selective enrichment of the surface by contact with a salty conglomerate of irregular activity (Maryon 1949: 106 n. 14).

In the graves of the Royal Cemetery at Ur colour contrasts were directly contrived in more obvious ways, although Plenderleith (in Woolley 1934: 294) noted how rarely gold and silver were directly juxtaposed. Striking exceptions are the rampant he-goats from RT 1237 with their gold-covered legs and genitals and their silver bellies (Woolley 1934: 582, pls. 77, 87–90). A most unusual patterning technique is illustrated by a silver bowl (U.10891) from RT 800 (Woolley 1934: pl. 173): 'the bowl itself is of silver, there are very slight vertical grooves in its sides, and in them strips of electrum have been fixed either by sweating or by lapping the silver over the edge of the inlaid material' (Plenderleith, in Woolley 1934: 297). The famous rein-ring from Pu-abī's land-sledge (Woolley 1934: pl. 166) has an electrum animal on a silver ring, and such silver vessels as U.11821 from PG 1133 have tubular handles of electrum (Woolley 1934: pl. 173b, right). A brooch

from PG 55 (U.8007: Woolley 1934: pl. 219, lowest right) has a background of filigree silver wire contrasting with its electrum boss. A roundel of gold from the Ur III Royal Mausolea was decorated with a whorl pattern whose outlines were inlaid with silver (Woolley 1974: 32, 102: U.17429). The decorative potential of variously coloured gold combined with silver was exploited throughout down into the Achaemenid period (cf. CAD, s.v. *šariru*).

Even with the handful of analyses at present available for the Royal Cemetery caution is necessary, since alloying of precious metals is already evident. A spear-head (U.9122) has 30.30 per cent gold, 59.37 per cent silver, and 10.35 per cent copper (Woolley 1934: 294: table III). The famous rein-ring from RT 800 (Pu-abī) has an equid of electrum (whether natural or artificial is an open question), comprising 65.60 per cent gold, 31.45 per cent silver, and 2.65 per cent copper, whilst the ring on which it stands is virtually sterling silver (93.5 per cent silver, 6.10 per cent copper, and 0.08 per cent gold). Bowls from PG 755 are also gold-silver-copper alloys (Woolley 1934: 294).

(c) Refining and assaying

The date of the introduction of refining in the Near East, as in Egypt, is still an open question. Cupellation will remove metals from silver or gold, but by itself will not remove silver; adding salt (see below) enables silver to be removed from gold (cementation). Jesus (1980: 89) is cautious with reference to Anatolia, arguing that silver separation was not known and only native gold was used. For Egypt opinions vary from dates as early as the Old Kingdom (Notton 1974) to the conservative position of Lucas (1962: 229), who saw no clear evidence for it before the Achaemenid period. This is certainly the period to which the best archaeological evidence now belongs, for at Sardis the American excavators found convincing indications of both processes operative in the same industrial area in the sixth century BC (Hanfmann and Waldbaum 1970: 310 ff.; Ramage 1970; Goldstein 1970; Waldbaum 1983). To this century also belong the texts of Nabonidus cited by Fossey (1935) as the clearest documentary evidence for refining in Mesopotamia (see below).

For cupellation the gold is alloyed with lead in a special clay vessel, known as a cupel, and the product oxidized by a strong current of air blown into the surface of the molten metal. The base metals are consumed, or drossed, as the oxides formed are absorbed by the porous walls of the cupel, whilst gold and silver survive. Precisely what form cementation took before the classical authors offer descriptions of it (Diodorus Siculus, iii. xiv. 1 f. (after Agatharcides); Strabo, iii. ii. 8) is a matter for continuing debate. Notton (1974) experimented with the method described by Diodorus Siculus and it proved very successful. A series of tests

were conducted on a nine-carat alloy (in the absence of a suitable gold ore). In the first, salt and the gold alloy were smelted under various circumstances. After five days heating at 800 °C, gold recovery was high. It was less so when salt, brick dust, and the alloy were used and also when tin and lead were added in two different ways. The presence of tin to a greater extent, lead to a lesser, inhibited the recovery rate.

On the evidence of these experiments, earlier suggestions about ancient methods of cementation gain extra credence. The Sardis excavators argued that 'the gold is hammered into thin sheets, which are then stacked in a vessel with layers of dry "pickling mixture" like common salt or alum, and heated for a long time, c. 700 °C. Silver especially combines with salts and the gold is left pure' (Ramage 1970: 22–3). Comparable techniques may have been current in Mesopotamia by at least the Old Babylonian period, to judge from the appearance in the Mari texts of the term *lurpianu* (a salt?), which is associated with the preparation of gold in contexts suggesting cupellation or a comparable process (Limet 1986: 288).

As there is, so far, no documentary evidence for the value of gold before the Akkadian period, it is only assumed to have been the most precious metal in the Early Dynastic period (and earlier) as it was consistently hereafter. In the Akkadian period the silver: gold ratio was 7.5 to 8:1 (Foster, B. R. 1983: 160). At Ebla, late in Early Dynastic III or early in the Akkadian period, references to gold are followed by numbers. These may indicate either parts of gold to another metal in a gold alloy, or its purity, in which case it would imply a technical means for determining the purity of gold in Syria at this time (Waetzoldt 1981). In Ur III, Old Babylonian, and Kassite texts from Mesopotamia gold is differentiated both in nomenclature and in silver valuation (Powell 1990: 79). It may perhaps be surmised that at first only the native alloy was used and that refinement of gold was a development of the second half of the third millennium BC. Waetzoldt (1985; cf. Powell 1990: 80–3) has demonstrated in most detail, following Young (G. D. 1979), that varying values of gold in Ur III texts primarily reflect not price fluctuations, but the varying quality of the gold itself. He postulates three descending levels of purity: almost pure gold with a yellowish-gold ('red') colour; 'mixed gold'; and 'normal' gold. Silver: gold ratios range from 21:1 to 15:1 for 'pure', 14:1 to 11:1 for 'mixed', and 10:1 to 6.5:1 for 'normal' gold. Even then there is no textual evidence to indicate how the various purities were established.

In the Kassite period the range of prices is narrower than in Ur III, with 'bright gold' at a silver: gold ratio of 4:1 distinguished from 'red gold' at 8:1 (leaving the anomaly that the silver value of the best gold is now only 40 per cent of its value in the Ur III period;

cf. Powell 1990: 81). This dichotomy begins to emerge at Mari in the Old Babylonian period (Durand 1983: 194 ff; Limet 1986: 510). Comments in the 'Amarna Letters' throw some light on refining. In two letters (Fossey 1935; Levey 1959: 193) the King of Babylonia complains to Amenophis III of Egypt about the quality of gold sent to him from Egypt (Knudtzon 1915: 70–1, 92–3). In one case only 25 per cent of the metal was in fact gold. From both letters it is clear that the Babylonians had a means of refining the metal; but the reference is simply to putting it into a furnace, without further explanation.

The role of assaying in ancient Mesopotamia, in which a sample is removed for analysis, is no clearer. Assay by fire, used in a qualitative not a quantitative way, is described in the Leyden Papyrus (X, no. 3: Oddy 1983), but how early such tests were used is unknown: 'If the gold is pure, it keeps the same colour and remains pure like coinage after heating. If it appears whiter it contains silver; if rougher and harder, it contains copper and tin; if black and soft, it contains lead.'

The use of a touchstone (*Lapis Lydius*, i.e. black chert) to test the relative purity of gold (its approximate carat value in modern terms) is attested by classical authors from at least the sixth century BC (Theognis, 417; Pindar, *Pythian*, x. 67). Theophrastus (*de Lapidibus*, 45) attributes them to the river Tmolus in Turkey. In this case it is siliceous schist (flinty slate), black in colour, usually for this purpose deep black, and fine-grained; but other black stones may be used. The surface has to be ground perfectly flat and left matt for efficient assaying by streak. Streaks are taken from gold alloys of known, graded composition for comparison with streaks taken from the metal to be assayed (cf. Oddy 1983; Moore and Oddy 1985). Actual examples of touchstones are almost impossible to identify except through laboratory study. Eluère (1986: 59) has shown that two stones from a late third-millennium grave at Telloh (called a 'goldsmith's tomb') exhibit no traces of gold and are not suitable for use as touchstones; the same is likely to be true of an example identified at Larsa in a 'jeweller's' hoard (cf. Arnaud *et al.* 1979: 20–1, 23, fig. 8). These haematite objects are either weights or burnishing stones, as may be the case with a gold-streaked stone reported from Assur (Pedersen 1985: 123 n. 7); this type of stone is not appropriate for use as a touchstone.

Gold, like silver, was regularly recycled in Mesopotamia, and texts make clear the care taken by administrators to ensure its honest use (cf. Durand 1983).

(d) Sources

(1) Ancient textual references

The evidence currently available for the sources of gold used in Mesopotamia is uneven and far from precise

(Leemans 1957-71: 505:2). There is also a need in using the documentary sources to beware (if no reference is made to mines) of confusing transit zones or ports-of-trade with source areas. Sumerian literary texts refer to gold from *Aratta* (Pettinato 1972: 79). Gudea records receiving gold from the mountain of *Hah(h)um* (Statue B, col. VI. 33-5; Liverani 1988), taken to lie in that part of modern Turkey near Samsat on the Upper Euphrates, and from *Meluhha*. In far less explicit terms the names of various mountains reputed to have gold sources are also recorded (Limet 1960: 94). Various texts refer to the almost mythical land of gold known as (*H*)*arallu*, perhaps somewhere in the Iranian hinterland (Komoróczy 1972; Groneberg 1980: 20). Shu-Sin (c. 2037-29 BC) refers to gold from 'Su-land', probably in western Iran, though its location is still open (Edzard 1959-60: 16-18) and from (*Mar*)*daman*, possibly identical with Mardin in south-east Turkey (ibid.: 7; Edzard and Farber 1974: 118). Documents relevant to the *Dilmun*, trade in the later third and earlier second millennium BC indicate that some gold was still reaching Ur up the Gulf at this time, but whence it came, perhaps *Meluhha*, is not stated (Oppenheim 1954: 7; Leemans 1960: 120-1, is more cautious). The renowned resources of Egypt and Nubia (cf. Lucas 1962: 224-8) contributed most certainly in the fourteenth century BC to Mesopotamian royal gold holdings (Edzard 1960; Wilhelm 1974). Then, for the first and only time in its history, Babylonia may have adopted the gold standard and large amounts of gold came from Egypt to assist Kurigalzu I in his major building projects (Brinkman 1972: 274-5; Müller 1982; Powell 1990: 79-82). Hittite inventory texts of the thirteenth century BC record gold from Babylon and *Lukka* (Lycia) (Kořak 1982: 195). Jankowska's study (1969: 254-5) of the booty recorded in Neo-Assyrian texts contributes little to isolating the origin of gold, since what is recorded is either local treasures or centres of manufacture. The most considerable amounts of gold were held by Tyre and *Muřařir*, smaller quantities by Carchemish, Damascus, and Jerusalem, and the towns of Tabal, still less by *Bit-Zamani* and *Zamua*. The tribes of Hama were richer in gold than those of Harran. An Iranian source, reminiscent of earlier references, is recorded by Tiglath-Pileser III (c. 744-727 BC): 'the land of *Ru(a)*, as far as the alkali desert, the lands of *Uřkakkana*, *řikraki* (the land) of gold, provinces of the mighty Medes . . .' (Luckenbill 1926: 285: 795). According to the 'Foundation Charter' of Darius I, the gold used at Susa in his time was from Sardis and Bactria (Vallat 1971).

(2) Modern source regions

So far as is known, there were no sources of gold exploited in antiquity in Mesopotamia, Syria, or Palestine; but the metal is widely reported on the periphery

of this region (Maxwell-Hyslop 1977): in Turkey, where there is a preponderance of sources in the west and south-west (Jesus 1980: 82 ff.); in Egypt and Nubia (Lucas 1962: 224-8); in considerable quantities in western and southern Arabia, not least in *Ophir* (1 Chron. 29: 4; 1 Kgs. 10; Job 22: 24; cf. Maisler 1951), being well known to both biblical and classical authors (Diodorus Siculus, III. xlv. 6 ff.; Strabo, xvi. 4, 18, 22; Periplus, 36, etc.); in greater Iran, notably in the north of the country and eastwards into Transoxiana and the region of modern Afghanistan, where there are substantial vein and placer deposits (Dunlop 1957; Chmyriov *et al.* 1973). Diodorus Siculus (II. xxxvi. 2) and Pliny (*Natural History*, xxiii. 66) refer to rich sources in India, though traces are no longer easy to detect (Allchin 1962; Ratnagar 1981: 106 ff.). With so wide a range of potential sources within her orbit, many of them in regions whence she is known to have received other metals, Mesopotamia is likely to have had a variety of choices if and when supplies were for some reason blocked in any particular locality. It will be immediately clear that the ancient texts already considered indicate import at various times from all the potential source zones listed here.

(3) Scientific source detection

The wide distribution of potential sources does not ease the quest for a scientific method through which Mesopotamian gold sources might be 'finger printed'. It is known that platinum group elements (hereafter PGE) such as ruthenium, rhodium, palladium, osmium, iridium, and platinum occur in gold objects from the ancient Near East both in solid solution and as inclusions. As such an association is rare in primary gold deposits, this has been taken to indicate the use of secondary (or placer) deposits, in which gold and PGE became associated by fluvial transport. On the evidence of the inclusions of the platinumiridium alloy in a number of Sumerian and other ancient gold objects, notably Lydian gold coins supposedly of gold from the Pactolus valley in western Turkey, Young (W. J. 1972; cf. Whitmore and Young 1973) argued that this region had been an important source of Sumerian gold. Within a few years Ogden (1977), after a comprehensive review, concluded that direct correlation of a gold object and its metal source through the PGE inclusions was not feasible. Maxwell-Hyslop (1977) also questioned the Whitmore and Young hypothesis, pointing to other more likely and closer sources for Sumerian gold, both in eastern Turkey and in Iran. Meeks and Tite (1980) investigated the problem through a wide range of objects in the British Museum. They found PGE inclusions in more than half the Early Dynastic III to Larsa period jewellery they tested from Ur and in the majority of the Sargonic jewellery from Brak. They also identified them in two-thirds of the Achae-

menid jewellery in the 'Oxus Treasure'. In contrast, they were rarely found in second-millennium jewellery from Tell Ajjul in Israel, Tell Atchana in Turkey, Enkomi in Cyprus, Ialysus in Greece, and Crete. Research on the evidence from Sardis now reveals a situation more complex than Young supposed (cf. Waldbaum 1983: 3 ff.). The gross distinction seems to be that the Sumerians drew upon sources of gold other than those most easily accessible to western regions.

Although absence of inclusions may be indicative of source, other possible explanations at present preclude categorical statements. Certainly, since the rare alloy type platinumiridium may not generally be used to characterize or identify the placer deposits used in antiquity, the Whitmore and Young hypothesis is not tenable. Nor do the iridium-osmium-ruthenium alloy inclusions necessarily provide a basis for characterizing sources; but there was enough consistency, in some cases, for Meeks and Tite (1980: 273) to conclude: 'It is therefore possible that, following considerably more work on PGE inclusions in gold from placer deposits of known location, some limited source characterization of the gold used in antiquity might, in favourable circumstances, be possible on the basis of the compositions of the inclusions.'

(e) The repertory of objects and uses

The surviving material evidence for the uses of gold and electrum in ancient Mesopotamia, except for small pieces of jewellery and miscellaneous fragments of sheet metal, is to all intents and purposes concentrated into a few Early Dynastic III royal graves at Ur and Neo-Assyrian royal graves at Nimrud. Had comparable graves for other periods been discovered, no doubt the picture would be different; but for the present it is restricted in range. The varied repertory of the goldsmith evident from texts has left virtually no trace in the archaeological record, apart from these outstanding instances. The reason is obvious and applies almost equally to silver. The precious metals were constantly recycled; they were always carefully plundered from any accessible place when cities were sacked; and they were always sparingly placed in graves, where they were also subject to plunderers. All the literary and documentary sources (Leemans 1957-71: 505 ff.) indicate that gold was pre-eminently for ceremonial and prestige purposes. It was amassed in temple and royal treasuries, where it was largely reserved for the decoration of buildings and furniture, for the adornment of high-ranking people, or for gifts and offerings in both religious and secular contexts. The archaeological evidence (save through intensive analysis of what little has survived to resolve questions of purity) does not offer answers to such key questions as to the relative roles of gold for bullion or for manufacture; or as currency

in 'private hands'; nor whether the recorded range of gold prices indicates the action of the laws of supply and demand or the metal's relative purity. It is significant that gold was treated like other commodities and its value was reckoned against a silver standard, even in the Kassite period (Powell 1990: 79).

The only gold objects for which some kind of systematic survey may be offered have been assembled and fully discussed by Maxwell-Hyslop (1971; cf. Spycket, 1973) in her study of jewellery. Consequently, no historical survey is offered here, as has been attempted for the base metals. Instead attention has been focused on categories of artefacts, so assembling under a single head whatever significant material evidence has survived. The recently discovered tombs at Nimrud, richly equipped with gold objects, have alone been given special treatment here.

(1) Personal ornaments and amulets

As this section does not repeat information given and well illustrated by Maxwell-Hyslop (1971), it is inevitably brief.

Gold jewellery of the later prehistoric period was not included in Maxwell-Hyslop's book. The evidence concentrates at present in two places: in the temple deposits of Uruk in the south, and in one or two tombs at Tepe Gawra in the north. The two earliest occurrences of gold are a piece of gold wire in what was said to be a late Ubaid period context at Ur (Woolley 1956: 185: U.16981) and a few fluted beads in level XII at Tepe Gawra of approximately comparable date (Tobler 1950: 193), some time in the late fifth or early fourth millennium BC. The context of a solid gold knob-headed 'rivet' from Tell Ziyada on the river Khabur is uncertain, but it is attributed to the fourth millennium (Buccellati, G., *et al.* 1991: 49, fig. 11). They indicate that manipulation of the metal was already varied. Gold metallurgy is evident earlier than this in Bulgaria, where in graves near the Lake of Varna, close to the Black Sea coast, dated by calibrated radiocarbon to the third quarter of the fifth millennium BC, hammered gold ornaments were remarkably numerous. It has been argued, on the basis of their platinum content (Hartmann 1978), that they were made of metal from an Anatolian source. In Anatolia itself the earliest evidence for goldwork may only be traced back to the much later Troy I (Jesus 1980: 88), whilst in Iran no goldwork has yet been reported before the later fourth millennium (Moorey 1982^a).

In the tombs of levels XI-X at Gawra (cf. Forest 1983: 19-55) of the later prehistoric period, the gold jewellery included beads, pendants of insects, combining gold and lapis lazuli (Tobler 1950: pl. CVI:46), hoof-shaped and spatulate pendants, and gold spirals (ibid.: pl. LVIIb; CVII:47-8); gold bands, decorated

hair-pins and spatulate objects (*ibid.*: pls. CIV:20, CV:29, 31). Rosettes, from levels X–VIII, cut from gold foil, some with pendant ribbons, some with insets of stone secured with bitumen, may have been made to sew on to clothes (*ibid.*: pl. LVIII; CVII:53–7). If so, this is the earliest instance of an enduringly popular means of decorating fine garments in Mesopotamia (Oppenheim 1949). At Gawra studs of gold sometimes had inlays of semi-precious stones (*ibid.*: pl. LIX:1–5; CVIII:59–63). By level VIII (late prehistoric to Early Dynastic I), gold ornaments and pendants have a bitumen core. A sheet-gold tube from tomb 109 may have been a cap or ferrule for some kind of wooden handle (Tobler 1950: pl. LIXa; CVIII:64). Undoubtedly the most significant object, for the extent to which it reveals technical mastery, is an electrum wolf's-head terminal from tomb 114 attributed to level X (*ibid.*: pl. LIXb; CVIII:65). It is 30 mm. long and 25 mm. high; described as follows:

The entire head is a single piece of metal with the exception of the ears, the lower jaw, and the teeth. The ears were attached by means of copper pins, long since decomposed into green copper-oxide. The lower jaw was carefully jointed into the rest of the head, and held in position by an electrum pin leading from the roof of the mouth, which passed through the lower jaw, where it was bent back. The eye sockets contain bitumen, which presumably held eyeballs of some kind of stone . . . the mouth is open, showing the teeth which were made of electrum wire finely drawn and sharp. The inside of the head was filled with bitumen, which served, together with the socketed neck, and the two pins through the neck, to hold the object in position.

(Tobler 1950: 92)

Later prehistoric Uruk yielded a sheet gold amulet in the shape of a goat with a bitumen core (Nöldeke *et al.* 1936: 14, pl. 231); whilst from Susa comes a dog-shaped gold pendant, of the late fourth millennium BC, which has been the subject of technical studies (Tallon 1987: no. 1161, I:265, figs. 31–2; II:113, pl. on p. 315; Duval *et al.* 1987; 1989). This pendant, made of an alloy (Ag: 9.3 per cent; Cu: 1.1 per cent) with a melting point of about 1050 °C, had a suspension loop brazed on at a temperature of about 950 °C. Analysis of the surface of the join indicated use of a brazing alloy (Ag: up to 15–20 per cent; Cu: 5–6 per cent).

To Maxwell-Hyslop's comprehensive survey of third-millennium gold jewellery little may usefully be added, save the fuller publication of the Susa jewellery (Tallon 1987: 227 ff.). Although its origin is unknown, a gold pendant of 'Gilgamesh' flanked by rampant bulls, probably of the Akkadian period, illustrates a use of gold at this time not otherwise well attested in the material record for elaborate ornaments (Margueron 1965: pl. 3: rear view in colour; Contenau 1931: ii. 695–6, figs. 486–7). For the earlier second millennium BC a recent discovery in the temple area at Larsa is of considerable

significance (Arnaud *et al.* 1979; Huot 1980). Even if it is unlikely that this was the site of a goldsmith's workplace (see p. 226), a jar hoard of gold jewellery, fragments of silver, beads and weights, with some jeweller's tools, add considerably to information on jewellery in the eighteenth century BC, for which the 'Dilbat' gold necklace, in the Metropolitan Museum, New York, had previously been the primary witness (Maxwell-Hyslop 1971: 88 ff., pls. 61–4).

Until 1988 a small selection of personal ornaments from various excavations was the only material complement to the unusually rich documentation of jewellery provided by Neo-Assyrian palace reliefs (cf. Curtis and Maxwell-Hyslop 1971; Hrouda 1965: pls. 8–9). The discovery of a number of royal tombs at Nimrud in the North-West Palace of Assurnasirpal II (c.883–859 BC) by Muzahim Mahmud, in 1988–91, has transformed the material record by revealing hundreds of gold objects, including every illustrated type of jewellery and all the standard methods of decoration, as well as many other luxury objects. The following brief summary of these tombs is wholly based on popular non-specialist sources, with relatively few illustrations (the same objects are constantly repeated), which are all that is yet available. The tombs were found in a part of the palace consisting of rooms protected by a substantial wall, perhaps the harem quarter. It was here in Room DD that Mallowan had earlier found a relatively modest female burial below the floor (Mallowan 1966: i. 114–5, pl. 58). This part of the palace may have been built by Shalmaneser III (858–824 BC).

Vaulted tomb under Room MM excavated in 1988 (room previously cleared by Mallowan). Man(?) buried in a baked clay coffin set in a brick-built vaulted subterranean chamber with inscribed bricks of Assurnasirpal II in the vault (cf. Harrak 1988). They were secondary, since the contents of the grave are late eighth or early seventh century BC in date. The '200 pieces of gold jewellery' include a gold comb attached to a double chain; a pair of bracelets inlaid with semi-precious stones (Harrak 1988: fig. 2); '4 pairs of earrings with 10 to 12 hanging conical bells, two earrings with two gold flowers, strips of gold foil, a fibula or pin with a figure of an eagle and another of a woman, a chain with hanging bells, beads of gold, and a number of gold pendants representing animals . . . three pomegranate-shaped pendants' (Harrak 1988a: fig. 3; 1990: 7).

Tomb under Room 49 excavated in 1989. Fifty metres to the west of the previous find. A shaft led to an antechamber, which was empty save for a long inscription in cuneiform set in a niche (Fadhil 1990). From this room two pivoted stone doors gave access to a vaulted brick chamber in which was a Mosul Marble sarcophagus, nearly eight feet long, covered with stone slabs. This contained the remains of a woman and child or young adolescent accompanied by goldwork that

weighs more than 250kg; 'the hoard consisted of 10,000 small pieces of jewellery, 119 large items, as well as an abundant assortment of bottles, goblets, pots and toilet articles' (Nashef 1990: 281–2, figs. 24–6 in black and white; *Time Magazine* (30 Oct. 1989), 44–5 in colour; *The London Times Review* (25 Oct. 1989), 31, colour; *Archaeology* (July/Aug. 1990), 45–83; Collon 1991). The associated objects included crowns or tiaras, some ornamented with sheet-gold rosettes; threaded necklaces of beads and pendants as well as elaborate cast-gold torcs (?87); a wide variety of earrings (?83); open-ended and closed cast-gold bracelets, upper arm bands and anklets (?16), some with zoomorphic (lion-head) terminals, others with polychrome inlays in glass, faience, and semi-precious stones worked into geometric and figured designs of gods, demons, and sacred trees; garment fasteners (?4); and innumerable gold *appliqués* shaped as rosettes, stars, and triangles. Four of the gold bowls are reported to bear inscriptions, for one or other of three women: Yaba, wife of Tiglath-Pileser III (c.744–727 BC), Baniti, wife of Shalmaneser V (c.726–722 BC), and Atahai, wife of Sargon II (c.721–705 BC), indicating a burial late in the eighth or early in the seventh century BC (cf. Harrak 1990: 91, fig. 11; Collon 1991). The jewellery also includes older Babylonian amulets with royal inscriptions and cylinder seals of the fourteenth to twelfth centuries BC mounted in gold as personal ornaments.

Tomb under Room 57, south of Room 49, excavated in 1989: A shaft led to an antechamber and a vaulted tomb chamber of bricks, many bearing inscriptions. In the antechamber were three bronze coffins of late eighth-century type containing 'almost twice the weight of gold in the second tomb' (*The London Times Review* (25 Nov. 1989), 31; Collon 1991). The range of luxury items, well over four hundred of them, is like that from the other two tombs, with at least one spectacular crown: 'domed openwork . . . decorated round the base with rows of rosettes and pomegranates. Above this, winged genies support an interlaced framework of vine leaves and grapes.' Various inscribed objects have been reported from this part of the tomb: a duck-weight of Tiglath-Pileser III (c.744–727 BC), a cylinder seal inscribed for a high official of Adad-nirari III (c.810–783 BC), a gold bowl inscribed for Shamshi-ilu, a high official of Shalmaneser IV (c.782–773 BC), and a silver bowl inscribed in Hittite hieroglyphs for a Neo-Hittite ruler (cf. Collon 1991; Fadhil 1990). The main chamber held an impressive empty stone sarcophagus. A cuneiform inscription indicated that it had been for the burial of Mullisu-Mukannishat-Ninua, wife of Assurnasirpal II, mother of Shalmaneser III (Fadhil 1990). Her tomb, built in the ninth century BC, had been robbed and resealed; the burials and goldwork in the antechamber, like the objects in the other two tombs, are predominantly eighth century in date.

Both the gold personal ornaments and the other gold objects are of varied origin. Many were of local manufacture, to judge by the style of their decoration, but others may either have been imported or made locally by captive foreign craftsmen. Neo-Assyrian texts refer to West Semitic goldsmiths deported to Nimrud and Nineveh (cf. Oded 1979: 101–2), whilst there is at least one gold bowl decorated in the Phoenician style reported from these remarkable tombs. Their contents illustrate, if illustration were necessary, that even the sculptured reliefs only give a general idea of the richness of Neo-Assyrian material culture.

(2) Weapons and tools

The use of gold for the working parts of weapons and tools is only archaeologically evident in the royal tombs of Early Dynastic IIIA at Ur. RT 789 contained sets of spearheads, their shafts decorated with sheet gold (Woolley 1934: 438, pl. 153); PG 755 was furnished with gold axeheads and a gold dagger (*ibid.*: 436, pl. 152); RT 580 (*ibid.*: 433–5, pl. 151) had a gold spearhead and a dagger, as did RTs 1054 (*ibid.*: 450, pl. 15b) and 1618 (*ibid.*: 476). Tools of gold, even here, were less common. RT 800, Pu-abi's tomb, had a gold saw and flat adzes ('chisels'; *ibid.*: 443–4, pl. 158B), whilst RT 580 (*ibid.*: 432–3, pl. 165) yielded an adze, an awl, and a chisel of gold. It is possible that RT 580 was also a woman's grave. Mallowan originally reported a horse-shaped cheekpiece from a Neo-Assyrian horse-bit found at Nimrud as 'electrum', but later published it as bronze (Mallowan 1966: 127, pl. 70). It has not been analysed.

(3) Cylinder seals

In Mesopotamia sheet-gold cylinder seals are only known from the royal tombs at Ur. RT 1054 (U.11904) contained one made of thin sheet gold, decorated with a banquet scene, over a core; it had sheet caps, one now lost (Woolley 1934: 127, pl. 193:21, fig. 23). That in RT 1236 (U.12457) was similarly made, but decorated with a contest scene (*ibid.*: pl. 197: 217). A related find was made in RT 800 (U.10444) whence came 'gold impressions from cylinder seals; 3 fragments of very thin gold foil which has been pressed into seals so as to take the engraving' (*ibid.*: 81, pl. 192:10–11).

(4) Vessels

Gold vessels are only known from the Royal Cemetery at Ur and the recently discovered royal tombs under the North-West Palace at Nimrud some two thousand years later. The gold vessels of Early Dynastic III from Ur include a strainer; a goblet (Woolley 1934: 159, pl. 160); fluted bowls (*ibid.*: 159, pl. 160, 162); spouted vessels (*ibid.*: pls. 41, 161, 164); a fluted tumbler (*ibid.*: pls. 157, 162); a cup and a cockle shell imitation (*ibid.*: pl. 165); an ostrich-shell replica (*ibid.*: pl. 170). A

unique object, whose manufacture in some ways parallels that of hammered sheet-gold bowls, is the imitation man's hairstyle or wig in gold from PG 755. Commonly known as 'Meskalamdug's helmet', this remarkable object, of Early Dynastic IIIA, is made in *repoussé* with chased details (Woolley 1934: pls. 21, 150).

It has long been possible to extract from the monumental Assyrian reliefs a typology of metal vessels, but survivors from Assyria are rare even in copper alloys (cf. Lushey 1939). Now the newly discovered royal tombs at Nimrud have yielded gold bowls, deep and shallow, variously ornamented in *repoussé* and in some cases inscribed (Nashef 1990: fig. 24). More unusual is a miniature cast(?) fluted gold alabastron (4.5 inches high) secured to a chain (*Archaeology* (July/Aug. 1990), 53 (colour)). It seems likely, as with the Achae-menids, that Assyrian royal tableware was in gold; the silver vessels overlaid with gold foil previously found in excavation at Nimrud appear to be vessels for lesser members of the court (Mallowan 1966: figs. 356–7, 427–30).

(5) Foundation deposits

Ellis (1968: 97 ff., 131 ff.) describes both the use of gold for inscribed foundation tablets from the Middle Assyrian period onwards and the appearance of gold among the more varied deposits of valuable materials buried in the processes of building for magical or votive purposes. Gold foundation tablets may have a much older history. Nabonidus (555–539 BC) claims to have found examples deposited by Naram-Sin (c.2254–2218 BC) (Kupper 1971: 93 n. 9): a strip of gold inscribed with this king's name was reported from Bismaya. (Banks 1912, 145; cf. Sollberger and Kupper 1971: 112: IIA5a, also on gold).

(6) Statuary

Biblical and classical references (Daniel 3: 1; Herodotus, i. 183) and local texts have sometimes been read so as to give exaggerated ideas about the currency of gold statuary in ancient Mesopotamia. Undoubtedly gold was lavishly used in the ornamentation of temple buildings and all temple furnishings, including statuary; but to what extent large-scale cast-gold statues existed it is impossible to say. Although statuettes, less than a metre high, might have been hollow or even solid cast of gold, it is unlikely that it was used in this way, save quite exceptionally, for larger pieces of sculpture. References to gold statuary of any size are likely to have meant ingenious combinations of hollow-cast parts, perhaps sometimes even of gilded base metal, and extensive use of sheet gold on a stone or wooden base. This is implied by the description in Diodorus Siculus (ii. ix. 5–10) of the deity statues set up by Semiramis, with their gold plates hammered into shape. A random selection of quotations from the *Chicago Assyrian Dic-*

tionary (s.v. *šalmu*) indicate similar methods of manufacture:

I cleverly built a likeness of his great godhead out of the choicest quarried stone and scraps of gold.

I had a statue of me as king made out of silver, gold and shining copper.

also *CAD šariru* (a poetic term for fine-quality or 'yellowish' gold):

I made their figures (deity statues) sublime with shining *šariru* gold, a product of *Arallu* . . .

(*CAD* N/1: 28a)

A revealing sidelight on this general question is offered by a passage in one of the 'Amarna Letters' (Knudtzon 1915: no. 27: 23–33) from which it is clear that Amenophis IV (Akhenaten) had replaced solid gold statues (size not given) ordered by his father for Tushratta of Mitanni, with wooden replicas only overlaid with gold: 'And now my brother, you have not sent the gold(?) statues, which your father intended to send, but wooden ones, that are overlaid, you have sent.' Dalley and Postgate (1984: no. 95; 159 ff.) have published a Neo-Assyrian text from Fort Shalmaneser at Nimrud in which a scribe appears to be calculating the area of statues in the Nabu Temple to be covered in gold leaf, and the quantity of gold that will be required for the purpose.

No gold statuette has yet been reported from Mesopotamia, though one is known, of the Middle Elamite period, from Susa (0.75 m. high; Amiet 1966: 420–1, pl. 319, on a bronze base). Very rare tiny deity amulets of gold have survived (cf. Wiseman 1960: pl. XXIIIe–h). An Early Dynastic III statuette in translucent green gypsum from Nippur has a sheet-gold face (Amiet 1977: pl. 3b (in colour); Spycket 1981: 108–9, pl. 71), perhaps once set on a wooden head. Gold-foil overlays were used on bronze statuary in the earlier second millennium BC (Amiet 1977: pls. 433–4; Spycket 1981: 232 ff. 288, pls. 159, 191) and a detached sheet-gold face overlay, of the Neo-Assyrian period, was found at Assur (Andrae 1935: 107, pl. 48h). Sheet-gold pendants or silhouettes were current throughout from the later prehistoric period. An early example from Uruk shows a profile face and torso (Nöldeke *et al.* 1936: 20, pl. 25a), whilst a Neo-Assyrian example, incised with a female worshipper, occurred at Assur (Andrae 1935: pl. 48L). Mallowan (1966: 121, fig. 63) found tiny gold silhouettes at Nimrud (cf. Moorey 1988).

Already at Uruk, in the later prehistoric period, cast gold was used to make the legs of composite statuary, in this case of animals (Nöldeke *et al.* 1936: 14, pl. 23q–s). Sheet gold, over a core, was used for animal horns (Heinrich 1936: 40: pl. 30d), as also later in the Early Dynastic III temple at Tell al-Ubaid (Hall and Woolley, 1927: pl. 5). The famous composite animal statuettes from Ur indicate an aspect of Sumerian production,

whose fragility meant they are only likely to be evident elsewhere in stray fragments of stone or metal. Stone statuary was also at times decorated with gold. There is a gold plaque from Djokha (Umma), cut to the shape of a 'beard' and prepared for inlay into a statue, inscribed with the name of Gishakidu, a contemporary of Enanatum of Lagash in Early Dynastic IIIB (Thureau-Dangin 1937). A statue fragment, of the later third millennium BC, from Telloh, is described as having 'les poignets . . . encore entourés par deux minces bracelets en cuivre plaqué d'or' (Sarzec and Heuzey 1884–1912: 345). Another from the same site and period has 'un collier dont les grains, de matières et de couleurs différentes, cornaline, turquoise et cuivre doré, sont enchâssés dans la pierre blanche' (ibid.: 345–6; illustrated Heuzey 1900: 10, fig. 1).

Woolley (1976: 185) commented of his excavations at Ur in levels of the earlier second millennium BC that:

So little gold was found that we have no criterion for judging the work of the period, but its mere absence is perhaps a sign that there was relatively little in use for ornamental purposes . . . though some of the stone objects found in the Giparku ruins had evidently been enriched with gold.

A sheet-gold ear from the Shamash Temple at Mari was probably from a statue (Parrot 1935: 6). Major deity statues in temples would have had attributes; but very few indeed have been recognized in excavations. The most certain is a lightning fork, presumably of Adad, of the Neo-Assyrian period, from his temple at Assur, made of gold hammered over a wooden core (Andrae 1909: pl. XXXIV). It was reported to weigh 290 grains, 250 of which represent the gold.

(7) Monumental decoration and furnishings

Even allowing for a degree of exaggeration, Sumerian and Akkadian texts make clear the significant role played by goldsmiths in providing temples and palaces with innumerable furnishings, containers, and decorative objects of gold, as well as wooden furniture, of all kinds, inlaid or overlaid with the metal (cf. Salonen, A. 1963: 248–50). Temple foundation documents show that the temples were not only lavishly adorned with gold, but that it was also extensively used for the cult equipment, including the decoration of chariots for deities. One document illustrates this particularly well, for it recounts the return to Babylon of the statues of Marduk and Sarpanitum from exile and the restoration of them and their shrines (Unger 1931: 276 ff.). Although written in the name of the early Kassite king Agum II (or Agum-kakrime), it may have been composed in the first millennium BC (Brinkman 1976: 97). In all this work gold was lavishly employed. Of this nothing has survived that gives any realistic idea of precisely what was involved, though it is known to have been a practice already current in the prehistoric period

and is regularly apparent in texts (cf., for example, Durand 1983).

One of the earliest, and best-preserved, examples of the use of sheet gold for temple ornament is provided by the 'altar' in the late prehistoric 'Eye-Temple' at Brak (Mallowan 1947: 93–4, pls. III–IV, XLVIII.4): 'The three sides of the podium were decorated with an empanelled frieze composed of fretted bands of white limestone and grey shale encased by a surround of gold strip' (ibid.: 32). Mallowan (ibid.: 93) commented in some detail on this goldwork:

The gold foil encasing the stone strips is bent over at right angles to the same depth as it is wide, 20 mm, giving the total depth of the frieze as it was originally when backed onto wood. The gold foil is solid and heavy, and was hammered down onto the wooden back by 20 nails on the top and 22 nails on the bottom strip. It is curious that although no expense was spared on the nails—the stems are of silver and the heads of gold foil—cf. pl. IV.2—they were very carelessly hammered in, at irregular intervals, and were perhaps added as an afterthought to give additional grip to the gold.

There may have been somewhat similar altars in this period at Uruk, to judge from fragments (Heinrich 1936: 47, pls. 34b, f, h, 35a).

Archaeologically speaking, such decoration may only be traced through the historical period by a very thin line of scattered gold fragments found in monumental buildings, such as the Archaic Ziggurat Terrace at Ur (Woolley 1956: 181: U.18225–6, 18236); the Mausolea of the Ur III kings at Ur (Woolley 1974: 100: U.16216, 16257–8); the Kassite palace at Aqar Quf (Baqir 1945: 14); and the Assyrian palaces, where, for example, the gilded-bronze column overlays from Khorsabad are amongst the most spectacular (Loud and Altman 1938: 16). Berthelot (1906: 81) reported that some of the 'gold' leaf found by Place was more properly described as 'electrum'. Layard (1849: ii. 417) recorded very thin gold leaf on baked bricks; and on the ziggurat site at Eridu Taylor (J. E. 1855) found fragments of gold, of gold leaf, and gold-headed nails of uncertain date.

(f) Techniques

The known goldwork from Mesopotamia is concentrated in the few royal graves of Early Dynastic III at Ur, and at Nimrud two thousand years later. What research has been done on the technology of Mesopotamia goldwork has been almost exclusively concentrated on Ur. This is not so restricting as it might sound, for, as is well known, there are very few techniques of metalworking known to the ancient world that were not represented in the Royal Cemetery. Sumerian metal crafts were so developed that the Ur graves may be taken to represent the whole tradition. Only enamelling, niello, wire-drawing, and spinning (in the manufacture of vessels) are techniques absent from the

royal graves and, so far as present evidence goes, also from subsequent contexts in Mesopotamia before the Achaemenid period, though they may in some cases have been practised earlier elsewhere in the Near East.

No goldsmith's workplace nor a certainly identified tool-kit has yet been reported from Mesopotamia. Nor has there been any systematic study of the texts relevant to the goldsmith's practice of his craft. Although the data are scattered, they appear to be rather more instructive in this case than for workers in base metals (cf. Limet 1960: 140 ff.; 1985; Weisberg 1967: 60 ff.). At Uruk the 'Stone-Cone Temple' was believed to have been built in Uruk IV over an area that had previously been used for various workshops, among them a 'metal foundry' (Lenzen 1960: pls. 3, 4, 39). None of the installations clearly indicate this. The squat-vessels with narrow hole-mouths found there have no obvious metallurgical role. A fragmentary gold ingot, only in the vicinity of the 'foundry', provides little more than a possible indication of secondary working hereabouts.

The suggestion that Room 13 of Court I of the *E. babbar* temple at Larsa in the eighteenth century BC was a goldsmith's workplace is not much more convincing. It is not even self-evident that the various hoards examined by Huot (1980) were deposited by a goldsmith or jeweller. As Bjorkman (forthcoming) has argued, this room lacks the evidence of diagnostic tools, equipment, and debris, whilst being very large for the purpose (10 × 3.8 m.).

The basic tools of the goldsmith were probably: a wooden block, a hammer, and some kind of anvil, with chisels to cut, awls to pierce, punches, gouges, and burnishers. The Old Babylonian hoard from Larsa may include a small copper-alloy anvil and three copper-alloy design blocks as well as burnishing stones or weights (Arnaud *et al.* 1979: 21, 23; Huot 1980: 115; Bjorkman (forthcoming)). Further to this essential tool-kit he would use a blow-pipe or small bellows, *tuyères* and melting crucibles; moulds and dies; solders and fluxes; fine sands for polishing and wax for modelling.

All native gold is very malleable and extremely ductile, easily stretched, beaten, or drawn thin. The metal is worked cold, but requires annealing, as it quickly becomes brittle. It may be hammered into sheets of less than 0.0025 m. thickness without annealing. The addition of copper to gold makes the alloy more durable and less subject to abrasion, but at the same time less ductile and malleable. Pure gold melts at 1036 °C; gold with 10 per cent silver melts at about 1048 °C; gold with about 10 per cent copper at about 925 °C; gold with 20 per cent copper at about 880 °C. Ogden (1982) provides a well-illustrated general review of goldsmithing techniques in antiquity, though little of the evidence used is from Mesopotamia.

1 Hammered sheet gold and gilding

Before proceeding to a discussion of gilding it is necessary to draw attention to a basic distinction commonly made between 'true gilding' and 'depletion gilding' (or gold colouring) (cf. Lechtman 1971: 2 ff.; also, in general, Alexander 1979). In true gilding gold is applied to the surface of another metal; in certain circumstances the two metals may undergo interalloying, with the result that there is complete metallic bonding. In the second case the gold is already alloyed with another metal and it is a question of internal changes. Depletion gilding is based upon chemical reactions that occur only at the surface of alloys: the object is to remove sufficient of the alloyed metals for the surface to be enriched in gold and eventually appear golden. The two processes involve major technical distinctions, with true gilding being the commonest in ancient Mesopotamia from its appearance in the later prehistoric period. With true gilding the gold may be applied in its solid state as sheet or leaf or as an amalgam. Lechtman (1971: 2) 'arbitrarily' defined gold sheet or foil as greater than about one micron in thickness, whilst leaf constitutes thickness smaller than this. Since no systematic measurements have been taken of Mesopotamian hammered gold, there is no accurate way of applying this fine yardstick, so terms are used here without any assumptions about thickness. Gold overlays on ivories from Room SW 37 in Fort Shalmaneser at Nimrud are 0.07 mm. thick. They may be Syro-Phoenician (Herrmann 1986: 58).

Gold was beaten into very thin sheets in Mesopotamia from its earliest appearance there in the fourth millennium BC, probably on flat hard stones with stone hammers; a rounded tool being better suited for this purpose than a flat-faced one. Ogden identified such a tool from Ur: 'like a tiny pestle, slightly bulbous at one end and measuring only 19 mm in length. The material is haematite' (Plenderleith 1934: 295; Ogden 1982: 35 pl. 4:3); but it seems hardly large enough for the purpose. There is no definite indication of the use of the 'goldbeater's skin', although Plenderleith (1934: 295) argued that use of gut for harp and lyre strings at Ur, in the middle of the third millennium BC, indicated a mastery of this material which might well have been turned to use in making such a 'skin'. The earliest type of gilding depended, not on a physical or chemical bond between the gold foil and the base metal, but only on a mechanical folding of the foil over the edges of the underlying object. The joint might be improved by an adhesive or the overlapping edges joined by burnishing them together. A series of silver nails from the late prehistoric 'Eye Temple' at Brak, examined by Oddy *et al.* (1981), had heads gilded by wrapping gold sheet over the silver. Of gold beads from the Royal Cemetery at Ur, Plenderleith (1934: 295) wrote: 'beads of bituminous shale, wood, etc., have been found covered with

gold which is so thin that when removed and held by one end it hangs down, possessing insufficient rigidity to remain horizontal'. This technique was long and widely used, not only for beads. Early Dynastic III gold bracelets were sometimes made by hammering gold over a core which was then withdrawn (Maxwell-Hyslop 1971: 66). A gold bracelet in the Ur III grave PG 1847 at Ur is made of thin sheet gold over a copper core (Maxwell-Hyslop 1971: 69). Two millennia later at Ur a sheet-gold pin, with a head modelled as a draped human figure, was made over a wooden core (Woolley 1962: 106, pl. 21: U.456). The sheet-gold overlays were themselves sometimes ornamented. The spear-shafts from PG 755 at Ur, for example, have gold overlays worked to represent 'bamboo' (Woolley 1934: pl. 154. U.10023; Powell 1992: 111–12, on bamboo). An adze-blade and two chisels from royal tomb 800 are of copper alloy overlaid with sheet gold (British Museum 121349–51).

Sheet gold, too thin to support its own weight, requires a method of attachment. This may be either an adhesive (perhaps one based on egg-white) or the leaf may be attached to fairly pure silver or copper by burnishing, provided the metal surface is scrupulously clean when the gold is applied. The adhesion of the gold is enhanced by application of low-temperature heat to promote interdiffusion with the underlying metal ('diffusion-bonding' or 'cladding' (Oddy *et al.* 1981)). Such was the prime means of gilding until at least the Achaemenid period.

It is not yet clear when fire-gilding first appeared in the Near East, though it was used in Greece by the fourth century BC (Craddock 1977: 109–10; Healy 1978: 190 ff.). It has been suggested that it was an innovation of the Achaemenid period (Cooney 1964: 75); but hard evidence for this is not yet available. As the new technique was quicker and more effective for larger and more irregularly shaped objects, it superseded earlier methods. In fire-gilding an amalgam of mercury and powdered gold is spread over the surface of the silver, which is then heated to vaporize the mercury, leaving the gold behind in contact with the silver. Woolley (1938: 24) found metallic mercury at Al Mina in level III (c.430–375 BC) and believed it to be a traded commodity at this time. It was also found in one of the Achaemenid palaces at Susa (Labrousse and Bouchardat 1972: 86–7). Cinnabar, native mercury sulphide, was available near Kirkuk according to Campbell Thompson (1936: 29, 30), though his translation of the Akkadian *kalgukku* as 'mercury' has been superseded by the rendering 'red ochre or similar mineral' (Oppenheim 1970: 52 n. 58). It was also available at various places in Iran (Labrousse and Bouchardat 1972; Allan 1979: 1–2) and in Anatolia (Ryan 1969: 69–72).

Depletion gilding may only be identified through laboratory examination and there has been little of that. It also has to be borne in mind that apparent depletion

gilding may be no more than the result of selective corrosion whilst buried in the earth. Plenderleith (1934: 292) reported on a spearhead (U.9122) from RT 580 at Ur (Woolley 1934: pl. 227) as follows: 'This specimen had been broken in two by an unfortunate accident . . . the fractured surfaces were white, granular and crystalline, whilst the surface of the object was such a rich yellow as to suggest that it was gold of a high carat. The metal proved on analysis to contain only 30 per cent gold with about twice as much silver, the remainder being copper.' Smith (C. S. 1974: 160) has taken this to be the earliest documented example of an attempt to improve the colour of the electrum by the removal of natural alloying constituents, primarily silver, to yield a surface of pure gold. The silver, he points out, might have been removed by cementation (hot) with chlorides or by a (cold) parting reaction. Cementation, done hot, 'intrinsically depends upon solid state diffusion of the base metal to the surface of the alloy where it can chemically react and be removed. In most cementation mixtures the base metal diffuses to the surface nearly as rapidly as it can cross it, so that a rich gold surface can only be achieved by depletion to a considerable depth.' It is usually argued that parting, a selective corrosion process, could not have been done before the discovery of mineral acids in the Middle Ages. Although there are alternatives (e.g. ferric sulphate), there is no evidence for their use in the ancient Near East. Smith believes there was a probable connection between such early attempts to improve the colour of electrum, as evident in this third-millennium spearhead, and the discovery of processes that later became the basis of industrial refining. Certainly, on present evidence, it precedes in date evidence for the refining in bulk of naturally occurring gold to remove the silver content.

The shaping of sheet-gold vessels differs in no significant way from the methods employed for base metal. Smith (C. S. 1972: 124) has given a graphic description of how one of the fine mid-third-millennium gold beakers from Ur might have been worked:

This probably began as a thick cake of gold, which was hammered to a round flat sheet, from which the main cup shape was made by raising, that is, by a sequence of local hammer blows from a slightly convex hammer against the sheet metal held at a slight inclination against the rounded edge of an anvil, so producing innumerable little bends in concentric circles or in a close spiral which eventually integrate into the formation of a progressively deepening cup. Because metal is hardened by cold work, it would have been necessary to soften it repeatedly by annealing to allow the work to proceed. The fluting originated by local punching, i.e. a combination of *repoussé* and chasing done not against a hard anvil, but against an internal filling of pitch or some other material of strain-rate-dependent properties which provides moderately strong distributed support for the metal under a local blow, followed by slow

relaxation to conform to the new shape in preparation for the next stage of deformation.

The use of sheet gold for animal-head fittings, as on the musical instruments from the royal graves at Ur, and as parts of composite statuettes, as for the pair of rampant he-goats from RT 1237 at Ur, presents special problems. These were made from thin sheets, in the case of the heads probably hammered first into a bowl form, and then shaped to final form with a hammer and chasing tools. Maryon (1949: 99–100) has described a possible method, implicitly criticizing Plenderleith's (1934: 297) original proposals:

To do this it is quite possible that the gold was laid upon a boss of wood covered with bituminous compound, which would support the gold mask while it was being chased to shape. I do not feel that the craftsman would have spent his time in carving the complete mask in wood as a preparation and backing for his gold work. That would not be the way of a metal worker. He would prefer complete freedom for *repoussé* work, rather than the restricted certainty of the carved model . . . In a number of surviving heads the bitumen backing still remains within the thin gold. I do not know of any example where a wooden form or core comes immediately next the gold.

Ears and horns were often fitted separately. This assumes that the bitumen formed part of the forming processing and was not just poured in afterwards to support the metal, as seems to have been the case with bronze animal heads at Tell al-Ubaid (see p. 260).

Plenderleith (1934: 296 ff.) found much of the finer decoration on the goldwork from Ur to have been done by chasing rather than by engraving. On the diadem (U.8173: Woolley 1934: pl. 139), 'all the outlines of the figures are impressed by hammering the flat edge of the chasing tool or die on the gold'. Real engraving was noticed on a gold bowl from PG 755 (Woolley 1934: pl. 160: U.10003) 'where the fluting has been touched up by the engraver whereas the pattern round rim and foot is chased'. Inlaying is also first observed in Early Dynastic III at Ur, when strips of gold were hammered into engraved lines on spearheads. This technique was used two millennia later by Assyrian, or possibly Levantine, craftsmen to inlay gold scarabs on cuboid bronze weights (Layard 1853: 196, figure).

(2) Cast gold objects

In view of the greater quantities of metal required, the role of cast gold in Mesopotamia is likely to have been largely confined to objects in the royal or temple service or to small pieces of jewellery, like the copper or bronze pin from PG 755 with a cast-gold monkey as its head (Woolley 1934: 300, pl. 115: U.10010). Here again, as with sheet-metal working, methods for the most part would have been those used also for base metals. Maryon and Plenderleith (1954: 626) have described the casting of some well-known objects from the royal tombs at Ur:

Three- or four-pieced moulds were in regular use. Examination of a little gold monkey surmounting a bronze pin (PG 755), of the electrum onager on 'Queen Shubad's' (RT 800: Pu-abi) rein-ring, and of the silver bull on the king's rein-ring (RT 789) suggests that they were probably first modelled in wax, but then, like the axes, cast in piece-moulds. The monkey and the onager, as their surfaces indicate, were thoroughly 'chased' (i.e. cleaned down) after casting to remove all the casting webs and rough surfaces. The silver bull, however, was not smoothed, and the original cast surface can be seen. Surviving parts of the webs outline a piece of the mould which covered most of the right side of the bull's body. There would be other pieces also. Rough evidence is available to show that the wax or clay in which the bull was modelled could have been removed piecemeal when the side piece was lifted away from the rest of the mould.

(3) Filigree and cloisonné

Filigree, the ornamental use of fine wire to make delicate tracery, is used on the famous gold dagger from RT 580 at Ur; but shown at a higher level of technical achievement on a double-conoid bead from the same tomb (U.9779), again combined with granulation (Woolley 1934: pl. 138). Alone, or combined, filigree regularly appears thereafter on the surviving gold jewellery from Mesopotamia, notably on the fine Abbasashti necklace from Uruk of the Ur III period (Maxwell-Hyslop 1971: pl. 45; Nöldeke *et al.* 1937: 22 ff., pl. 39); in the 'Larsa Hoard' (Arnaud *et al.* 1979); on a Kassite bracelet from Aqar Quf (Maxwell-Hyslop 1971: pl. 127); in the remarkable collection of Middle Assyrian jewellery from grave 45 at Assur (Haller 1954: 140 ff.; Maxwell-Hyslop 1971: 169 ff.); and on the so-called Nimrud Jewel (Curtis and Maxwell-Hyslop 1971: 102 ff., fig., pl. XXXII) and many finds in the Nimrud royal tombs. From the earliest period gold wire had been used in simpler ways for beads and pendants, as is well illustrated by examples in the Royal Cemetery at Ur (Maxwell-Hyslop 1971: 10–11, pl. B (colour), 9–11).

The manufacture of gold wire throughout the time of this survey was without use of the draw-plate, not yet certainly known before the European Dark Ages (Oddy 1977; 1984). Carroll (1972: 323) has argued for a neat dichotomy in the early methods of wire manufacture: 'Egyptian smiths, and possibly other Near Eastern smiths, drew wire from a straight strip. Greek and Etruscan smiths twisted the strips before drawing them.' Oddy (1977 with important illustrations; also 1979; 1984) challenged this simple distinction and offered clear descriptions of the various ways gold wire might have been made before the draw-plate was invented. The concomitant, detailed examination of actual examples from Mesopotamia remains to be done. Oddy's categories were:

1. *Hammering*: in this, the simplest and most basic (though not necessarily the easiest) method, an ingot is hammered out until a wire with more or less round

and even section is produced. The wire, if not polished, has a faceted surface.

2. *Block-twisting*: this is done by hammering out an ingot to give a rod of the required thickness for the wire, twisted as tightly as possible and rolled between two flat pieces of wood (cf. Plenderleith 1934: 296).

3. *Strip-drawing*: this involves taking a strip of metal foil and drawing it through a series of holes of decreasing diameter so that the strip curls in upon itself to form a hollow tube. A steel draw-plate is not needed; the holes could be pierced in a hard wood or bone.

4. *Strip-twisting*: a strip of metal foil is cut and wrapped round an existing wire which is then removed. This helix is then tightened and gently extended by hand. This type of wire might also have been drawn through dies to finish it off.

A particular application of gold wire is illustrated by third-millennium gold chains. Plenderleith (1934: 296: pl. 134) examined the *brim* (male) headdress U.8693 from PG 429 at Ur and commented:

consisting of two lengths of gold chain and three large beads of gold and lapis divided by carnelian rings; but whereas the chains seem to have interlocking links giving a square section of traditional form (loop-in-loop) they are not really chains at all, not even flexible, but lengths of cut wire twisted on themselves and soldered together into an imitation which without careful examination would pass muster as the genuine thing.

A piece of fine gold chain was recovered from the area of Cemetery 'A' at Kish, but without precise context, though probably Early Dynastic III or early Akkadian in date. Mackay described it as follows:

It is 18.70 cm long and 5 mm thick, and is built up of wire links of such a form as to make the chain square in section. The wire of which the links are made is slightly over 1 mm in diameter and uniform in thickness. On examination under a magnifying glass the wire showed the characteristic longitudinal grooving associated with drawn wire . . .

(Mackay 1929: 182, pl. XLIII. 3, 5)

Mackay suggested drawing 'through a carnelian bead'. As Oddy has demonstrated, such lines need not be evidence of drawn wire in the strict modern sense of the term, and the Kish example fits well into his scheme for ancient wire-making. A piece of gold chain apparently of comparable type, if slightly later in date, was reported from old French excavations at Asherah (Terqa) in 1923 (Dhorme and Thureau-Dangin 1924: 288, pl. LX.8–9). A recent attempt to elucidate the technology of third-millennium loop-in-loop chains through an art-market example, purchased as Anatolian, raises more questions than it answers (Athanasopoulos *et al.* 1983).

Already in the Ur royal tombs *cloisons* were soldered to a base-plate to form cells for inlay on finger-rings (Woolley 1934: pl. 138: U.9778), and there is a particularly well-preserved example of this technique of the

same mid-third-millennium BC date from Telloh. This finger-ring is inlaid with lapis lazuli and cornelian (Sarzec and Heuzey 1884–1912: 391, pl. 44ter, fig. 3a, b; Margueron 1965: pl. 43 (in colour)). Silver hair-ornaments from RT 1237 at Ur, terminating in inlaid flowers, are more ornate illustrations of the same technique in Early Dynastic III (Woolley 1934: pl. 136). It became a technique recurrent through the history of Mesopotamian goldworking down to magnificent examples produced in the Neo-Assyrian period. Then, and perhaps earlier in the Kassite and Middle Assyrian periods (Maxwell-Hyslop 1971: 167), it is possible that sporadically closer contacts with Egypt, where this technique was typical, stimulated the use of *cloisonné* work in Mesopotamia and Iran. Very fine examples of such decoration are to be seen on Neo-Assyrian gold bracelets found at Nimrud in 1988–9 (*Archaeology* (July/Aug. 1990), 51 (colour); Nashef 1990: figs. 24–5).

(4) Joining methods

Archaeological literature contains many confusions over the terms soldering, brazing, and welding that have not been eased by technical experts introducing such words as sweating, fusing, and autogenous soldering. An important fundamental distinction has first to be drawn between soldering (whether 'hard' or 'soft') which involves an agent (the solder), and welding, which does not. As soft-soldering is not relevant to goldworking, it will be discussed elsewhere (see p. 274); but it may usefully be defined here as the employment of lead, or occasionally tin, rarely tin-lead before late Roman times, with a melting point which is below 427 °C (800 °F), that is below the temperature at which the work is done, and also below the melting point of the metals to be joined. 'Soldering and brazing are joining techniques employing filler metal at temperatures below solidus of the metals being joined. Conventionally, soldering refers to processes below 450 °C; brazing to processes above 450 °C' (Fell 1982).

To promote flow of the solder a liquid flux is required. Pliny was the first to describe specific fluxing agents (oils and fats, wax and honey, and artificially prepared products from dung and urine, etc.); but they are extremely difficult to detect, with the possible exception of borax, in corroded ancient joints. Fell (1982) has tested a whole series of potential fluxes listed in classical and medieval literature for low-temperature and for high-temperature work; but his results cannot at present be directly correlated with Mesopotamian evidence.

Brazing (or hard-soldering) is 'the production of a joint by means of an alloy of reasonably high strength having a melting point somewhat lower than that of the metals or alloys to be joined' (Roberts 1973: 113). Brazers form molecular bonds with the surface they unite and are therefore stronger than soft-soldered

joints. Whereas soft solders are generally greyish white in colour, brazers may be made to match closely the colours of the metals to be joined. Plenderleith (1934: 296) and Maryon (1949: 108) suggested that the goldsmiths at Ur used a native gold alloy:

The highly decorated beads like U.9779 (Woolley 1934: pl. 138), are generally sweated, i.e. the filigree and granulations are attached to the background by carefully controlled heat without the extraneous medium of solder; but the flat disk beads made from two thicknesses of metal joined together so as to leave a hole for the thread through the centre were apparently soldered (Type 16, Woolley 1934: fig. 70). Apparently the gold beads of tubular form, either barrel-shaped or in the form of two cones, base to base, all have a longitudinal soldered seam; the solder used would be either a thin strip of the same gold (autogenous soldering) or an alloy richer in silver and consequently of a lower melting point than gold.

(Plenderleith 1934: 296)

The selection of such a brazing alloy for the manufacture of gold joints would have been a matter of some complexity. The extremely high melting point of native golds makes them difficult to use as brazers, whilst native gold alloys containing enough silver to be of use for brazing are distinctly lighter in colour. But the striking feature of some Ur objects is the very uniformity of colour in the area of joins. This may sometimes, if not wholly, be explained by the disappearance of metals other than gold from the surface of the brazing alloy through the action of chemicals in the earth among which it was buried ('surface enrichment'), as Maryon argued (1949: 114). He also cited the view of Littledale that 'when a joint is overfired the solder penetrates further and further into the surrounding metal, alloying itself with it, and becoming more like it in quality, until the colour of the solder is indistinguishable from that of the work'. Smith (E. A. 1930: 22) and Plenderleith (1934: 296) explained this lack of colour difference by the use of a piece of metal of the same alloy as the pieces they joined. Even when the ancient craftsmen had solved the problems both of colour and melting point, they still had to control the flow of the brazer, which tends to flow towards the hottest area of the parts being fastened. With a charcoal fire and blow-pipe or bellows, the amount and direction would have been very hard to control successfully.

Roberts (1973: 115) has described early brazing technique, suggesting natron (sodium carbonate) as the most likely flux, though he does not demonstrate that this would be effective (use of a weak acid might be more likely):

small pieces or chips of the chosen brazing alloy would then have been laid in position, or held in position by small pieces of wire, around the joint to be made, a flux of some kind would have been applied to the surfaces to be joined, and the work put into a charcoal fire—or held by tongs in the fire—until the brazing alloy became

molten. The flame was then concentrated on the joint, with the reed blow-pipe, and the brazing alloy would flow by capillary attraction into the space between the surfaces to be joined. Later the metalworker would clean off residual traces of flux from the work, probably by scraping.

Roberts examined in detail a pedestal bowl (U.10452 (BM 121345): Woolley 1934: pl. 160a) from RT 800 at Ur, which had held green eye-paint. It is electrum (25 per cent silver) with a double-walled upper part, and a brazed joint round the junction of bowl and pedestal foot. There is a mechanical joint at the rim. On a bowl from the same tomb, with a twisted wire handle, the fillet of the brazed joint between the tubular lugs and the body of the vessel is still clear (cf. Lang and Hughes 1977: 169: U.10851 (BM 121344), Woolley 1934: pl. 161b).

Duval *et al.* (1989) have reported on the joining methods used on three pieces of Elamite gold jewellery from Susa. The earliest, a late fourth-millennium dog-shaped pendant, has already been noted (p. 222). A mid-third-millennium BC basket-shaped earring had apparently been joined without use of a solder; 'welding was attempted, despite the difficulty of limiting the damaging effect of the necessarily high temperature (in excess of 1050 °C) on the components or decoration'. The metal was approximately 90 per cent Au, 10 per cent Ag, 1–1.5 per cent Cu. A piece of later second-millennium BC Middle Elamite gold foil, with granulation, offered evidence of hard-soldering by diffusion bonding. The metals were:

Granule: 67% Au; 31–2% Ag; 1.5–2% Cu.

Foil: 79% Au; 20% Ag; 2% Cu.

Join: 25–8% Ag; 3–4% Cu.

The melting point of the granule and foil would be about 1000 °C; introduction of the copper mineral compound allowed for a join at 800–900 °C. A copper salt may have been mixed with an adhesive or flux before use.

It is necessary to say that cold welding, in the modern sense of pressure welding, is not practical under ordinary conditions and is most unlikely to account for any ancient solderless joints. Only the gold-beater, who makes gold leaf for gilding, may be accounted an exception, for he repairs a defective leaf by laying a fresh piece of gold over the gap and welds it into position by hammer pressure alone.

(5) Granulation

Granulation is the most studied (Wolters 1981; 1983), and consequently one of the most controversial aspects of ancient jewellery, for it may not be assumed that only one method was used throughout antiquity nor that variations are predictable, as has sometimes been done in the past in the large literature on the question (cf. Carroll 1974). In granulation the craftsman arranges small grains of metal in an ornamental or figurative pattern on a metal surface, with the granules held

in place by joining them to the base (Wolters 1981). Many examples of granulation showing remnants of solder were obviously produced with solder alloys and fluxes, probably in no way different from those used for other contemporary goldwork described above (metal alloy granulation). Modern experiments to replicate such work have used a gold, silver, and copper solder for gold, and a mixture of silver and copper for silver (Carroll 1974: 35). But granulation without evident traces of solder must have been produced in some other way. The extent to which sintered granulation was used in ancient Mesopotamia remains a matter for detailed investigation. In this method a join is made by heating the metal surfaces to be joined to melting point (without reaching the point at which the bulk of the metal would become liquid), so that both surfaces are enriched in copper and silver relative to the insides. Carroll (1974: 36) has demonstrated that such a method is feasible with simple equipment, since temperatures can be estimated by observation of the visual changes at the surface (but cf. Wolters 1981: 125–6). A grain ring-bead from the Royal Cemetery at Ur may be the earliest recognized example of sintered granulation (Plenderleith 1934: 297; cf. Seeley, in Maxwell-Hyslop 1977: 86); its date, however, is not certain.

Much early research into methods of granulation rested on the false assumption that only one technique had been used in antiquity. This, it was argued, had been 'lost' and then 'found' again by modern research, notably through the experimental work of H. A. P. Littledale, patented in 1933 (cf. Maryon and Plenderleith 1954: 657). The key to this method was the use of copper-salt as solder (copper-salt granulation): a method, of greater adaptability than sintering, which might be used both for granulation and filigree, and achieved bonding through surface alloying. Finely powdered copper-salt is laid on the surfaces to be joined,

with carbon as the reducing agent. Under heat, the copper-salt is reduced to metallic copper. At sufficiently high temperature it alloys with gold in the surface zones and lowers its melting point. 'The carbon monoxide from the charcoal fire, and also from the reduction of the copper oxide, will not only serve as a reducing agent to remove any oxide films on the work, but also prevent access of oxygen to the parts being heated. Thus the parent metal surface is free from oxides and the prime requirements for the production of a brazed joint have been satisfied' (Roberts 1973: 117). Wolters (1981: 127) has argued that, apart from the very obvious use of metallic solders, bonding with non-metallic solders in this way is the only feasible method with ancient heating resources and produces all the technical characteristics of ancient granulation. As small metal particles tend to assume a spherical shape in melting, their formation would not have presented a problem. They would have been positioned with the use of an organic adhesive before proceeding with the joining process.

As Carroll (1974: 38) pointed out, care is needed in identifying granulation. Among the gold objects in the royal tombs at Ur, there are dagger-hilts which appear to be decorated in this way, but are not (Woolley 1934: pls. 151, 155, 157, 190). The 'grains' in these cases are the heads of tiny nails, possibly made by heating the tip of a wire until it became molten and formed a ball.

(g) Select Analyses:

1. *Tepe Gawra*: gold bead from tomb 109; late prehistoric period (Tobler 1950: 88 n. 30).

Cu: 0.56 per cent
Ag: 61.39 per cent
Au: 38.05 per cent

2. *Ur*: A: All Early Dynastic III 'Royal Cemetery', from table in Woolley 1934 (table III); analyses by Plenderleith, Johnson, Matthey, and Co.; and E. C. Padgham:

	Gold (%)	Silver (%)	Copper (%)	Approx. carat
1. Spearhead (U.9122)	30.30	59.37	10.35	7
2. Ass on rein-ring (U.10439)	65.60	31.45	2.65	16
3. Mes-kalam-dug 'helmet' (U.10000)	—	—	—	15
4. Plain beaker (U.10452)	75.62	23.34	1.04	18
5. Fluted beaker (U.10453)	73.48	24.73	1.79	18
6. Round bowl (U.10002)	58.16	40.04	1.80	14
7. Oval bowl (U.10001)	60.63	37.07	2.30	15
8. Fluted bowl (U.10003)	72.56	25.44	2.00	17
9. 'Lamp' (U.10004)	60.00	38.60	1.40	14
10. Dagger (U.10020)	91.11	7.69	1.20	22
11. Headdress: leaf (U. no. absent)	67.17	32.38	0.45	16
12. Ribbon (U.12388)	77.84	21.74	0.42	19
13. Hair-ribbon (U. no. absent)	75.11	24.57	0.32	18
14. " (U. no. absent)	77.77	21.16	1.07	19
15. " (U. no. absent)	77.44	22.06	0.50	18

			Gold (%)	Silver (%)	Copper (%)	Approx. carat
16.	..	(U. no. absent)	77.77	21.16	1.07	19
17.	..	(U. no. absent)	70.91	27.52	1.57	17
18.	..	(U. no. absent)	77.44	22.06	0.50	18
19.	..	(U. no. absent)	71.36	27.86	0.81	17
20.	..	(U. no. absent)	83.95	13.95	2.10	20
21.	..	(U. no. absent)	76.98	20.72	2.30	18

Source: After Woolley 1934: table III.

B: (i) 6-granule gold ring, said to be from RT 800 (Pu-abi): (Seeley, in Maxwell-Hyslop 1977: 86); this provenance and the early date are not absolutely certain.

Granule 1: 100% Au
Granules 2-5: 80-90% Au
9-20% Ag
0.5-1% Cu

(ii) Fragment of gold strip with attached granules, also said to be RT 800 (Pu-abi):

Granules: 77% Au
18% Ag
5% Cu
Base: 88% Au
10% Ag
2% Cu

3. *Private Collection, London*: source unknown; tiny Neo-Assyrian winged, bird-headed demon carrying a bucket (cf. *Boston Museum of Fine Arts: The Museum Year 1989-90*: 28 (figure)); lost-wax casting:

Au: 63%; Ag: 33%; Cu: 2%; Pb: 2% (the presence of lead indicates an artificial alloy) (J. P. Northover: personal communication, 1991).

4. *Ingots*: the electrum ring-ingots of the Chalcolithic period in Palestine (c.4000-3500 BC) illustrate long-distance exchange of gold at an early date, possibly from sources in Egypt. They are the only gold ingots from the Near East so far published; see table below for analyses.

(iii) SILVER

(a) *Recovery*

Silver (Ag) is found in nature both as a metal and in its non-metallic state. It also occurs in practically all gold. Native silver is rare (20 per cent as abundant as gold; 0.2 per cent as abundant as native copper) and is usually found in quantities not worth melting to make larger, workable lumps (Patterson 1971). It generally appears deep underground as, if appearing at the surface, it is liable to have been converted into chloride by traces of chlorine invariably present in rain-water. It is practically pure. The principal ores of silver are the sulphides (argentite: silver glance) and the chlorides (cerargyrite: horn silver), which yield up their metal by simple smelting. It has long been generally assumed that most of the silver used in the Near East in antiquity was extracted from argentiferous lead ores, notably galena (lead sulphide) and cerussite (lead carbonate), but it is possible that the silver ores were used more than is presently assumed.

No.	Maximum outer diameter (cm)	Maximum inner diameter (cm)	Width (cm)	Thickness (cm)	Weight (g)	Volume (cm ³)	Specific Gravity	% Gold	Surface % Gold	% Silver	Surface % Silver	% Copper	Surface % Copper
1.	4.35	2.50	0.73-0.87	0.78-0.92	106.9735	6.5992	16.21	64.43	80.40	35.22	19.40	0.35	0.20
2.	4.79	2.82	0.87-1.02	0.71-0.87	137.3847	8.1539	16.84	71.45	90.29	28.04	9.42	0.51	0.29
3.	4.28	2.47	0.75-0.95	0.64-0.80	88.0622	5.2913	16.64	87.61	87.61	30.33	12.15	0.42	0.24
4.	4.46	2.41	0.97-1.07	0.72-0.87	136.0862	7.0886	19.19	98.00	96.38	1.47	3.32	0.53	0.30
5.	5.04	3.13	0.90-1.03	0.82-1.13	165.0271	9.9138	16.64	68.68	86.05	30.07	13.24	1.25	0.71
6.	4.89	3.29	0.78-0.80	0.80-0.93	108.5928	6.5071	16.68	69.53	88.47	29.81	11.15	0.66	0.38
7.	4.47	2.47	0.87-1.00	0.82-0.86	—	—	—	—	—	—	—	—	—
8.	4.59	2.52	0.87-1.02	0.67-0.84	—	—	—	—	—	—	—	—	—

Note: Composition determined by scanning electron microscope JEOL-840 with energy-dispersive X-ray microanalyser LINK-860, with analyses made at 6-12 points on both upper and lower surfaces. No. 3 was examined by atomic absorption spectroscopy both unetched and etched by hydrochloric acid + chromium oxide (c.1 : 20). Nos. 7 and 8 were found after the analyses of the others had been completed.
Source: After Gopher *et al.* 1990.

Smith (C. S. 1967: 35), indeed, has argued that the earliest silver artefacts were made either of native crystals or of cerargyrite. Wertime (1973: 883), following his expeditions to Turkey, suggested that in the Anatolian-Iranian highlands the lead-miners of the early periods concentrated on the rare cerussites rather than mining for galena. It was below the water table and its smelting was far less rewarding than the working of cerussites. Meyers (in Waldbaum 1983: 188) shares this view:

Based on comparisons of elemental compositions of silver coins, silver objects and ore samples and using information from geological and archaeological surveys and from literary evidence, it appears that most silver produced in Anatolia, including that excavated at Sardis (Achaemenid Period), was extracted from the ore cerussite (lead carbonate), the major component in the oxidized portions of lead deposits.

Meyers (*Archaeomaterials*, 2 (1988), 196) has further argued, on the basis of a thousand silver analyses, that cupellation from galena did not start in Iran until the ninth or tenth century AD; previously cerussite had been used. He points out that gold and iridium are the major discriminating elements because they appear in high concentrations in cerussite, low in galena. By contrast, it appears, Aegean silver was largely produced from galena.

Two steps are involved in producing silver from lead ores. Lead ore is smelted first under the appropriate reducing and/or oxidizing conditions to produce metallic lead. Silver is then extracted from the lead by cupellation by which the lead is oxidized to litharge (lead oxide), leaving behind the silver. For this the lead is heated under strongly oxidizing conditions in a cupel. The lead oxide so formed is absorbed in the porous material of bone or ground-up potsherds in the cupel, leaving silver metal behind. This process may be repeated several times to purify the silver; it is very efficient in freeing silver from such common impurities as copper, antimony, arsenic, tin, iron, zinc (less well from bismuth), in the argentiferous lead. Silver derived from argentiferous galena will be characterized by gold contents from zero to about 0.5 per cent, lead contents between 0.01 per cent and 1 per cent, or rarely a little higher (Gale and Stos-Gale 1981: 107). Silver derived from the native metal, with or without admixture of cerargyrite (a 'dry' silver ore very easily reduced to silver metal), will generally contain less than 0.01 per cent gold and significant quantities of mercury (*ibid.*).

It is possible that silver was recovered sometimes from the cementation process (see p. 218) through which electrum was purified into gold. But there is, as yet, no hard evidence for this from literary, archaeological, or analytical sources, in the area and time range considered here.

It has recently been suggested that liquation, using

lead metal to extract silver from copper, thought first to have been described by Agricola in the Renaissance, had already been practised in the Late Bronze Age in installations excavated at Ras Ibn Hani in Syria (Bordreuil *et al.* 1984: 404-8, figs. 4-5). This identification is doubtful. The Old Babylonian texts from Mari cited in support of the existence of this process in the Near East in the second millennium BC do not sustain the case. They indicate that 'mountain copper' was 'washed' (? purified/refined) to produce 'washed copper' and that lead was used with silver to produce 'washed silver'; but they do not show that lead was added to copper to produce 'washed' silver, which is what would be expected if they are to be taken as evidence for the extraction of silver from copper by liquation (Bordreuil *et al.* 1984: 407, citing Durand). That lead was plentiful in excavations at Ras Ibn Hani is not relevant to this question. What matters is the method of purifying, and there is no reason to suppose it was liquation either at Mari or at Ras Ibn Hani (cf. Muhly 1988).

Any conjectures about the origins of silver metallurgy in the Near East have to take into account the long interval between the first appearance of lead, some time in the seventh millennium BC in Turkey (Jesus 1980: 76), and the earliest manufactured silver, some three millennia later, when it appears relatively suddenly over a wide area (Prag 1978). Lead, which could only have been obtained by smelting, had long been experimented with before the appearance of silver. The view, argued over a long period by a number of scholars (cf. Gowland 1920: 132; Hoover 1950: 390; Wertime 1973: 883), that silver was discovered in the course of the accidental cupellation of lead, remains a strong possibility in the Near East. But, even after the initial discovery, the recovery of worthwhile quantities of silver required the solution of a number of technical difficulties, for a ton of smelted lead will only contain a few ounces of silver.

Oppenheim (1966) published and commented on a text from the library of Ashurbanipal (668-627 BC), for making a silver-like alloy from base-metal ingredients. How much older such deceptions were has yet to be established. The later economic texts from Mesopotamia are much concerned with the quality of silver and carefully stress the percentage of permitted additions; but far too few analyses have been done to offer any information on the ways in which, for specific purposes, silver might be debased. Nor, owing to the way in which buried silver corrodes, is it likely that archaeology will ever provide any check on textual indications that silver surfaces were variously treated with heat (Limet 1960: 49-50). Moreover, under field conditions corroded silver may easily be confused with copper or bronze, so the number of silver objects from excavations may at present be underrated.

(b) Sources:

(1) The evidence of ancient texts

As Limet (1960: 94) has pointed out, textual indications for the ultimate sources of the silver used in Mesopotamia are singularly rare and meagre. Pettinato (1972: 80–1), in his review of the Sumerian literary evidence, listed such relatively well-known regions in Iran, the Gulf and the Indus valley, as *Aratta*, *Dilmun*, *Elam*, *Marhashi*, and *Meluhha*. 'The Silver Mountains' limited the campaigns of Sargon of Akkad to the north-west (Hirsch 1963: 38, lines 22–8) and are usually identified with silver-mines at Keban on the Upper Euphrates, just south of its junction with the Murat river. Manishtushu recorded a campaign in which his army was divided into two, one part invaded 'Anshan and Sherikhum' in Iran, whilst the other waged war 'up to the silver mines' (Hirsch 1963: 69; Gadd 1971: 438 ff. considers the geographical problems). Heimpel (1982: 67) suggests they might just be 'metal' mines. Gudea wrote of silver from its mountain, taken by Limet (1960: 94–5) to refer to a source east of the Tigris in Iran. In his summary table of the evidence provided by the *lipšur* litanies and the HAR-ra series 22, Snell (1982: 212) lists *Zar-šu*, *Hašbar*, *la-an-na-ki-ta*, and *Ku-su* as silver sources; but of these places only one may be tentatively identified: *Ku-su*? = Kush (Nubia) and that seems unlikely before the first millennium BC.

It is to the earlier second millennium BC that some of the best textual evidence for the use of Anatolian silver belongs. Larsen (1967: 4) has succinctly described the famous trade between Assur and eastern Anatolia at this time: 'The pattern of the trade as revealed by the texts is clear; tin and textiles were imported into Anatolia and in return silver and gold were sent back to Assyria. The trade in copper was vigorous but seems to have been mainly an internal Anatolian affair.' The silver was either in ingots passing by weight, or sometimes in rings or packages containing bars of metal. Different types of silver are distinguished, probably by quality; various towns in the vicinity of Kültepe (Karum Kanesh) are listed as the sources of silver, but they are probably just the principal centres for its distribution (Garelli 1963: 265 ff.). Leemans (1960: 130 ff.) preferred not to speculate on the origin of the silver current in Babylonia during the Old Babylonian period, as it was then widely used as currency. There is some indication of silver coming up the Gulf (Oppenheim 1954). Hittite inventory texts of the thirteenth century BC attribute silver to *Saqqamaha* and *Arpa* in the north-central region of Turkey (Koşak 1982: 197).

For the Neo-Assyrian period, on the evidence of the tribute lists analysed by Jankowska (1969: 261), in the ranking of the regions with the most silver, Carchemish (*Khatti*) and Damascus come first, with the centres of

Tabal (east Anatolian plateau), *Karduniaš* (Babylon), and Judah next, *Muṣasir* ranked third. A mention of 'silver (capital) of the Habur river' refers only to the direction of trade (Oppenheim 1970: 10 n. 22). However, Shalmaneser III wrote of going to 'Mount Tunni (Taurus), the silver mountain, (and) Mount Muli, the marble mountain' (Meissner 1912; Luckenbill 1926–7: i. 246). According to the 'Foundation Charter' of Darius I, the silver used in his time at Susa was from Egypt (Vallat 1971).

Three circular silver ingots ('cake-ingots') bearing the name of Bar-Rakib were found in an eighth-century context at Sinjirli in south-east Anatolia (Andrae 1943: 119–21, pl. 58); the only complete example weighs 497.37 g. They were accompanied by a number of small cast-silver blocks of irregular weight. Silver ingots are otherwise rarely found in Near Eastern excavations (cf. Bivar 1971; Curtis 1984 (Nushi-i-Jan, Iran); Karageorghis *et al.* 1983 (Cyprus and Egypt)).

(2) Scientific determination

Lead isotope provenancing may be used to fingerprint silver recovered from deposits of argentiferous lead (see p. 293.) Another approach is to be seen in work by Meyers (1981) on Sasanian silver from Iran. This demonstrated that 'the elemental compositions of the silver alloys, especially the concentrations of gold and iridium and to a lesser extent those of arsenic, antimony, zinc, tin and selenium—allow a number of conclusions on the use of ore sources and the distribution of silver to mints and workshops'. As with lead isotopes, although it may not be possible to demonstrate the location of ore sources, it is possible to define compositionally homogeneous groups of artefacts probably made with metal from a single ore source.

(3) Known mining areas

To the east. Deposits of argentiferous lead are widely distributed in Iran. Ladame (1945: 276: 89; cf. Tachizadeh and Mallakpour 1976) listed sources in Azerbaijan, in the Miyana-Zanjan and the Sava-Qazvin-Teheran regions, in Khwasan, in the Isphahan-Kashan and Anarak-Yazd areas, and in Kerman. In medieval times two Iranian provinces in particular, Transoxiana and Khwasan, were renowned for silver (Allan 1979: 13). Some of these sources were worked from the fourth millennium and could have supplied Mesopotamia. Surface survey and analytical data from the restudy project at Tepe Hissar in north-east Iran in 1976 (Dyson and Howard 1989) indicated that lead was being smelted in the 'Craftsmen's Quarter' on South Hill in the third millennium BC. Among the slags and other metallurgical debris is a certain quantity of what may be litharge (Tosi 1989: 14; cf. Stech and Pigott 1986: 49). It is likely that the silver objects in Hissar II–III, personal ornaments save for a few vessels in III,

had been made from silver cupelled from lead smelted at the site. Silver objects appear sporadically on late fourth- and third-millennium sites in Iran, most commonly as ornaments (Stech and Pigott 1986: 49). A number of ornaments and some elaborately decorated vessels, recovered through the antiquities market, may indicate wider exploitation in Iran for high-status purposes from the fourth millennium BC through the third (Hansen 1970; Hinz 1969: 11 ff.) than is yet apparent in publication of controlled excavations.

Marco Polo documents productive silver mines in Badakhshan (i. 24; cf. Chmyriov *et al.* 1973). Among the metalwork circulated on the antiquities market in recent years as from 'Bactria', there is recurrent use of silver, even for weapons, alloyed with copper or arsenical copper, in the later third and early second millennium BC. Some of this silver may be from silver ores rather than argentiferous lead ores (Pieter Meyers: personal communication). Modern mineralogical reports on Afghanistan suggest the sources lay outside this modern political unit, since it is said to have virtually no silver and its numerous lead deposits are very low in silver (Stech and Pigott 1986: 49). India is a possible silver source according to classical sources (Strabo, xv. i. 30, cap. 700; Ktesias, *Indika*, cap. 11), though Ratnagar (1981: 140 ff.) attributes the rare occurrences of silver in the Indus Valley Civilization to trade with Sumer.

To south, south-west, and west. The Arabian peninsula is poor in silver and lead ores, save for those east of the Gulf of Aqaba exploited by the Nabataeans (Strabo, xvi. iv, 26, cap. 784). Reliable reports of silver sources in antiquity in the Gulf are absent. The origin of the silver used in ancient Egypt is a long-standing problem (Lucas 1962: 254 ff.). Neither native silver nor the dry silver ores, nor jarositic, nor other gossan-associated silver ores have been reported there. Analyses (Gale and Stos-Gale 1981) also indicate that the silver content of local galena is too low for it to have been exploited in antiquity. As a result of analyses it is increasingly thought that the primary local source of silver was aurian silver (with more than 10 per cent gold) extracted from gold mines, perhaps in the eastern desert. How early this was exploited is still an open question, since the silver found in Predynastic Egypt may have been imported from Western Asia (Prag 1978; cf. lead isotope analyses: p. 293 here). No silver sources are geologically verified in Syro-Palestine.

To the north and north-west. Anatolia has the greatest quantity of geologically identified silver-bearing ores of any of Mesopotamia's neighbours. 'The lead-silver deposits are widespread in Turkey, but they do not seem to have a dense concentration like those of copper or iron. However, there is a tendency for the deposits to limit themselves to the northern Anatolian fold and the southern Anatolian fold' (Jesus 1980: 64 ff., map

13). In recent years Yener (1986; *et al.* 1989) has masterminded an interdisciplinary research project on the ancient sources of silver in Anatolia, focusing in particular on the Bolkardag mining district of the Taurus Mountains (cf. Muhly *et al.* 1991), thought in general to be the 'silver mountain' of the Akkadian kings' inscriptions. This area has long been known for some of the richest argentiferous lead ore deposits in the Near East and for its potential role in early metallurgy (see p. 294 for lead isotope analysis). Although there are still chronological problems, it seems that silver may already have been extracted from lead ores for manufacture in Anatolia during the fourth millennium and that silver was already exported to ports like Byblos in the Lebanon for onward transmission to Egypt (Prag 1978; Stech and Pigott 1986: 50–1).

In the third millennium a distinct pattern becomes evident which strongly suggests silver trading from Anatolia down the line of the Euphrates into Sumer. The Kültepe texts of the earlier second millennium BC vividly document a trade in which merchants from Assur sought gold and silver from Anatolia in exchange for textiles and tin (see p. 298 here). That much, if not the greater part, of the silver used in Mesopotamia from the fourth millennium to the Achaemenid period came from Anatolia rather than elsewhere seems most probable; but much remains to be discovered about which mining regions were most exploited in antiquity and how. Marco Polo (i. 4) specifies Armenia (eastern Anatolia) as rich in silver. Bulgar Maden, which has produced a sample containing 1.8 per cent silver, has long been assumed to be a major source of silver in antiquity (Meissner 1912), but the case remains unproven (Jesus 1980: 64).

(c) The repertory of objects. c.3500–350 BC:

In the second half of the fourth millennium BC there was a 'surprisingly widespread use (and preservation) of silver objects, which have been found in relatively large numbers, relatively that is in metallurgical terms, in Egypt, Levant and in Anatolia' (Prag 1978: 36). Although the indications remain meagre, this silver was, at least in part, cupelled silver (Prag 1978: 40; Gale and Stos-Gale 1981). This marked increase in the presence of silver objects coincides broadly in Mesopotamia with an unusual occurrence of lead vessels, not so well documented before or after in the archaeological record (see p. 294 here). The silver objects of the later prehistoric period from Mesopotamia are not numerous: vessels (Heinrich 1936: 45, pl. 35); parts of animal statuettes (Nöldeke *et al.* 1936: pl. 23a–s); a stamen in an artificial flower (Heinrich 1936: 41, pl. 30c); cast recumbent animal handles on large cylinder seals (Heinrich 1936: pl. 17a, b; cf. Hamilton 1967); a recumbent stone bull 'support' with a silver spike projecting upwards from its back (Heinrich 1936: pl. 6); a copper-

silver alloy (25 per cent Ag) harpoon-head (Lenzen 1959: 10, pl. 18b; Müller-Karpe 1991: 109, fig. 3). There are isolated earrings from the so-called Jamdat Nasr graves at Ur (Woolley 1956: 116, gr. 219; 188, gr. 239). A child's necklace from Susa, dated to the Ca(?) phase, in the middle of the fourth millennium BC., has seven silver pendants with *cloisons*, inlaid with haematite partially gilded (Amiet 1966: pl. 46; Tallon 1987: 263, nos. 1159–60).

As Prag (1978) argued, the pattern of silver finds in the Levant and in Egypt towards the end of the fourth millennium would be consonant with an Anatolian source for the metal (Jesus 1980: 75 ff.; the Beycesultan silver ring should be dated c.3000 not 4000 BC, cf. Prag 1978: 44 n. 60). In northern Mesopotamia, apart from silver nails in the 'Eye-Temple' at Brak (Mallowan 1947: 93), the isolated early silver finds are not closely dated. They are probably of the third rather than the later fourth millennium BC, like a silver pin and finger-ring from a tomb in stratum 6 at Tell Billa (Speiser 1931: 12); another pin attributed to level 5 in Mallowan's deep sounding at Nineveh (Campbell Thompson and Mallowan 1933: 145, pl. LXVIII:7); and a disk from Brak (Mallowan 1947: 171, pl. XXXII:7).

By the time of the royal tombs at Ur, in the middle of the third millennium BC, the silver repertory was more extensive: belts (Woolley 1934: pls. 12–13); a 'comb' (ibid.: pl. 20); bowls (ibid.: pls. 33, 42, 167, 171–2); a ewer (ibid.: pl. 172); a fluted bowl (ibid.: pls. 172); tumblers (ibid.: pl. 172); lyre fittings (ibid.: pls. 75–6, 111–12); a cow's head (ibid.: pl. 120); the head of a lioness (ibid.: pls. 127–30); hair-ornaments (ibid.: pls. 136–7); imitation cockle shells for cosmetics (ibid.: pl. 137); sheet-silver bindings for spear-shafts (ibid.: pl. 149); pins (ibid.: pls. 159, 189); a boat model (ibid.: pl. 169); a lamp (?) (ibid.: pl. 170); a libation vessel (ibid.: pl. 171); vessels with electrum handles and electrum ribbons 'sweated on' (ibid.: pl. 173); a tube with holes at regular intervals; double pipe (ibid.: p. 258); nose-rings for oxen (ibid.: 64, pl. 35); and a rein-ring (ibid.: 78, 301, pls. 166–7). Four silver spearheads were found in RT 789 (U.19472: Woolley 1934: pl. 153) and silver axeheads in PGs 250 (U.8428), 560 (U.9247), and 1422 (Neo-Sumerian: U.12478: Woolley 1934: pl. 223). RT 580 contained 'two long spindles of silver with lapis lazuli spindle-whorls' (Woolley 1934: 53: U.9777).

Millichamp and Levey (cited by Organ 1967) published a series of analyses of the more massive pieces of silver jewellery from Ur, now in the University Museum, Philadelphia. In all the objects silver registered as the major constituent, but with copper in a range of 1–5 per cent. The presence of this copper might have been an inevitable impurity in repeated remelting, or an economy, or an attempt to harden the silver.

Away from Ur there is a wide scatter of evidence. Coiled silver wire was found at Tell al-Ubaid (Hall and Woolley 1927: 103, fig.) in an Early Dynastic IIIB context. Some particularly fine filigree work is encountered on silver medallions during Early Dynastic III (Maxwell-Hyslop 1971: 15, pl. 14 (Uruk)). A grave of a child at Abu Salabikh contained a remarkable collection of silver objects: a roundel; an 'eye-patch'; a pair of sandals and a long bead (Postgate 1980: 94, pl. X). The so-called Early Dynastic III 'Treasure of Ur' from Mari contained silver, gold, and lapis lazuli pendants, silver bracelets and pins, silver 'rosettes', and, on a necklace, a silver 'wheel' and bead separator (Parrot 1968: pls. XI, XIII, XV, XVII).

The outstanding silver object to have survived from Early Dynastic Mesopotamia is the display vase of King Entemena of Lagash found at Telloh and now in the Louvre (Maryon and Plenderleith 1954: 653). It was hammered up from a single sheet of silver except for the inside of the neck, which is lined with a plain deep silver collar, silver-soldered into position. The vase is set on a copper foot, now much corroded. It is engraved(?) with an inscription on the tall neck, then with a frieze of calves *couchant* on the shoulder. On the body of the vessel, framed by herring-bone bands, are four repeats of the lion-headed eagle (Imdugud). First he grasps a pair of lions in his talons, then two goats, again a couple of lions, then a pair of oxen (Sarzec and Heuzey 1884–1912: 261–4, pl. 43, 43bis; Parrot 1948: 108–9, pl. VIIIa). A fragmentary silver bowl from PG 1130 at Ur (Woolley 1934: pl. 167, 217: U.11794) is decorated round the side with a frieze of mountain goats moving through hilly country. It is all in *repoussé*, finished by chasing.

A bronze bull statuette, said to have been bought in Mosul, inlaid with silver, now in the Louvre, is so far unique. It is commonly identified as the ornament of a rein-ring and dated to the middle of the third millennium BC, though it might be later (Heuzey 1900; Calmeyer 1964: 74, fig. 16). The animal is 'piebald'; inlaid across the body with variously shaped patches of silver. The base-plate on which the beast stands was analysed by Berthelot (1906: 81), who reported Cu: 82.4 per cent; Sn: 11.9 per cent; Fe: 4.1 per cent; no lead, antimony, zinc, nor arsenic was traced; so far as I am aware the 'silver' identification is only by eye (cf. Braun-Holzinger 1984: no. 114).

After the middle of the third millennium BC, as with gold, the range of evidence for silverwork is only sustained archaeologically through personal ornaments (Maxwell-Hyslop 1971: *passim*). Limet (1960) concluded that the Sumerian metalworkers primarily used gold and copper, and it is not, apparently, until the Akkadian period that silver comes more commonly into use for jewellery (Maxwell-Hyslop 1971: 19, 59, 77–9). There are isolated surviving silver vessels of the Old

Babylonian period (cf. Uruk: Lenzen 1962: pls. 27 f, 29a–e) and of the Neo-Assyrian period (cf. Mallowan 1966: pls. 356–7). Even in the Achaemenid period they are not so commonly encountered in Mesopotamian excavations as in other parts of the western Empire, perhaps suggesting that they were less commonly placed in graves there (cf. Nippur: McCown 1967: pl. 108: 8–9; Ur: Woolley 1962: 194, pl. 21; fragments: Reade 1986). Though well documented in texts, and known in isolated cases in neighbouring countries, examples of silver statuary have yet to be recovered from Mesopotamia (cf. Spycket 1981), though they have been found at Susa, as have silver inlays for statuettes made in other materials (Amiet 1966: pls. 318, 355, 404). Salonen (1963: 250–1) has listed some of the textual evidence for the use of silver to decorate furniture.

(d) *As an index of value: silver as money*

One of the more important functional distinctions between silver and gold in Mesopotamia (for in much else they were interchangeable) was the general role of silver, passing by weight, as a primary means of exchange and payment. Silver is first attested as an index of value in the Fara texts of Early Dynastic IIIA, when it was used together with copper with a silver: copper ratio of 1:180 (Powell 1990: 82). From the middle of the third millennium BC in the textual record degrees of purity in silver are regularly apparent (Limet 1960: 46–7), indicating technical means for establishing it. Among the earliest relevant texts, that inscribed on the silver vase of Entemena of Lagash (c.2450 BC) is of particular significance since it refers to purified or fine silver (Sollberger and Kupper 1971: 69: IC7e). From the Akkadian period silver's primacy as an index of value is evident through to the middle of the second millennium BC. An Old Assyrian text, of the earlier second millennium, apparently refers to cupellation: 'I refined the silver and from five minas (only) three minas came out (of the kiln)' (CAD, s.v. *kaspu*). Kupper (1982) has reviewed the contemporary evidence for the use of silver at Mari. Akkadian has a variety of terms to describe silver alloys (cf. Eilers 1954–9), but so few of the surviving objects have been analysed that direct correlations with the material evidence are not yet possible.

Powell (1990) has recently summarized the textual evidence from the end of the Old Babylonian period (c.1600 BC), when there is a two-century gap in the evidence:

After which we find both silver and gold as means of valuation, with gold seeming to predominate down to the end of the Bronze Age (at least in the surviving sources), when silver emerges once again as the standard metal money. Exactly what this 'gold interlude' means is still unclear. However, one point is worth noting: prior to the Chal-

daean period [seventh to sixth centuries], silver, when used as money, is normally not differentiated as to quality, whereas, in the Ur III, OB, and Kassite periods, gold is differentiated both in nomenclature and in silver valuation. The very fact that gold is differentiated as to quality in Kassite texts, whereas silver is not, suggests that silver-not-gold is still the primary index of value. . . . The general lack of qualifiers for silver, its use as an index for gold, and the relatively stable silver equivalences for a whole range of objects over most of the history of ancient Babylonia suggests that, under normal circumstances, silver, when used as money, would have been between 21 and 24 carat [i.e. about 87.5–90 per cent pure].

(Powell 1990: 79–80)

The material evidence for silver as currency is scattered and varied, and not always easily identified. In Akkadian, as in French, the word for silver came to mean money. The earliest coins of local origin from Babylonia are silver staters issued in the governorship of Mazaeus, 331–328 BC. They have very erratic weights (Newell 1978), suggesting that they were still passing by weight rather than by a standard face-value. Powell (1978: 217) notes payments given by weight but to be paid in staters (cf. CAD: *istatirru*) in the Seleucid period. It has surprised many scholars that coinage, devised in Asia Minor as a convenient way of storing and dispensing wealth in the earlier seventh century BC, had not appeared even earlier in Mesopotamia, where many textual references were assumed to imply its existence. Passages in cuneiform texts formerly translated as 'Heads of Ishtar', or of other deities, were taken to indicate the existence of standard currency units stamped with such representations (Smith, S. 1922; cf. Lipinski 1979). In the continuing absence of material evidence to this effect, and in view of more recent renderings of these phrases as references to particular stores of wealth in temples of the deities referred to, such a hypothesis is now redundant.

However, if true coinage was absent from Mesopotamia until the introduction there of Achaemenid Persian coinage (from the later sixth century BC), this does not mean that there were not standard media of exchange in silver in addition to miscellaneous collections of scrap metal passing by weight. Silver was certainly cast as standard ingots, or cut from ingots in pieces sufficiently regular, in terms of an established system of weights, to pass as currency ('Hacksilber') (cf. Herodotus, iii. 96). Such money took distinctive forms from an early date, most commonly rings (*hullu*; *šeweru*) (Powell 1978; Michalowski 1978) or miniature axeheads (*ḫaššinu*) (cf. Bottero 1957: 332). This range of silver is particularly well illustrated in a hoard of the seventh century BC from Tepe Nush-i Jan in western Iran (Bivar 1971; Curtis 1984: 1 ff.).

It is not until the Neo-Babylonian period that common terms for assaying and refining regularly appear in texts; but checks and balances had long

existed in the system to counteract fraud. Even small quantities of silver are mentioned as being marked 'normal', and there may well have been sheets of silver stamped all over with such a mark, then cut up and weighed out as payment (Oppenheim 1978: 665 n. 223). When payments were received in temples or palaces in uncoined silver currency (rings, wires, cut pieces, objects, fragments, etc.) they were dropped into a box, the contents of which were then smelted in the official foundry. When refired, the metal was cast as ingots of standard size and fineness and deposited in the treasury (Oppenheim 1947: cf. 2 Kgs. 12: 9-10 for temple collections of this type).

Some surviving hoards of scrap silver may have been personal 'bank deposits' (bullion), buried at times of peril, or jewellers' stock-in-trade for recycling; but they all illustrate the role of silver as bullion and are not paralleled in gold or base metals, though pieces of gold may sometimes appear mixed in with the silver. Relevant hoards are known from the later Early Dynastic and Akkadian periods at Tell Agrab, Tell Asmar, and Khafajah (Delougaz 1967: 45; Powell 1978: pl. IIIA, B) and in the north at Tells Brak, Chuera, and Taya (Mallowan 1947: 166, 176-9, pls. XXXIII-XXXVI; Moortgat 1960: 7 ff., figs. 11-12; Reade 1968: 248; 1973: 165). For the Old Babylonian period there are hoards from Larsa (Parrot 1933; Arnaud *et al.* 1979; Huot 1980). A hoard from the Neo-Assyrian level V in area TA at Nippur was 'in a small pot, which contained numerous chunks of silver as well as beads' (McCown 1967: 98, pl. 147: 1); and another of cut silver, ingots, and rings found at Assur in a jar under a private house floor (Andrae 1908: 22; Preusser 1954: 35). A sixth- or fifth-century hoard of silver fragments (bracelets, complete rings, and earrings) concealed in a pot was found in the ruins of a Kassite period building at Qalat al-Bahrain (Bibby 1964: 102-3, fig. 1; Krauss *et al.* 1983).

Scrap coined money appears for the first time in Mesopotamian hoards with silver vessel fragments and pieces of jewellery in the Achaemenid period. Reade (1986^a) has published in detail the objects in such a hoard found by Rassam at Babylon and brought back to the British Museum, previously studied in part by Robinson (1950), who believed that the associated coins indicated a date 'about the middle of the first quarter of the fourth century' for the hoard. Apart from the coins, it includes a bull-shaped vessel-handle, jewellery, offcuts of sheet metal, some from vessels, a melted lump of silver (ingot), and small items in other materials. Analyses, by Hughes, of the silver other than coins ranged between 98.9 per cent and 95.3 per cent silver, with no clear indication of the bands of purity, which have been thought to be implied by the types of silver distinguished in texts (cf. Reade 1986: 85-6). The main alloying element was copper, as is the case with

virtually all ancient silver. Hughes regarded an addition of over 2 per cent of copper as a deliberate debasement of the silver. Another fourth-century hoard, discovered by chance on the line of the Tigris early in the nineteenth century, included ingots of silver with coins (Jenkins 1964).

A hoard of jewellery, both gold and silver, from under the Persian period level and above the Nebuchadnezzar pavement in Room 5 of the *Enunmah* at Ur, might be considered a votive deposit, rather than a capital or currency hoard, were it not for the presence of a pair of silver balance pans, which seem unlikely in a votive deposit (U.456-500: Woolley 1962: 106-8, pls. 21-3).

(e) Manufacture

The principal uses of silver in Mesopotamia were for bowls and other vessels, for personal ornaments, for plating wood, bricks, and other metals, for small statuary, and for currency, either specially made 'rings' or scrap metal passing by weight. Silver is not so malleable as gold and requires more annealing in manufacture. It may be beaten out to form sheets of foil, but not to such thinness as the finest gold leaf. Berthelot (1906) reported a piece of Egyptian silver sheet as varying in thickness from as little as 0.001 to 0.0025 mm. Pure silver is generally too soft for use in itself. As the few analyses of objects from the Royal Cemetery at Ur (Woolley 1934: 294) make clear, it was alloyed with copper (comparable to modern sterling silver) for purposes of manufacture from at least the middle of the third millennium BC.

The methods for working gold described above also apply to silver, whether it be hammered or cast, decorated with granulation or filigree; but less laboratory research has been directed to silver jewellery. It has not, for instance, yet been shown whether diffusion bonding to produce silver plate was a technique used in Mesopotamia, as it was to the west in the second millennium BC (cf. Charles 1968; Khalil 1980: 50, pls. 58-9, no. 34); nor has niello yet been identified on an object manufactured in Mesopotamia. Hammering was the main technique for vessel production. Relief decoration was in *repoussé*; the high relief may most often have been achieved with insets: separately manufactured pieces placed in hollowed-out slots and secured by hammering the lip of the slot over the inset to crimp it. Such methods may have been used in the fine Neo-Assyrian silver bowl with lion-head protomes all round the side found at Nimrud (Mallowan 1966: 430, pl. 357). Further decoration was by chasing or engraving.

The silversmith's tool-kit is unlikely to have differed in any significant way from that of the goldsmith. One of the later third-millennium hoards of silver from Tell Taya was associated with a chisel and three other tools

(Reade 1968: 248), perhaps constituting the stock-in-trade and equipment of a silversmith.

Graham, who restored some of the silver objects from the Royal Tombs at Ur, allocated to the University Museum in Philadelphia, commented briefly on the metallurgy of the silver vessels: 'The structure is that of annealed metal with numerous cases of twinning indicating previous working. One may conclude, therefore, that the silver alloy was first cast and then alternately annealed and hammered until the desired object was obtained' (Graham 1929: fig. on p. 257). In forming a bowl 'at least three to five annealing operations would be required depending on the skill of the workman, in order to keep the metal soft enough to work into shape' (Graham 1929: 253). Oddy (1984) has reported on the silver wire jewellery from Tepe Nush-i Jan in western Iran, found in a hoard deposited in the seventh century BC, though the contents may be older (Curtis 1984). The wire was hammered and then smoothed, perhaps with sand.

To judge by the evidence of a text from level VII, seventeenth century BC, at Alalakh (Atchana) in Syria, even divine statues (once they had become obsolete) were recycled to provide silver for mundane objects. In this case the statue provided 685 shekels (about 5.5 kg.) of silver for the manufacture of vessels and for plating various wooden and ivory objects (Na'aman 1981). Similar recycling of precious metals, including silver, is evident in the Mari texts (cf. Durand 1983).

(f) Select analyses

1. *Unprovenanced: Proto-Elamite silver figurine of a kneeling bull holding a spouted vessel*: Metropolitan Museum, New York, no. 66.173 (Hansen 1970). Analyses by Sayre and Meyers (Hansen 1970: 23: *thermal neutron activation analysis*):

	Silver	Copper	Gold
A. <i>Solders</i> :			
U.1: solder (neck overlap)	95.3	4.6	0.1
U.2: solder (near base)	86.7	13.3	0.004
B. <i>Figurine</i> :			
SB1: left hoof	99.4	0.6	0.008
SB2: left haunch	98.3	1.7	0.01
U.2: back of head	99.1	0.9	0.006
U.6: left haunch	99.3	0.7	0.03
U.8: across edge of sternum	98.6	1.4	0.04
C. <i>Vessel</i> :			
U.9: vessel held by figurine	96.8	3.2	0.01

Meyers also undertook spectrophotographic analysis in certain areas; the *silver* sample contained the following elements:

Ag(XO.O), Cu(X.O), Pb(.X), Sn(.OX), and Au, Ni, Fe, Al, Mn, Sb, Ca, Cr, and Mg (trace amounts); not detected: Zn, As, Co, Bi, Ti, V, and Ba.

Analysis of a solder sample: Ag(XO.O), Cu(10-20 per cent), Pb(X.O-X), Sn(.X-OX), Mg(greater than trace), and Au, Ni, Fe, Al, Mn, Sb, As, Bi, Ca, Cr, V, Ba (trace amounts); not detected: Zn, Co, Ti.

2. *Ur: Silver rein-ring* (Woolley 1934: pl. 166) Early Dynastic IIIA: Analysis by J. R. Ogden (Woolley 1934: 293):

Silver	93.5 per cent
Copper	6.10 per cent
Gold	0.08 per cent
Zinc	0.15 per cent

Although no further analyses are published here, Plenderleith commented that 'traces of gold are commonly found in the silver from Ur'.

3. *Ur: Silver pin with lapis head* (Metropolitan Museum, New York: 33.35.44) Early Dynastic III: Analysis by Pieter Meyers (thermal neutron activation analysis) (Hansen 1970: 23).

Silver	95.5 per cent
Copper	4.4 per cent
Gold	0.07 per cent

A series of analyses of silver found in some of the more massive pieces of jewellery from Ur, now in the University Museum, Philadelphia, have been published by Millichamp and Levey (1963). They may be summarized as follows:

Range of concentration (per cent) for all objects

Ag	Major
Cu	1-5
Pb	0.01-0.5
Au	0.02-0.1
Sn	0.1 (present in one object only)
Zn	1
As	n.d.-0.2
Bi	0.02-0.2
Fe	0.01-0.05

Analyses done by Dayton (1978: 85, 448 ff.) have not been fully published.

4. *Telloh*: Analysis published by Berthelot (1906: 78); the objects are not dated, but came from Heuzey's excavations: 'Lingot et rognures (anciennes) d'un

métal blanc, trouvés avec des objets chaldéens dans un vase de grosse poterie:
La limaille du lingot refermait, pour 100 parties

Argent	96.3
Cuivre	3.5
	99.8

pas de plomb.’

5. *Kish* (as cited in Aitchison 1960: i. 180): ‘Sumerian’ finger-ring: Ag: 94.86 per cent; Au: 0.29 per cent; Cu: 4.85 per cent. ‘Later’ fragments: Ag: 92.98 per cent; Au: 1.57 per cent; Cu: 4.23 per cent; Pb: 1.22 per cent.

6. *Brak*: Akkadian Period; Mallowan 1947: 258, no. 4: pin (F.447): Cu present in ‘analytical quantity’; traces of Pb and Bi.
7. *Tell ed-Der*: Old Babylonian Period: ‘metal fondu’: Cu: 4 per cent; Sn: n.d.; Pb: n.d.; Sb: n.d.; Ag: 95.0 per cent. Lerberghe 1984: 117.
8. *Khorsabad*: Neo-Assyrian Period (Berthelot 1906: 81): piece of sheet overlay from Sargon’s palace (Place): ‘Cet or ne referme ni cuivre, ni plomb, ni fer en proportion sensible. Il contient une dose considerable d’argent . . .’ i.e. ‘electrum’.
9. *Babylon*: Achaemenid period hoard in the British Museum (Reade 1986*; analyses by Hughes):

Object No.	Description	Weight	Ag	Cu	Au	Pb	Sn	Fe
82-12-20, 24*	Handle, winged bull		98.3	1.10	n.a.	.49	.1	n.a.
82-12-20, 24	Handle, winged bull		98.1	1.10	.30	.60	n.a.	n.a.
82-12-20, 25	Earring	15.80	98.9	.14	.30	.01	n.d.	.08
82-12-20, 27	Sheet	25.53	98.9	.84	.30	.06	.20	n.a.
82-12-20, 28	Folded sheet	72.41	95.9	3.40	.40	.05	n.a.	n.a.
82-12-20, 29	Folded sheet	32.17	98.1	1.10	.45	.11	.10	.04
82-12-20, 30	Sheet	1.67	96.3	3.00	.27	.22	.07	.10
82-12-20, 32	Sheet	4.52	98.7	.74	.35	.06	.07	0.3
82-12-20, 33	Sheet fragment	3.48	97.7	1.31	.38	.48	.06	.03
82-12-20, 33	Bead (stuck to sheet)	3.48	95.6	2.40	.46	1.20	.12	.14
82-12-20, 34	Sheet (outer)	2.50	98.7	.60	.32	.30	.05	.01
82-12-20, 34	Sheet (inner)	2.50	95.8	2.70	.57	.85	n.a.	.06
82-12-20, 35	Sheet	8.68	95.3	3.61	.55	.46	.03	.02
82-12-20, 36	Sheet	3.50	98.1	1.11	.60	.06	.04	.00
82-12-20, 37	Sheet	7.09	95.6	3.47	.44	.35	.02	.05
83-1-18, 902	Ingot	159.27	98.9	.26	.49	.13	.09	.02
82-12-20, 42	Earring	3.52	16.6	9.80	73.3	.16	.98	.04

n.a. = not analysed.
n.d. = not detected.
* Analysis by atomic absorption. All the rest are by X-ray fluorescence.

3. Base Metals

(i) ARSENIC

There is no analytical evidence for the ancient use of arsenic (As) as a metal in Mesopotamia, nor has any word for it been reliably identified in Sumerian or Akkadian (see under Antimony). So far as present evidence goes, it seems neither to have been isolated as an independent element nor recognized as a native metal in ancient Mesopotamia. As an alloying element in copper, for which there is increasing evidence throughout the ancient Near East (see pp. 250), it may have occurred with copper ores. With smelting and reducing conditions, it formed natural alloys whose value was early recognized by observation and experience in copper casting. At a subsequent stage arsenical-

copper alloys may have been artificially achieved by reducing suitable arsenic ores in contact with molten copper in a crucible.
The use of the brightly coloured arsenic sulphides, realgar (red) and orpiment (yellow), is a distinct matter relevant to the history of pigments (see p. 328).

(ii) ANTIMONY

A number of Akkadian words, notably *guhlu* (CAD ‘G’: 125; *AHW* 296) have been taken to mean antimony (Sb). Shamshi-Adad V (c.823–811 BC) mentions that on campaign to the east he crossed ‘the mountain of *guhlu*—mineral’ (Meissner 1914). *Guhlu* is also recorded as tribute in Neo-Assyrian records, from the King of Judah, from Arabia, and from *Dilmun*. Various other Akkadian words used to denote cosmetics or ingredients in glass-making recipes may also mean anti-

mony (cf. Oppenheim 1970: 19 ff). Limet (1960: 55 ff; cf. Oppenheim 1970: 21) argued that in metal texts of the Ur III period the Sumerian term SU.GAN or SÚ.GAN might refer to antimony (or arsenic), whilst Hallo (1963: 140) argued that it was some material (‘dross’) left unaccounted for in manufacturing bronze. The case in favour of an expensive additive used in small quantities has strengthened without any precise definition of what it was. Some scholars argue strongly against its identification as an arsenic compound or antimony (cf. Röllig and Muhly 1983: 350), others in favour of a deoxidizing agent like fine charcoal or borax (tinical), both of which would have been available to bronzesmiths in Syria and Mesopotamia (cf. Waetzoldt *et al.* 1984).

Few chemical analyses of Mesopotamian eye cosmetics have yet been published. When they are available, they bear out the view expressed by Lucas (1962: 80–3, 196) for ancient Egypt, that antimony compound was very rarely used as eye-paint (Oppenheim 1970: 117 n. 13; Bimson 1980), so the ancient vocabulary for antimony may have been more restricted than is at present believed (see p. 138 here).

In view of what are taken to be textually attested uses of antimony compounds in Mesopotamia, it is particularly important to be clear about this metal’s character. It occurs in nature chiefly as the sulphide (stibnite) and, to a much lesser extent, in combination with other metallic sulphides. It is unlikely that the preparation of metallic antimony from stibnite was a process practised in antiquity. It was known in Europe only from the later Middle Ages. It is more likely that the metallic antimony of antiquity was the rare native metal, which is occasionally found as granular masses with a tin-white colour and a metallic lustre in limestone or marble veins. Antimony occurs in small quantities in three Iranian mines, two near Anarak, the other about 100 miles north-west of Birjand (Harrison 1968: 512). It has also been reported from the mountains of Kurdistan (Partington 1935: 256) and Transcaucasia (Selimkhanov 1975).

Antimony, as a trace element, has been recognized in copper and bronze objects from Mesopotamia and adjacent regions (Moorey 1971: 298; Berthoud and Francaix 1980: fig. 4; Berthoud *et al.* 1981). Where antimony was available in association with copper ores it was exploited in prehistoric copper production in Europe (Davies 1935) and in Caucasia (Kuftin 1941). Antimony, like arsenic, has a hardening effect on copper, but in percentages up to about 7 it is quite suitable for casting and a good temper may be given to cutting-tools by hot-forging. However, high percentages of antimony produce a brittle alloy and it is no competitor for tin-bronze (Charles 1980: 171–2).

Instances of the use of metallic antimony for objects in Mesopotamia are still rare. Two examples have long

been established in Assyriological literature, originally through a lecture by Herbert Gladstone (1892: 227): ‘M. Oppert indeed found at Khorsabad a tablet of metallic antimony, and M. Sarzec found at Tello part of a vase of pure antimony.’ A remark made on the same occasion, in discussion, by Austen remains highly relevant:

we only know antimony at the present day as a highly brittle and crystalline metal, which could hardly be fashioned into a useful vase, and therefore this remarkable ‘find’ must represent the lost art of rendering antimony malleable . . .

Partington (1935: 256; citing Berthelot) said the metal consisted of ‘antimony free from copper, lead, bismuth and zinc, but with a trace of copper’.

Selimkhanov (1975), with the assistance of the Louvre laboratory, reinvestigated the Telloh fragment and published the following analysis:

Sb	Cu	Sn	Pb
Major	0.072%	0.002%	0.05%
Ni	Co	Fe	Mo
0.002%	0.002%	0.01%	0.001%
Na	K	Ca	Al
0.045%	0.019%	0.2%	0.01%
Zn	As	Ag	Bi
0.003%	0.02%	0.017%	0.003%
Li	P	Sr	Mg
0.0005%	0.001%	0.004%	0.009%
Mn	Ti	V	B
0.002%	0.0005%	0.01%	0.0005%

He attempted to relate the metal to Transcaucasian natural antimony and to local manufactured antimony; but the results were indecisive. It is not certain that the object in question was a vase. The antimony objects from Transcaucasia are all small personal ornaments.

The supposed foundation tablet of antimony from Khorsabad is simply a misidentification by eye, which had already been corrected by 1887, though it lingered long in the literature. Both Bjorkman (1987) and Brinkman (1988) have now analysed the confused history of the publication of the five foundation tablets of different materials excavated at Khorsabad by Place. The material of the fourth tablet was given as ‘matière blanche’ in Place’s 1856 inventory, but had become ‘antimony’ by the time of the definitive excavation report (Place 1867: i. 62; iii, p. viii, pl. 77). By 1887 Berthelot had established through scientific examination that it was not made of metal, but of a stone, identified as magnesite (cf. Ellis 1968: 194, no. 78).

A cast tube, possibly a bead (L80–63), from a third-millennium context at Tell Leilan is made of 99.7 per cent antimony (Tamara Stech: personal communi-

cation). Jewellery of antimony is reported from Assur, c.2000 BC (Michael Müller-Karpe: personal communication). Small personal ornaments of antimony (96–9 per cent) have been reported from Iron Age levels at Hasanlu in north-west Iran (Dyson 1964; Stuart Fleming: personal communication). Antimony combines readily with many other metals to form alloys; an alloy of tin and antimony makes a white metal of bluish tint that is malleable and ductile. In an archaeological context the eye might well confuse it with silver. Dayton (1978: 450) found that four beads from an Iron Age grave at Tell el-Farah (South) in Israel were made of 66 per cent tin and 33 per cent antimony. It appears that sporadic use of antimony, plain or alloyed, was recurrent in the ancient Near East and only likely to be fully exposed by analysis.

(iii) COPPER AND ITS ALLOYS

Copper (Cu) was the most widely used of metals in Mesopotamia, where it was the cheapest of all until the Neo-Babylonian period, when iron became cheaper. Although, for the most part, only the manufacture of copper is represented in evidence from Mesopotamia, where it invariably arrived as a processed or semi-processed import, some general review of the preliminaries is necessary for a proper understanding of this metal's crucial role in lowland metallurgy (cf. Röhlig and Muhly 1983).

Copper occurs naturally in small quantities in various parts of the world, the Near East among them (Coghlan 1975: 18 ff.). Of copper ores the oxides, appearing in the weathered surface (gossan), are the most accessible in most regions and the simplest to work. Their rich colours would have made them particularly eye-catching to pioneer prospectors. This group includes cuprite and melanconite, the carbonates malachite (green basic carbonate; the richest in copper of all the ores) and azurite (blue basic carbonate), and the silicate chrysocolla (blue or bluish-green). More difficult to work are the secondary sulphides, from the parent ore, which is unweathered, and from a zone of secondary enrichment between the primary sulphides and the gossan. This group embraces chalcocite (copper glance) and covellite from the zone of secondary enrichment, and the iron sulphide minerals chalcopyrite (copper pyrites) and bornite (peacock ore). It has become increasingly clear to students of Near Eastern metallurgy that certain copper-bearing ores of more restricted occurrence also played an important role, as it is probably through their use that the metals arsenic and antimony entered early copper objects. These ores include a sulphide tetrahedrite (fahlerz), containing iron and antimony; bournonite, containing lead and antimony; tennantite, containing iron and arsenic; and enargite, containing arsenic and copper. Recent

research in Iran has also placed emphasis on certain native arsenides of copper, algodonite, and domeykite, found close to the surface and included in copper-bearing gossans notably in the Anarak region (Heskel and Lamberg-Karlovsky 1980).

No less important for the history of metallurgy is the role of copper in alloys. An alloy is the result of combining intentionally or inadvertently two or more metals in the presence of heat. A deliberate alloy is usually made either through co-smelting various ores; through the combination of ores and metals; or through combining metals already processed separately (by smelting to the metallic state), as is most usual in an industry. As tin is of limited occurrence in nature, particularly in the Near East, it is conventionally assumed that tin-copper alloys (bronzes) are deliberate man-made combinations. Such also is the case with combinations of zinc and copper to make brass, which does not appear in the Near East until the mature Iron Age. Contrivances may not be so confidently identified in the case of arsenical coppers, which occur in nature more commonly. On the basis of geological evidence alone it is not possible to say whether an arsenical copper is a natural or an artificial alloy, so the term arsenical bronze, which implies the latter, is avoided here in order to retain the necessary element of ambiguity. However, even at the lowest level of selection of ores, there was a deliberate exercise of choice, so the term 'alloy' is permissible. Both with tin and arsenic the lower limits for an international alloy are arbitrarily set, usually at about 2 or 3 per cent for tin (though much lower figures may reasonably be argued) and at about 0.9 per cent for arsenic, since most values in this case are either above this figure or merely parts per thousand.

Both Sumerian and Akkadian have a varied terminology for distinguishing qualities of copper (Limet 1960: 33 ff.; CAD, s.v. *erû*), none of which may yet be identified with any precision among archaeological material (Röhlig and Muhly 1983: 345–6).

(a) Support technology

The processes of mining and basic smelting would generally have been remote from the knowledge and experience of Mesopotamian smiths. Gudea's reference to the mining of copper is exceptional (Falkenstein 1966; Statue B: VI: 21–3; Cylinder A: XVI. 15 ff; cf. CAD, s.v. *hurru*); if ore travelled at all, it is likely to have been as carefully selected pieces. In her study of the materials listed in Neo-Assyrian annals, Jankowska (1969: 265) commented:

Highly significant is the predominance of ingots in the reserves of all the countries, whether it be precious metals, bronze, copper, tin or iron. Apparently it was usual only to smelt the ore in the mining regions . . . all further

processing being done by the consumers, who had available craftsmen.

Of the regions likely to have been supplying Mesopotamia with copper, Oman is the only one where field research at present embraces both the procurement and processing of metal as well as its manufacture (Hauptmann *et al.* 1988). The local copper deposits may be divided into two groups:

1. Massive sulphide deposits, predominantly of pyrite with a copper content of 2–2.5 per cent. The eye-catching surface gossans were exploited by ancient miners.
2. The predominant mineralizations and ore deposits are veins in gabbros and peridotitic rocks. The main copper mineral under the surface is chalcopyrite; but the outcrops are characterized by very distinctive and rich secondary copper mineralizations with malachite, brochantite, and chrysocolla. These would easily reach 30 per cent copper, and more, after hand-picking and were probably the prime target of early miners.

Oxide ores, sulphur-containing ores and only partly sulphidic ores, were smelted together in a single-state process. There is no evidence to indicate if or how the matte produced with the metal was further treated: 'the production of matte in this period (third millennium) is not surprising according to the form and type of mineralization. Here the question of when humans started to use sulphur-containing ores (sulphide ores and sulphate ores!) is not of primary importance. The crucial point is to find out when humans first recognized matte as a high copper-containing material and when they were able to treat it as a metal' (Hauptmann *et al.* 1988: 37). It is possible that recorded complaints from Sumerian customers about the quality of the copper they received from *Magan* (Oman) turned not on its high metallic iron content, but on the imperfect separation of the metal from the coexisting matte. In general the evidence points to inefficient copper production with low technical knowledge. The ingots recovered at Maysar in Oman had high nickel (0.1–0.5 per cent), not remarkable in relation to local ore, and high arsenic, though the variability was higher. This suggests that there was little or no refining of the raw copper before ingot production. Indeed, it seems to have been widespread practice that smelters did not generally purify the metal at source; that was done by metalsmiths.

Before the meagre evidence for furnace development in the ancient Near East is assessed, some attention must be paid to the possibility of copper smelting in crucibles, which are usually regarded only as vessels for alloying or refining copper. As Tylecote (1974) argued, pure oxidized copper (malachite) can be converted into copper metal in a crucible (cf. Rehder 1986: 88–9). Rostoker *et al.* (1989) have recently suggested that cru-

cible co-smelting of copper oxides and sulphide ores (chalcopyrite) in a single smelting step was also possible. 'In co-smelting, there is no precise and/or desirable set of proportions in the mixture of oxide and sulphide ores. Thus, it is unnecessary to assume that metalworkers had to mix the ores in the charge consciously, at least in the early stages of the penetration of the sulphide zone . . . the idea that matte smelting was a discovery rather than a development should be discarded . . . Only later, in historic periods, perhaps under conditions of more organised metallurgical production in fixed furnace installations, did the "matte" smelting process come into more common usage'. (ibid.: 85). As the major copper deposits in Anatolia, Cyprus, Iran, and Oman are of sulphide ore, this is very likely. The key question is not so much when did man begin to exploit sulphide ores as when did smiths start to deal with matte (see above; Hauptmann *et al.* 1988).

Indeed, it is possible that the virtual absence of copper-smelting furnaces in the archaeological record may not simply be a matter of chance. It might reflect the extent of crucible smelting in the pioneer phases. Unfortunately, it is rarely clear from the published evidence whether concentrations of crucibles on settlement sites were for melting metal or for smelting. A number of sites in Iran, where evidence of metal production is evident in the fourth to third millennium BC, yielded significant numbers of crucibles: Tal-i Iblis (Caldwell 1967: 17–21), Tepe Ghabristan (Majidzadeh 1979: 83–5), and Seh Gabi (Levine and Hamlin 1974: 212).

Furnace development is a subject for which there is very little hard evidence from the ancient Near East. The original Sumerian pictograph for the sign for a smith, in the middle of the fourth millennium BC, appears to show the plan of a smelting furnace with attached blow-pipes or *tuyères* (Falkenstein 1936: no. 325). A number of words in the relevant ancient languages at present variously translated as 'furnace', 'kiln', or 'brazier' have yet to be elucidated technically (Salonen, A. 1964). It is assumed at the present that *kiškattu* (CAD, s.v.) is the Akkadian word most likely to have denoted a metallurgical furnace.

It needs to be stressed that metallurgical furnaces differ from those of other fired materials in requiring that the metallic ores be placed in direct contact with the fuel (charcoal or coal) if they are to be reduced from their oxide, carbonate, or sulphide states and to be separated from siliceous gangues (Tylecote 1980). With rare exceptions, and even then there may be acute problems with close datings for industrial installations (Rothenberg (ed.) 1990; Tylecote 1980), the early technology of smelting has been reconstructed by analogy and inference. Modern primitive methods (though they display a bewildering variety of possibilities) and

common-sense application of metallurgical chemistry (despite often poor understanding of many early processes) are the key resources in such discussions.

When their date may be reliably established, and that is all too rare, the potential of slags for reconstructing smelting methods has been increasingly exploited (cf. Tylecote 1980); but progress is inevitably slow. Iron ores were one of the prime fluxing agents for removing silica gangue in copper and lead smelting and left a fayalite or iron-silica slag (Cooke and Aschenbrenner 1975). Norsun Tepe in south-east Anatolia, probably using ore from the Ergani Maden mine, is one of the few sites from which slag analyses are available (Zwicker 1980). In all the examples examined, of the mid-fourth millennium BC, chloride fluxes had been used to smelt copper ores. There was also evidence of trials with a more complex ore containing arsenic and antimony. By about 2800 BC sulphide ores were being smelted on this site. Slag analyses have also been undertaken for the third-millennium mining areas of Oman (Hauptmann *et al.* 1988: 37–40). Iron ores such as haematite and limonite were used as fluxes. The liquidus temperatures of these slags were barely reached or only for short periods; tapping had been carried out with only partially liquid slags, preventing proper separation of slag, matte, and metal. It was concluded that 'smelting not only was carried out according to the principles of a strong reducing process, but also contained chemical reactions typical of the more oxidizing atmosphere of the reverberatory furnace' (Hauptmann *et al.* 1988: 40).

Even if furnaces for the extraction of metals from suitable minerals are unlikely to be found in excavations in Iraq, those suitable for the remelting or re-forging of metal for making objects are certainly to be expected. They may not be easy to trace: 'for the purpose of melting scraps of metal in crucibles, a ring of stone, a pile of hot charcoal, and a clay *tuyère* connected to bellows are all that would have been required. Nothing would have remained of this arrangement except, perhaps, the clay *tuyère*. It is possible to obtain sufficiently high temperatures for melting bronze (950°C) with a cylindrical furnace with a grate like a brazier. The air would have entered underneath the furnace assisted by the chimney effect of the cylindrical portion. Usually there would have been a side hole through which the crucible could have been placed in the hottest part of the fire a short distance above the grate. The grate would of course be of clay, pierced with holes like a pottery kiln' (Tylecote 1980: 197). In the actual manufacture of tools, etc., in Sumerian towns minute quantities of wood and bundles of reeds were used. A text from Ur of the IIIrd Dynasty (Legrain 1947: no. 152) cites, over and over again, 2 minas of wood and 3 bundles of reeds. By contrast, fuel consumption in copper smelting was considerable. Horne

(1982) has examined the role of charcoal, and its production, in ancient Near Eastern metalworking. Taking 5 kg. of copper, enough for about 20 shaft-hole axeheads, as the potential product of a single smelt, she calculates a consumption of at least 100 kg. of charcoal. This would have taken 3.3 man-days of labour to produce (at 30 kg. per man daily) and would have used 700 kg. of wood. It is possible that bronzesmiths used date-stones instead of charcoal when working metal (cf. Strabo, xvi. i. 14).

It might be anticipated that one of the most obvious indicators of a commerce in metals into Mesopotamia would be ingots; but very few are known from controlled excavations there. The earliest smelting furnaces are likely to have produced little more than scraps of metal in the slag. This would have been broken up to release the metal for melting in crucibles and casting into ingots (cf. Tylecote 1980: 193–6). Of particular interest are the circular bun-shaped ingots found on third- to second-millennium sites in Oman (Hauptmann *et al.* 1988: 41, fig. 4:6), which indicate that this was the shape in which at least some Omani copper was traded in the Near East at this time. It may, however, have been standard for many other source zones. A group of five circular bun-shaped ingots of copper were included in the mid-third-millennium BC 'Vase à la Cachette' excavated at Susa. They have been associated with ingots of this shape found in the Gulf and in Indus Valley settlements (Tallon 1987: nos. 687–92, pls. 262–4). Two bun-shaped ingots were found in a contemporary context at Tell Chuera in Syria (Moortgat and Moortgat-Correns 1978: 66 ff., fig. 29a–b).

A disk-shaped copper ingot was included with the hoard of Old Babylonian agricultural equipment found at Tell Sifr (Moorey *et al.* 1988: 46, fig. 4). It is almost pure copper with iron (0.43 per cent) as the major impurity; it also contains a trace of bismuth with very low nickel and arsenic. As these are features not found in the metal objects associated with it, it might then be traded raw or recycled copper awaiting use in local manufacture rather than recycled copper objects of the type found with it. A large plano-convex ingot of unknown provenance in the British Museum was again of unalloyed copper and contains a low level of impurities, apart from 0.63 per cent iron (Moorey *et al.* 1988: 46, table 1: 136862). Plano-convex shaped ingots appear still to have been current in Assyrian workshops of the earlier first millennium BC. An example from Nimrud in the British Museum seems to be copper from a first smelt (15.5 per cent iron) (Moorey *et al.* 1988: 47).

Bar-ingots are evident by at least the earlier second millennium BC for general purposes. They were being cast in the Tell edh-Dhiba'i workshop (see p. 265) and two were found in the *Giparu* at Ur (Woolley 1976: 56; U.6622, 6685; see also Woolley 1962: 105; U.109, 115;

U.9048). They may represent a secondary processing stage, perhaps made from larger ingots or from scrap to aid in the production of particular objects. Texts make clear that this was generally regarded as a convenient shape for packaging in overland trade.

Oxhide-shaped ingots were characteristic of the Mediterranean trade in copper in the Late Bronze Age and have been the subject of intensive study in recent years (cf. Gale 1991). There is only an isolated example from Mesopotamia at present, from level I (of the twelfth century BC) at Aqar Quf (Baghdad: IM 51170: DK-4-124, R. 76; 45 × 33 × 6 cm.). Such ingots were probably cast in this distinctive shape to facilitate handling and packing in transit (cf. Tylecote 1980: 194–5). A rock-cut mould for such an ingot was found at Ras Ibn Hani in Syria in a palace workshop (Lagarce 1983: figs. 13, 15). Oxhide-shaped ingots may be shown carried by a tributary on the 'Rassam Obelisk' of Assurnasirpal II (Reade 1980: pl. III (top right)) and in the hands of tributaries from the Amuq region of Syria on Shalmaneser III's throne-base from Nimrud (Mallowan 1966: fig. 371a).

Ring-ingots, as texts indicate, would have been easy to thread and transport, though they may more commonly have been produced for purposes of exchange than for manufacture. It is probable that a number of the objects from Mesopotamian excavations catalogued as 'heavy bracelets/anklets' were, in fact, ring-ingots. In a widely ranging study Dayton (1974) called attention to the great variety of copper and bronze rings encountered on excavations in Mesopotamia, and elsewhere in the ancient Near East. He attempted to relate their weights to a system based on equivalents in barley and wheat. The use of ring money in the region is well documented; but its role as a medium of exchange, passing by weight, has yet to be properly demonstrated in terms of the material evidence. The clear identity of ring money, as distinct from personal ornaments or the like, is not always readily apparent. Even when identity is securely established, weighing individual objects in search of an established standard may be to misconceive an essentially random system in which the total weight of pieces used as currency on a specific occasion was what mattered, rather than the weight of individual rings.

So far only one ingot fragment, probably of the mid-third millennium BC, possibly found at Tell al-Ubaid, has been identified as alloyed copper (Moorey *et al.* 1988: 47). It is 88.2 per cent copper, 8.91 per cent tin with impurities. Since in texts bronze as a raw material seems rarely to have been the object of commercial transactions in Mesopotamia, it has sometimes been assumed that it was most often prepared on the spot from copper and tin by the manufacturers of bronze objects. This fragment might indicate that it was circulated ready-made as ingots; but it could equally well

be melted scrap metal awaiting re-manufacture. This routine metallurgical process is amply documented (cf. Limet 1960: 45, 145 ff.; Finkelstein 1978: 248) as indeed is the issue of bronze (rather than copper and tin) by court officials for the production of tools and weapons by palace artisans (cf. Rouault 1977: 178; Durand 1990). Hall and Woolley (1927: 38) published Scott's analysis of a copper ingot from Tell al-Ubaid. It was said to contain 4.4 per cent lead.

(b) Sources

(1) Textual evidence

Muhly (1973: 220 ff.; 1976: 104 ff.) has thoroughly reviewed the ancient textual sources for the use of copper and its trade in Mesopotamia, with extensive commentary on their relation to known deposits in the area. Archaic texts from Uruk (III) indicate that already by the later fourth millennium BC *Dilmun* was engaged in the metals trade (Englund 1983). In the third millennium Sumerian texts list copper among the raw materials reaching Uruk from *Aratta* (Pettinato 1972: 82–3, 128) and all three of the regions *Magan*, *Meluhha*, and *Dilmun* are associated with copper, but the latter only as an emporium (Limet 1960: 85 ff.; Waetzoldt 1981). Gudea refers obliquely to receiving copper from *Dilmun*: 'He (Gudea) conferred with the divine Ninzaga (= Enzak of *Dilmun*), who transported copper like grain deliveries to the temple builder Gudea . . .' (Cylinder A: XV. 11–18; Englund 1983: 88, n. 6). *Magan* was certainly a land producing the metal, since it is occasionally referred to as the 'mountain of copper'. It may also have been the source of finished bronze objects (Limet 1972: 14–17).

In the early second millennium BC Mesopotamia may have lost direct contact with *Magan*, and with *Meluhha*, also earlier mentioned in relation to copper. Copper now came through *Dilmun* and its traders. Gudea refers to mining copper in the mountain of *Kimaš* (Falkenstein 1966: i. 50 ff.: Statue B.VI: 21–3). This region is assumed to have been somewhere between the Jebel Hamrin and the Lesser Zab (Edzard and Farber 1974: 100–1); an old identification with Ergani Maden in Anatolia is no longer regarded as tenable. If this location is correct, it may have been just an entrepôt for copper from mines deep in Iran, or it might be a direct reference to the copper-mines visited by Layard in the Ti-yari mountains, north of Amadiyeh (Layard 1849: i. 223).

Since all these documentary sources are from southern Sumerian sites, the absence of references to Anatolian mines is not surprising, but it is a significant gap in the evidence. Muhly (1973: 208) has taken the available evidence to suggest Anatolia was not an exporter of copper in the third and early second millennium BC; but probability, if nothing else, requires that the case be left open in view of the meagre

evidence (cf. Kelly-Buccellati 1990). What information there is in the Old Assyrian texts indicates a copper trade within Anatolia, almost certainly facilitated by the Assyrian mercantile organization there, but gives no grounds for postulating shipments of copper back to Assur itself (Muhly 1973: 206–8). Leemans (1960: 121 ff.) showed that in the earlier second millennium BC the price of copper in the north was much higher than in the south and that copper from the north would not have been able to compete in Babylonia with copper from the Gulf.

As already noticed, after the Ur III period direct trade from Mesopotamia down the Gulf to *Magan* appears to stop and *Dilmun* becomes the primary entrepôt for all Gulf Trade, including metals, in the earlier second millennium BC. Copper came this way until at least the eighteenth century BC, when there is a break in the records almost exactly at the same time as the earliest surviving textual indications of copper from *Alashiya* (Cyprus) reaching Mari and Babylonia (CAD, s.v. *alašu*; Schaeffer 1971: 547 ff.; Millard 1973). The Mari texts also refer to a type of copper qualified by the term *te-ma-yu*, for which Dossin (1970a: 39 n. 1) suggested an association with Teima in Saudi Arabia, serving as an entrepôt for copper from the Feinan/Wadi Arabah mines (cf. Hauptmann *et al.* 1989). Muhly (1976: 109) was sceptical; but it is not an impossible routing.

It has been argued that it was the eclipse of the Indus Valley civilization in the second quarter of the second millennium BC that brought to an end the flourishing Indus–Mesopotamian trade up the Gulf; but this has yet to be satisfactorily confirmed. Stray indicators suggest continuing, if intermittent, activity. In the middle of the fourteenth century BC a Babylonian official was stationed on *Dilmun*, whence he reported back on local threats to the date crop. Then Tukulti-Ninurta I of Assyria (c.1243–1207 BC), after his sack of Babylon, assumed the title 'King of *Dilmun* and *Meluhha*', emphasizing contemporary Babylonian interest in these regions, even if the full implications of the ancient names no longer applied (Brinkman 1972: 275–6; 1976: 314). Danish excavators revealed considerable evidence for the occupation of Bahrein and Failaka in the Kassite period (Bibby 1972: 358 ff.). Otherwise documents contain no explicit references in the later second millennium to the sources of copper (cf. Potts, D. 1990: i. 232 ff.).

One of the most important copper sources in Neo-Assyrian times for the north was eastern Anatolia when the *Nairi*-lands constantly yielded massive amounts of metal, including copper, to the Neo-Assyrian kings (Muhly 1973: 290 ff.). In the Neo-Assyrian royal annals copper utensils were mentioned as booty more frequently and in more regions than any other goods; the Mediterranean coastal region and the Upper Euphrates

were particularly rich in them (cf. Walker 1988). Janowska (1969: 262–3) specifically commented:

The local manufacture of bronze objects of art in *Muṣaṣir* is recorded by the annals specifically (Luckenbill 1927: 173); here copper was mined. But other centres too can indirectly be identified. Particularly multifarious was copperware in the tribute of *Zamua*, of *Bit-Zamani*, and of Carchemish (Luckenbill 1926: 454, 466, 476, 501). While the handicrafts in Carchemish, a major transit centre, could have flourished on the base of imported raw materials, the treasuries in this city having constantly considerable stocks at their disposal, *Bit-Zamani* and *Zamua* were more likely to depend on local copper mining.

Muṣaṣir is modern Mujeisir, in the north-eastern corner of Iraq adjacent to the headwaters of the Greater Zab (Boehmer 1973). As Dalley (1988: 100–2) has shown, a fragmentary passage in the annals of Sargon II (c.721–705 BC) does not, as had been assumed, indicate that he discovered mines of copper (and silver) in Syria, notably in the mountain *Ba'al-Sapuna* (Mt. Hazzi, Jebel al-Aqra). The reference is to centres of secondary, nor primary, metalworking.

The role of Gulf copper sources in supplying Babylonia in the first millennium BC remains obscure (Brinkman 1988: 141), though textual indicators may suggest that *Dilmun* was still an important entrepôt in the distribution of copper from sources further down the Gulf. It is possible that copper and bronze were still widely used there as metals of utility after the period in which iron achieved this role in Mesopotamia (cf. Dalley 1988: 102–3). Two mid-sixth-century BC texts from Uruk, published by Oppenheim (1967: 236 ff.), mention copper from *Yamana* (as also iron), which refers to Cyprus or some locality in south-eastern Anatolia colonized by Greeks.

Although attention is commonly concentrated on the trade in metals, the value of booty to Mesopotamia's metal industries at all times, and the craftsmen often taken with it, should never be underestimated, even though, by the nature of the surviving evidence, its contribution is now incalculable. Isolated indicators, one from the beginning, one from the end, of the period treated here, will suffice to establish the point. After his triumphs over Elam and *Marhashi*, Rimush (c.2278–2270 BC) gave the temple of Enlil at Nippur 3,600 minas of copper (Hirsch 1963; Rimush b7.xxiv. 49–62). Sargon II (c.721–705 BC) explicitly claimed that he had imported so much metal from Anatolia and northern Syria as tribute and booty that 'they fixed the rate of silver in Assyria equal to that of copper'. Even if this is a gross exaggeration, it points to the magnitude of such confiscations (cf. Dalley 1988: 101–2).

(2) Modern mining areas

Copper occurs widely in Anatolia, though only a few deposits are rated as worth large-scale exploitation

(Jesus 1980: 21 ff.; map 7). Today the most prevalent copper mineral is chalcopyrite; nodules of native copper may still be picked up in a number of copper-producing areas. The only confirmed prehistoric mine is that at Kozlu, about 15 km. south of the well-known archaeological site of Horoztepe, in central, northern Turkey (Giles and Kuijpers 1974; Jesus 1981). This was open at least as early as the third millennium BC, when the miners were exploiting a copper sulphide deposit. The Ergani mine is the most famous in Anatolia and has certainly been open for a long time, though it is not yet known how long (Jesus 1980: 22). Here the ore is also found as a sulphide (Birgi 1951); in antiquity, as recently, copper may have been exported from the mine area as 'black copper' (copper with some iron, sulphur, and arsenic) for refining and manufacture in nearby towns. Hittite inventory texts of the thirteenth century BC list copper from *Ankuwa*, in the vicinity of Alishar, and *Kizzuwatna* (Cilicia) (Kořak 1982: 195).

All modern surveys of Iran have also shown extensive copper resources, widely distributed across the country (Ladame 1945; Bazin and Hubner 1969). The most satisfactory description of an ancient mine has been provided by research in the Veshnoveh area, between Qom and Kashan, in west-central Iran (Holzer and Momenzadeh 1971). Here a series of low, narrow tunnels were traced following the natural configurations of the ore veins, with indications of mining by fire-setting and subsequent hammering with stone mauls. The copper occurs in the form of malachite, with some azurite and chalcocite, and specks of native copper. The earliest pottery found there was an isolated vessel of Sialk IV type (c.4000–3500 BC). Copper also occurs extensively in Afghanistan (Berthoud *et al.* 1977) and the Indian subcontinent (Muhly 1973: 234 ff.; Ratnagar 1981: 96–7).

Since the pioneering studies of the metalwork discovered in excavations at Kish and Ur in the 1920s, through a special committee sponsored by the British Association for the Advancement of Science 'to report on the probable sources of the copper used by the Sumerians', it has been argued that Sumerian copper came from Oman, consequently identified with ancient *Magan* (Peake 1928; cf. Potts 1990: i. 117–19). Initially this case rested on the high nickel percentages found both in the copper of Oman and in Sumerian copper and bronze artefacts. It is now recognized that this alone is not a diagnostic trait. However, in recent years the ancient copper production of Oman has become a major focus for research by expert archaeometallurgists and archaeologists (cf. Hauptmann *et al.* 1988; Potts, D. T. 1990: i. 199–25). At the same time, analyses have increased the basic information available for interpretations which are more statistically rigorous.

Berthoud (1979; cf. Malfoy and Menu 1987) has analysed ore samples and artefacts from various sites in

the Near East, from which, on the basis of multivariate analysis using thirty-one chemical elements, he argued that the copper ores of Oman matched artefacts of Susa D particularly well in the middle of the third millennium BC. Previously, in his view, Susa had used Iranian copper from Anarak. Further expert investigation has questioned some of his analytical procedures and geological assumptions (Seeliger *et al.* 1985: 643). For instance, high nickel is not characteristic of all deposits in Oman (Hauptmann *et al.* 1988), whilst it is reported that there are copper deposits at Anarak with relatively high nickel. Until this can be as thoroughly investigated as the ores of Oman have now been, the source of copper used at any specific time at Susa remains debatable. However, as Potts (1990: i. 135) argued, this continuing uncertainty over details does not yet significantly challenge the view that mines in Oman were indeed the source of the copper recorded as reaching Iraq from *Magan*, at least from the third quarter of the third millennium BC through the Neo-Sumerian period. The textual references at this stage already include a unique mention of an object made of bronze said to come from *Magan* (Limet 1972: 14). The mechanics of this metal trade have still to be elucidated, as does its fate in the second millennium BC.

To the west of Mesopotamia, though Cyprus is renowned for its copper mines, problems still surround the chronology of their exploitation and the methods employed, particularly before the Late Bronze Age (Muhly *et al.* 1982). Despite assertions to the contrary, it seems that modern Syria has no geologically attested copper sources (cf. Muhly 1973: 214). Further south, in the Wadi Arabah, copper was widely available, and the ancient mines at Timna in Israel (Rothenberg (ed.) 1990; Conrad and Rothenberg 1980) have been the subject of intensive research, as increasingly are those in Feinan, Jordan (Hauptmann *et al.* 1989). Copper ores occur in Egypt, in Sinai, and in the eastern desert; but it is unlikely that they ever directly served Mesopotamia (Lucas 1962: 201 ff.).

Taken together, the ancient documentary sources and the distribution of potential copper sources indicate a coherent pattern. The major source areas of the region were those in Anatolia, Cyprus, Iran, and the Gulf. The mines of Cyprus sporadically exported copper to Mesopotamia, probably through the major Syrian cities; Iran and the Gulf largely supplied the copper used in Sumer and Babylonia. The copper mines of Palestine and Egypt, Afghanistan and India, were primarily of local significance. In countries like Iran and Turkey isolating sources will always be difficult, since there may have been many small copper-mines exploited so long as fuel was locally available, then abandoned until the wood cover was rejuvenated (cf. Allan 1979: 35). Both regions were vital sources of copper at various times for Mesopotamia.

It is still uncertain whether or not deposits of copper, and other metals, in the mountains north of Mosul contributed to the metal supplies of the Assyrian state, or even perhaps to much earlier settlements in the region where copper is evident from an early date:

In the Tiyari mountains, particularly in the heights above Lizan, and in the valley of Berwari, mines of iron, lead, copper and other minerals abound. Both the Kurds and the Chaldaeans make their own weapons and implements of agriculture, and cast bullets for their rifles—collecting the ores which are scattered on the declivities, or brought down by the torrents.

(Layard 1849: 223 ff.)

(3) *Scientific investigations*

Scientific study of metal objects found in Mesopotamia was encouraged from the outset of modern research in the region, notably by Layard (Percy, in Layard 1853: 670 ff.). The earliest students of ancient metalwork were interested both in the methods of working and in the composition of alloys. Layard (1849: i. 220 ff.) himself explored some of the mining regions immediately within the range of the major Assyrian cities; but it was not until the researches of Desch (1928–38; 1934) and his colleagues, in the 1920s and 1930s, on Sumerian copper and bronze objects, that the identification of the sources of Sumerian copper became a subject of primary interest on the basis of trace-element analysis. This rests on the general proposition, crudely put, that the source of the copper used for any particular group of artefacts can be identified by comparison of their trace elements with those of the parent ore as it came from the mine. Fifty years later, this procedure has met with increasingly rigorous criticism, despite the employment of ever more refined physical, chemical, and statistical methods for the study both of artefacts and of ores, and the steady accumulation of a body of highly diverse analytical data.

Craddock (1988) has usefully summarized the problems from the point of view of an archaeometallurgist. The following paragraphs draw heavily upon his assessments. The composition of an artefact reflects three aspects of copper retrieval and processing:

1. The trace elements originating with the ore are potentially indicative of the metal's source.
2. Trace elements (notably iron) from the fuel, fluxes, and ore which entered the metal during smelting, most probably done in the locality of the mine (cf. Berthoud *et al.* 1980), may be diagnostic of the smelting process involved.
3. The deliberate additions (alloying) at the place of manufacture may show characteristic variations in the pattern of alloying indicative of where it was made.

Trace elements and copper ores. Early attempts to locate ore sources through trace-element analysis failed

through the absence of careful study of the source area(s) rather than through analytical inadequacies. Both the geology of the copper source and the technology of its ancient exploitation have to be recovered by survey and selective excavation to provide the necessary information through discarded ore and smelting debris, preferably in stratigraphical contexts: 'the chemical composition of a metal ore undergoes radical change during smelting and . . . without a knowledge of the various stages of ore processing, smelting and refining at *each* potential site, serious errors are possible' (Craddock 1988: 323). This has been well illustrated in recent years by such field research as that done in Oman (Hauptmann *et al.* 1988), at Feinan in Jordan (Hauptmann *et al.* 1989), and at Timna in Israel (Craddock 1980a).

However, providing each source with a single fingerprint is a complex problem only likely to be achieved by combining detailed and very sophisticated trace-element analysis with lead isotope signatures. Most copper-ore sources are generally similar, but any one source may vary considerably, but systematically, through the three distinct horizons of deposit: weathered zone towards the surface (up to 100 m. thick) where the sulphides have been slowly oxidized and the copper ores tend to be deficient in other metals; contact zone (Fahlerz or Fahl zone, from the German) with ores relatively rich in associated metals; and the primary unweathered zone. The Fahl ores were particularly exploited by the fourth millennium bc in the Near East, yielding copper with several percent of other metals. But in any one mine all three zones might well have been simultaneously mined and 'ores from the same horizons many hundreds of miles apart are quite likely to be more similar in composition than two horizons within the same mine' (Craddock 1988: 324).

Trace elements and smelting. In the primitive or simple smelting process, where high-purity ore was smelted directly with charcoal, only very small amounts of iron minerals would have been present. Large quantities of iron ore were, however, present with the use of a slagging process, which enabled much lower grades of ore to be exploited and a higher rate of metal recovery to be achieved. Contrasts in the iron content of copper or copper-alloy artefacts may illustrate this distinction, but only if statistically significant groups of analyses are available for comparison. The two processes were, of course, used side-by-side after the introduction of a slagging process in the Near East. Analytical evidence indicative of a slagging process before the fifth millennium bc, as at Yarim Tepe (p. 255) in Iraq and in the 'slag' reported at Chatal Hüyük in Anatolia, is equivocal and has been questioned (cf. Craddock and Meeks 1987).

Trace elements, purification, and alloying. Purification was very often the first step in Mesopotamian

workshops far from mines, and it is likely that most metalworkers there were ignorant of the smelting process. The copper they received varied much in quality and may at times have been so impure that it would only be cast not hammered. Simple purification would be achieved by melting in a crucible, so that the iron-rich surface could be skimmed off, or by adding clean sand to form a slag. It has been shown experimentally that the iron content could be reduced relatively easily to 0.5 per cent; but not so easily thereafter.

The complex question of whether alloys were accidental or deliberate will be considered below in the appropriate sections. The trace elements involved in copper alloying were arsenic and tin, lead, and later zinc, with antimony sometimes occurring in sufficiently high percentages to raise questions about its presence. It is in the isolation of alloys that trace-element analysis offers its most direct contribution to the study of metalwork, though the interpretation of the results is by no means always equally clear.

A programme of trace-element research was undertaken by Berthoud (1979; with Francaix 1980), who, fully aware of the basic problems of interpretation, set out to investigate the source zones for the copper-based industries of Lower Mesopotamia and Iran in the fourth and third millennia bc, when native copper and copper smelted from simple oxide and carbonate ores are assumed to have been primarily in use (but cf. Oman, p. 244). Berthoud concluded that additions of such elements as arsenic were made at a late stage in the production processes and therefore have no provenancing value, whereas manganese, chromium, and nickel, together with the well-known indicators selenium, tellurium, and silver, have. Iranian and Omani ores were distinguished by the higher quantities of such elements as nickel, cobalt, vanadium, and chromium in the latter. This research programme had two main aspects. First, careful investigation of potential ancient mines and systematic physio-chemical characterization of their ores; secondly, analysis, by the same methods as for the minerals, of artefacts from controlled excavations on key sites, using more than thirty trace elements. In view of the crucial chemical changes implicit in the processes of metal and artefact production, this information may only be married up through specific thermodynamic and statistical models, upon which critical assessment of the work inevitably turns. As a result of his research, Berthoud summarized his conclusions as follows (in Berthoud and Cleuziou 1983: 243):

Site	Mining Region
Susa A (Early Uruk Period), Iran	Anarak (Central Iran)
Susa B (Late Uruk;	Bardsir (Iran), Kashan

Jamdat Nasr Period), Iran	(Iran). No clear correspondence
Susa D (Early Dynastic), Iran, Umm an-Nar, Abu Dhabi, Iraq (Ur)	Oman
Tepe Yahya (fourth millennium bc), Iran	Sheikh Ali (mine close to site)

Subsequently, Seeliger *et al.* (1985: 643) questioned some of the analytical and geological assumptions and procedures in this project, with the result that decisive analytical evidence for whether the copper of a particular range of objects came originally from Oman or from Iran remains elusive (cf. Müller-Karpe 1991: 108).

(c) *Mechanical properties and varieties*

Copper, as cast, is soft and unless hardened is not suitable for the cutting edges of tools and weapons, though for the production of vessels from sheet metal a soft condition may be crucial. Pure copper is hardened either by the introduction of impurities which alter its physical characteristics, as in tin-bronze production, or work-hardened through the action of cold-hammering (forging). Cold-hammering alters the elastic properties of the metal so that the harder it becomes, the less malleable it is, until it will eventually crack. This may be reversed by annealing: heating the metal in a fire for a short time to a moderate temperature (400–500 °C) and then cooling it. This returns the metal to a soft and workable condition. The prehistoric smith is likely to have discovered this before either melting (which follows naturally from it) or smelting.

A landmark in the history of metalworking was the discovery that the properties of copper could be varied by alloying it with other metals. The earliest history of alloying is a complex subject for which the evidence is still minimal. Rostoker and Dvorak (1990) conducted experiments to show that mixtures of certain minerals could interact or would be co-reduced to form copper-based alloys. But the key question remains whether these mixtures were naturally occurring in the ore or intentionally compounded by pioneering metalworkers.

(1) *Native copper*

Although the linear evolutionary development of ancient metallurgy in which native copper played a key initial role is no longer regarded as axiomatic, the particular problems presented by this metal are of considerable interest. Native copper might have been used at any time in the ancient Near East as part of routine metal procurement. In outward appearance a nodule of native copper is not unlike a flint nodule with a white coating; but the density is about four times that of the corresponding flint nodule. Native copper was available to pioneer metalworkers in Iran, notably in the Tal-messi-Anarak region (Berthoud 1979), in Anatolia, and

perhaps also in Cyprus (see, in general, Patterson 1971). However, circumstances may have been very different in antiquity from place to place. At Ergani Maden in Anatolia, for instance, modern open-cast mining has destroyed all traces of ancient workings. As the native copper picked up there today comes from 60 m. below the original surface, it does not have the same composition as archaeological native copper artefacts like those from Çayönü (Stech 1990).

Native coppers are highly variable in composition, even within the same deposit, so trace analysis or conclusions based on trace elements need to be used with due caution (cf. Rapp 1988). There is considerable uncertainty as to whether or not adequate criteria exist for distinguishing artefacts of native copper from those of worked or recrystallized smelted copper of high purity, even when metallographic studies have been made (Maddin *et al.* 1980; Rapp 1988: 23). It is generally assumed that all the earliest metal artefacts in the Near East were made of cold-worked native copper; but this is not certain. Native copper may contain significant quantities of arsenic (up to 15 per cent), as at Talmessi in Iran (Berthoud *et al.* 1982), so arsenical copper objects could have been manufactured from melted native copper. Native copper may be cold-hammered into artefacts, though there is some disagreement over how effective this is (Coghlan 1975: 76 ff.; Smith 1967), shaped by periodic annealing (only requiring a fire of 150 °C for very pure copper), or melted and cast, requiring a temperature of 1084 °C and a crucible.

The best available body of evidence for pioneer metallurgy using native copper is that from Çayönü in Anatolia (cf. Stech 1990; Muhly 1989). At least forty artefacts (awls, hooks, wire, beads, sheet) of native copper were recovered, and hundreds of malachite disk beads and debris from processing malachite as a semi-precious stone in the late eighth to early seventh millennium BC. Significantly, there was evidence both for cracking from excessive cold-working and for annealing to increase the workability of the metal (Muhly 1989: 6–7, figs. 1:6–8). The use of heat in this context might have arisen from previous experience with the heat treatment of flint and obsidian to improve flaking.

(2) Arsenical copper (see also arsenic)

General understanding of early metallurgy in the Near East has been slowly modified in the last forty years by the demonstration that arsenical copper was the dominant copper alloy, either natural or artificial, from at least the fourth into the second millennium BC (particularly Charles 1967; cf. Selimkhanov 1977). Natural arsenical coppers are known in various parts of the region, including Anatolia (Jesus 1980: 91), Iran (Heskel and Lamberg-Karlovsky 1980: 233), and

Cyprus (Panayiotu 1979). There has been much discussion about the level of arsenic which might indicate deliberate addition.

In the absence of metallographic data it is impossible to say whether X per cent arsenic indicates an alloy or not on the basis of a chemical analysis. High-arsenic coppers can be, and were, made with no regard to their properties; there was no control or selection of the metal to achieve desired properties. But possible separation of the same impurity group in a set of analyses into high- and low-arsenic parts may be a sign that deliberate alloying selections were being made in some third-millennium industries in the Near East. Experiments by Lechtman and Tylecote found that all the following processes produced copper-arsenic metal: addition of arsenic-containing minerals to molten copper; direct smelting of roasted copper sulphur arsenide ores; and co-smelting of copper sulphur arsenide ores with oxide ores of copper (reported in *Historical Metallurgy* 19(1) (1985), 141–2). Nor should the role of scrap metal be overlooked from an early date.

A high-arsenic copper has a decorative advantage: a silvery colour which tarnishes less readily than silver itself. On casting, even a relatively low-arsenic copper exhibits inverse segregation and a small quantity of arsenical copper (c. 15–20 per cent As) is forced to the surface forming a complete outer skin of silvery metal. Shalev (1988: table 2) has compared the surface composition of Early to Middle Bronze Age (c. 2300–2000 BC) copper daggers from Palestine with that of the core to reveal marked arsenic enrichment at the surface: up to 28 per cent at the surface with 4.5–6 per cent at the core. This suggests that by the third millennium BC, at least, smiths deliberately exploited the inverse-segregation property of copper-arsenic alloys to obtain a silvery surface. This was the case in the manufacture of mirrors in Egypt and statuary in Anatolia (cf. Smith 1973). It is possible that at Susa this property was already being exploited by c. 4000 BC for mirror surfaces (cf. Tallon 1987: i. 314 n. 5).

Maréchal (1958; cf. Böhne 1965) showed that arsenical coppers were not inferior to tin-bronzes for hardness or malleability in the annealed state, and were well suited to the hot and cold-forging methods used in antiquity. Their mechanical properties were adequate to meet the mechanical strength requirements for the tools and weapons generally used. As arsenic, like tin, also acts as a deoxidizing element in an alloy, it would facilitate a casting operation. More recently, Northover (1989) has demonstrated that small quantities of arsenic (up to about 2 per cent) offer very little improvement over pure copper; only at 4 per cent (up to about 8 per cent) is there a good balance between strength and toughness with properties approaching those of medium tin-bronzes. But, he argued, that 'even a 3–4 per cent tin-bronze offered a significant advantage

over a majority of contemporary arsenical coppers' (Northover 1989: 114). It is possible that it was not until after alloying with tin had become more or less routine in Mesopotamia that true alloying of arsenical coppers was established.

Eaton and McKerrell's (1976) suggestion that the Akkadian word *annaku* was an arsenic-rich master alloy of copper to be used in the production of arsenical copper, not tin as it is usually translated, is not sustained by the published analyses said to demonstrate the case for this modification in translation. Currently available analyses, varying greatly in arsenic percentages, give little indication that metalsmiths could control arsenic content in the artefacts they were manufacturing. What they do show is that the transition from copper-arsenic 'alloys' to tin-bronzes in the Near East was a far lengthier, more irregular, and more complex process than had previously been supposed. At Ur, by at least Early Dynastic III, although arsenic and tin in significant quantities are found in the same object, the high arsenic contents are not found in tin-bronzes, indicating a degree of control over the alloy (Craddock 1984; Philadelphia, Sumerian Metals Project).

Arsenical copper objects are evident from early in the history of manufacture from smelted copper in such notable cases as the Chalcolithic industries of Israel and the upper Euphrates, in the earlier fourth millennium BC (Levy and Shalev 1989; Çukur and Kunç 1989: 114, 119). There is a consistent pattern of evidence for the late fourth and third millennium BC, but the best sequence of analyses available for Mesopotamia at present is that from Susa (Malfoy and Menu 1987: 356–60; table A). The lowest percentages of arsenic occurred early (in Susa I: c. 4000 BC) and late (early second millennium BC), but whether this is to be related to changes in copper sources from Anarak to Oman, as Menu and Malfoy argue, is still open to question (see p. 249); it may be more indicative of technology than of metal origin. Arsenical coppers are most generally used in Susa IV (Early Dynastic III–Akkadian period; Menu and Malfoy 1987: 360; table B). In working with material from Iran, Berthoud *et al.* (1980) found that arsenic only appears in slags from urban sites, where alloying is likely, not in slags found at smelting sites in mining areas.

In Mesopotamia low-arsenic coppers are evident by the later fourth millennium BC (Moorey and Schweizer 1972: 180; Philadelphia, Sumerian Metals Project) through Early Dynastic I (cf. Berthoud 1979: nos. 6601–4, 6607–9, 6611, 6613, 6616–9 (Kheit Qassem); Moorey and Schweizer 1972: 182 (Kish: Y Cemetery)) into Early Dynastic III when, as in Susa, they are recurrent, though much more evidence is required to establish their relative use in comparison with copper and tin-bronze. Almost half of the objects so far analysed from Cemetery A (Early Dynastic IIIB) at Kish have

arsenic in excess of 2 per cent, as do about 33 per cent of those from the Royal Cemetery at Ur; in the north an arsenical copper tradition is the most prevalent throughout the third millennium BC.

At all times, and in all places, it is difficult to assess whether arsenic was introduced into the system at an early stage by the addition of an arsenic-rich mineral to copper, or whether the arsenic has come through from the original ore, possibly selected deliberately for its arsenic content. Nor yet is there any clear correlation between type of artefact and alloying material; but, as a tin-bronze tradition established itself, it appears that there were categories, like routine tools, for which tin-bronze was not generally employed (see below). Only with many more analyses will it be possible to plot the eclipse of arsenical copper. It is possible that it went on being employed in the Near East to some degree as long as unalloyed copper was in use there.

(3) Bronze (see also Tin).

The term *bronze* is taken here to embrace a range of binary alloys consisting of copper and tin, though commonly with a variety of other ingredients in small proportions. It is not used to describe alloys of arsenic and copper, whether natural or contrived (see above). It is assumed that in the manufacture of Mesopotamian bronzes the primary constituents were copper and tin and that traces of other ingredients detected by modern analysis just happened to be present in the raw materials involved. Only lead is likely at times to have been introduced intentionally as an additive. A standard modern bronze has about one part tin to nine parts copper; but in antiquity the proportions, since less easily controlled, varied more. For instance, texts of the late third millennium BC from Ur give proportions of tin and copper that would yield alloys with 9 per cent to as much as 17 per cent tin (Limet 1960: 58 ff.). Lower percentages of tin are more problematic, since they involve the distinction between a natural and an artificial alloy. This limit has been much debated and is, anyway, difficult to define with any confidence in isolation from specific groups of metalwork.

Some copper slags contain tin in amounts from 0.1 per cent to 0.5 per cent (Bachmann 1982: 26; cf. comments of Craddock 1980^a). Maréchal (1962) has shown that, when copper ores with noticeable tin contents are smelted, reduction of tin is promoted in the presence of copper due to intermetallic affinity. Thus low tin-bronzes might have been manufactured earlier than the reduction of tin ores to tin metal. Cleuziou and Berthoud (1982: 15), who have studied much Iranian metalwork of the later prehistoric and early historic periods, argue that 'the definition of a minimum tin content is strongly dependent on local conditions . . . We have therefore concluded that tin values above 0.5 per cent indicate deliberate combination of copper

and tin at some point during the process which transformed ores into metallic bronze, though this is not to imply that the operation was totally controlled and that the results were standard.' Such small percentages might well be deliberate additions in periods when contemporary bronzes have up to 10 per cent tin; but earlier it is debatable and is probably more often accidental. There is a tendency to argue that 5 per cent or more is a better benchmark on the assumption that ancient metalsmiths are unlikely to have appreciated the effects of tin in lower concentrations (cf. Hall and Steadman 1991: 225 n. 5.). However, Mesopotamian texts indicate a wide range of alloys, some of them with less than 3 per cent tin, from an early date (Waetzoldt *et al.* 1984: 7–14). The addition of tin to copper hardens the metal so long as it is not excessive; it lowers the melting point from 1083 °C to 1050 °C (5 per cent Sn), to 1005 °C (10 per cent Sn) to 960 °C (15 per cent Sn) (Lucas 1962: 217); and much increases the liquidity of the metal.

It is likely that tin entered metal industries in the Near East in a variety of ways. Where it was locally available, as in Afghanistan (and possibly Turkey), precocious bronzes are to be anticipated, if only as small objects like pins and rings. In these circumstances scrap containing tin would filter into general circulation. Tin and tin-bronze would only become regularly available for larger products with the establishment of larger-scale workshops, particularly those servicing expanding exchange networks. Apparently it was through these that tin was introduced to Mesopotamia.

The recognition of the role of arsenical coppers in the early history of metallurgy has modified views about the first emergence of copper-tin alloy in the Near East, as elsewhere. The distinction between copper and bronze is first made in the 'archaic' texts from Ur (Early Dynastic I) (Burrows 1935: no. 373) at the time of the earliest archaeologically attested tin-bronze objects in Mesopotamia (see below). Wertime (1980) and Charles (1978; 1980) have both associated the exploitation of arsenical ores of copper and the subsequent introduction of tin ores by calling attention to the polymetallic character of many ore-bodies (Wertime), and to the community of colour between some tin ores and arsenical copper ores (Charles). The tin ore stannite, for example, resembles in appearance the copper-arsenical mineral enargite, so anyone used to enriching copper with enargite would be happy to use stannite for the same purpose. Both scholars have suggested that another context in which miners might inadvertently have come into contact with tin is offered by the stannic ferrous gossans that may cap sulphide ore bodies, especially if such gossans were used as fluxes in copper smelting.

There is little information on early methods for manufacturing bronze. The key question is how the

alloy was produced. Did the smith work with metallic copper and metallic tin or was cassiterite added to the copper in smelting or melting? Both Charles (1978) and Wertime (1973) have seen the addition of cassiterite to molten copper as the most common means of bronze production in early times; but this may only have produced a low-quality bronze and may anyway not have been a method much favoured at a distance from the source of the cassiterite. The oldest known Sumerian text relevant to the question is one from Telloh, dating to Early Dynastic III (Limet 1960: 67; with important emendation Hallo 1963: 139a). This document is the first to offer the standard formula for proportions, in this case 13 1/3 shekels of tin, which is exactly one-sixth of the 80 shekels of copper which precedes it in the text. Sargonid and Neo-Sumerian texts use the phrase 'seven parts bronze', i.e. in the proportion of six parts copper to one part tin. As appropriate weights are given, these and later recipes indicate that metallic tin was used for bronze-making from at least the middle of the third millennium BC in Mesopotamia, though, as both texts and analyses show, proportions varied. Since bronze is not known much before this time, it is probable that tin always reached Mesopotamia ready processed as ingots. In a country to which metals were brought from considerable distances, presumably much more often than not in a processed or semi-processed form, this is not surprising. Bronze as a raw material seems rarely to have been the object of commercial transactions in Mesopotamia, as it was customarily prepared on the spot from copper and tin by the manufacturer of bronze objects. In a Sumerian hymn to the god Ninurta a bronze-producing country is mentioned, but its name is lost in surviving copies (Cohen, S. 1973: 28; lines 146–7). An ingot from Tell al-Ubaid is 88 per cent copper and 9 per cent tin (Moorey *et al.* 1988: 45, 47).

The introduction of tin-bronze as a commodity into Mesopotamia early in the third millennium BC, and its slow adoption in the following centuries, remains to be charted systematically through a wide range of analyses. Enough is now known of the introduction of tin-copper alloys into various parts of Europe to indicate that no pattern consistently applies; regional variation is marked. The same is likely to be the case for Western Asia. If tin was reaching Mesopotamia from as far away as Afghanistan, apparently at first by-passing workshops in many parts of Iran (Moorey 1982^a: 50; 88; Berthoud *et al.* 1982), its advantages must have been known after long experiment closer to the source zone. Cleuziou and Berthoud (1982) have argued that tin, before it was widely used for alloying, was added in casting to facilitate the processing of copper by lowering the melting point and increasing fluidity. If this were so, it is surprising it was not used more consistently in this respect on arrival in Mesopotamia, for instance, in the production of metal statuary. Its effect on surface

appearance and use for soldering, however, seem to have been recognized in Sumer, particularly in the manufacture of vessels (Müller-Karpe 1991: 110–11), as early as its advantages in the production of fine-cast weapons, like daggers and axeheads.

If tin was travelling as ingots, at a high price, as seems very probable, and if tin-bronze has no very obvious advantage over a well-made arsenical copper weapon, its adoption is not easily explained in purely economic terms. Charles (1967) has seen the toxic effects of arsenical copper as a disincentive to its use; but, in view of this alloy's prevalence in time and space, it does not appear to have been a crucial factor. For those who could afford it, the key was probably technological as 'the hardness imparted to the cutting edges of arsenical copper axes is quite appreciably below that of tin-bronzes' (Coghlan 1975: 83). In general, the effect of tin upon copper in the cast or annealed state was more marked than in arsenical coppers and skilled smiths no doubt soon recognized this. If status value was also involved, appearance or decorative factors may have had as much influence as efficiency. Tin-copper alloys are distinctive in colour. By the fourth century BC in Greece, if not earlier elsewhere, quality controls were exercised over copper-tin alloys through distinctions of surface colour, using a set of well-polished copper-tin alloys of known composition (Varoufakis 1974: 95). So it is possible that initially the golden colour of some copper-tin alloys increased their status value.

Although there is a steadily increasing range of analyses for third-millennium BC metalwork from Mesopotamia, publication has not proceeded far enough for coherent general statements to be made about the relative levels of tin-bronze production. It appears first in Early Dynastic I, as in graves of the Y Cemetery at Kish (Moorey and Schweizer 1972: 182; Müller-Karpe 1991: 110). By Early Dynastic III it is most evident in the high-status graves of the Royal Cemetery at Ur, where it is notable in the sheet metal used for the production of vessels (Müller-Karpe 1991: 111, table I).

As part of the Philadelphia Sumerian Metals Project (Stech: personal communication), 32 Early Dynastic III and 27 Akkadian objects from Ur were analysed. There is no marked contrast between the two periods. More or less pure copper is relatively rare; arsenical copper is the most common metal, with arsenic percentages ranging up to 4.05 per cent; bronzes, about a third of the total, have tin from 0.012 to 15.9 per cent. A rather different pattern has been revealed for Tepe Gawra by the Philadelphia Project. Forty-seven artefacts, ranging in date through levels XI (Late Prehistoric) to IV (Old Assyrian), but mostly from VI (Akkadian and post-Akkadian), were analysed and studied metallographically. No bronze was detected before level VI. Pure copper and copper with arsenic levels usually lower than 1 per cent were common. Even in levels VI

and V bronze is rare. These results isolate even more the old analysis of a pin from level VIII said to contain 5.62 per cent tin (Speiser 1935: 102). It may no longer be identified to check this analysis. Although, at both Gawra and Ur, arsenical copper was the metal in greatest use, Ur yielded relatively greater numbers of arsenical coppers than Gawra in both periods and the objects from Ur reveal a greater range of arsenic percentages.

It is already clear that well into the second millennium BC there was an extensive use of unalloyed and arsenical copper (cf. McKerrell 1977; 1978). It is possible that it was not until the move to sulphide copper ores in all the source zones that the demand for another additive was sufficiently stimulated to create a regular bronze industry throughout Mesopotamia. It seems, to judge from the analysis of a hoard of Old Babylonian agricultural tools from Tell Sifr (Moorey *et al.* 1988), that in routine production tin may always have been sparingly used and, when it was, for the hardness it gave a cutting edge; though even there consistency is not evident. Outside palace and temple workshops, whose production the textual evidence most commonly documents, and perhaps even there, it is likely that unalloyed copper and arsenical copper were the utility metals, with medium or high tin-bronze always to some extent a prestige commodity until the middle of the second millennium BC. With the history of tin still so obscure, particularly whether or not sources in Anatolia were at any time servicing metal workshops in Mesopotamia, even the most basic statements are necessarily tentative. Limet (1985^a) has assembled the evidence on bronze-working in the Mari archives, where the quantities listed are moderate.

Systematic study of the use of tin at Susa (Malfoy and Menu 1987: 360–2) showed that a tin-bronze metallurgy began there in earnest with Susa IV A2 (Early Dynastic IIIB: contents of the 'Vase à la Cachette'). The French analysts defined three thresholds for tin: 500 p.p.m., 1 per cent, and 5 per cent, concluding that tin served a dual purpose at Susa: it was added at the same time as arsenic to copper to increase fluidity, or it was added as the principal constituent of an alloy. In the Early Dynastic III phase experimentation is still evident, with percentages varying widely, most often 6–11 per cent. Although alloys over 5 per cent Sn are still rare in Susa IV B (Akkadian period), there is clear indication of the use of tin to increase fluidity in casting an inscribed axehead (Tallon 1987: no. 20) when the remaining weapons are unalloyed copper or arsenical copper. Only some 10 per cent of the Susa VA (Ur III) sample are tin-bronzes; but in Susa VB (Isin-Larsa) this rises to 48 per cent of the sample (Malfoy and Menu 1987: 333, 361, 363; table D), though it appears to be largely confined to weapons: axes, hammers, dagger-blades. In the case

of daggers the blades may be tin-bronzes with cast-on copper hilts.

Analyses of copper and its alloys after the Old Babylonian period in Mesopotamia are so rare as to allow for no conclusions about composition, though elsewhere in the Near East standard tin-bronzes were in the range 8–12 per cent Sn (cf. Curtis (ed.) 1988: *passim*) in the Late Bronze and Early Iron Ages. For the Neo-Assyrian period Zaccagnini (1971) concluded from his review of the use of *erû* and *siparru* in texts that:

1. *siparru* means 'copper' when referring to unworked metal; 'bronze' when the object is finished work.
2. *erû* means 'copper' in all contexts; sometimes 'not iron'.

More recently Brinkman (1988: 137–8) has broadly accepted this conclusion, but points to persistent problems over *siparru* occasionally meaning worked 'copper'. This is not surprising since copper and bronze may not be separated consistently by eye, least of all by the inexpert. It is a potential confusion that almost certainly also applied to administrative records in earlier periods.

(4) Brass (see also Zinc)

The early history of brass has long been confused by the use of the name in so fundamental a source as the King James Bible of 1611 to describe all copper alloys irrespective of composition; indeed, Johnson defined the new word 'bronze' in his Dictionary (1755–73) as 'brass'. In strict modern usage brass is a yellow-coloured alloy of copper and zinc, usually containing about a third of its weight of zinc. Zinc is found in nature as the sulphide blende or sphalerite; the carbonate calamine or smithsonite, and hemimorphite, once also called calamine. These ores are found together with copper and lead ores. Sulphide copper ores contain some zinc, but this is lost during the smelting of the copper and only in exceptional cases would any be retained in the copper to appear as small traces in artefacts, as from time to time happened. However, the reference to a 'brass ring open at its ends' from the prehistoric site of Yarim Tepe I is an error of some kind, presumably in translation (Merpert *et al.* 1977: 82). It is an open question whether or not smiths were conscious of the presence of zinc in the copper before the regular production of brass in the last century BC in the Phrygia-Bithynia region of Anatolia (Craddock 1988: 320).

Fibulae and metal vessels from the Phrygian capital of Gordion (Craddock 1978: 3; Steinberg 1981: 287–9) and at Urartian sites such as Altintepe and Toprak Kale (Hughes *et al.* 1981; Meyer 1968) are the first properly documented 'brasses' from Anatolia. A Urartian bull's head examined by Gettens (in Hanfmann and Hansen 1956) is made of tin-bronze with at least one horn of

brass, originally providing a distinctive colour contrast. These are all low-zinc brasses, with zinc generally below 10 per cent (but see comments by Craddock 1988: 320). To what extent such alloys were produced in Mesopotamia is still uncertain, but two of the metal bowls from Nimrud typologically identified as Assyrian contained 'about 6 per cent zinc in addition to tin. Others contain less than 1 per cent zinc but still considerably more than the trace levels found in the rest of the Nimrud bowls' (Hughes *et al.* 1988: 313).

Significantly, when Greek authors refer to *oreichalkos* it is as a rare, exotic, and expensive material, manufactured in Anatolia. How it was made is still an open question. Craddock (1978: 9) suggested the cementation process: 'fragments of copper were packed in a sealed crucible with charcoal and zinc oxide and heated to a temperature of between 900° and 1000 °C; that is, hot enough for the zinc to have been vapourized but not so hot that the copper melted and ran to the bottom of the vessel. The zinc vapour in the sealed vessel readily dissolved in the widely dispersed copper and brass was formed. At the end of the process the temperature was raised and the then molten brass was stirred to form a uniform alloy' (cf. also Werner 1970).

(d) The repertory of objects

The enormous range of objects for which copper and its alloys were used in ancient Mesopotamia is neatly epitomized by the despair of an eighth-century clerk listing spoils for the renowned account of Sargon's eighth campaign. In reference to 120 objects of bronze he remarked: 'the setting down of whose names for the purpose of writing is not easy' (Thureau-Dangin 1912: 567: line 364). This is a philological problem, unlikely to be much eased by the archaeological data (cf. the list in Limet 1960: 195 ff.). Archaeology has retrieved only a tiny fraction of the metal repertory for any period, usually the personal ornaments and weapons, with a scatter of tools and other isolated implements and vessels. The main source of such evidence is graves; if a period is not well represented in the archaeological record by graves, its metalwork is likely to be correspondingly little known. Only in exceptional cases are settlement sites rich in metal finds. This is to be explained by the systematic recycling of metal objects, since the practice of melting down and reusing base metal tools and weapons was a commonplace of daily life in Mesopotamia (Moorey 1971^a). No less devastating was the rigorous plundering by victors, as is explicitly recorded in a Hittite text: 'The *Araunna*-people have looted the bronze implements of the town as is customary' (Kempinski and Kořak 1977: 87).

Three volumes in the series *Prähistorische Bronze-funde* so far cover metalwork from Mesopotamia (Braun-Holzinger 1984; Rashid 1983; Müller-Karpe, forthcoming).

(1) The prehistoric period

The history of copper metallurgy in Mesopotamia is conventionally pushed back to the oval pendant from the Shanidar Cave, probably dating to the ninth millennium BC (Solecki 1969: 311 ff.). As it is now completely mineralized, it cannot be accurately described. It may do no more than illustrate the use of malachite for ornamental purposes as is evident elsewhere later, particularly at Çayönü in Anatolia (Muhly 1989: 6). Indeed, the holes drilled in the Shanidar pendant suggest that it is made of malachite worked as a decorative stone not hammered out of native copper.

The awl from the aceramic settlement at Tell Maghazaliya, 7.5 km. north-west of Yarim Tepe, of the seventh millennium BC, is then the earliest copper artefact so far reported. Soviet scientists (Ryndina and Yakhontova 1985) have identified it as made of cold-worked native copper (cf. Muhly 1989: 2–4), which they suggest may be from Anarak in Iran. As trace-element analysis is not at present a conclusive means for identifying source, this must be an open question. Geographical proximity, and the evidence from Çayönü, would suggest an Anatolian source is equally (if not more) probable for the copper used in settlements in the Sinjar region of Iraq. It is not clear whether two copper beads reported among stone and shell beads from the pre-Hassuna period settlement at nearby Tell Sotto are of malachite or of folded copper, like the better-known examples from Tell Ramad on the Euphrates in Syria, Ali Kosh in Khuzistan, Iran, and Çayönü in Anatolia (Merpert *et al.* 1978: 47, see also copper from Kul-Tepe; cf. Smith 1969; France-Lanord and de Contenson 1973: 109 ff.; Stech 1990).

By the sixth millennium BC copper is more evident on sites in Northern Iraq. Pieces of copper 'ore' (malachite), as well as simple trinkets and tools, have been reported from the early levels of the settlement at Yarim Tepe I–II (Merpert and Munchaev 1987); earlier still was a lead bracelet (see p. 294 here). Some copper work was also evident at Tellul eth-Thalathat II, north-east of the sites excavated by the Russians in the Sinjar (Fukai *et al.* 1981: 65); but none was reported from Hassuna itself. Down the line of the Tigris at Tell es-Sawwan, the excavator reported 'three beads of copper . . . on the floor of building No. 3 level II, and a very small knife with a boring at one end . . . in level I inside a grave . . .' (Al-A'dami 1968: 59). The analyses of copper 'ore' from Yarim I and Sawwan (Merpert *et al.* 1977^a) which have been published show high levels of iron (1–15 per cent) in the copper. This might be taken to indicate the use of an iron flux in smelting. However, the semi-qualitative method of analysis involved is unreliable, especially for heavily corroded objects, and native copper can be quite rich in iron (Rapp 1988). It must be concluded, for the moment, that this is not evidence for a slagging process

at an early date. The 'slag' from level VIA at Chatal Hüyük in Anatolia (c. 6000 BC) is equally ambiguous in its significance. It could be a crucible or melting slag and the 'ore' reported with it, as on early settlement sites in Anatolia and Mesopotamia, maybe malachite for working as a decorative stone (cf. Muhly 1989: 4). In Egypt and Syro-Palestine crucible smelting was still the method employed into the fourth millennium BC.

An equivocal position is held by the copper spatula, pin, and two simple sheet-metal bowls from Samarra (Herzfeld 1930: 4, 5, figs. c, e), from the layer containing prehistoric graves. Initially Herzfeld accepted the metal as contemporary, but three years later (1933: 29) he rejected it as intrusive from Islamic levels and said there was no metal contemporary with the graves. With informed hindsight this might be an unnecessary revision since, typologically, a Samarra/Halaf date is not impossible.

The important cultural complex named after Tell Halaf in Syria is still singularly devoid of metal finds in Mesopotamia. Yarim Tepe II, the Halaf period settlement, was far less productive in this respect than I (Merpert *et al.* 1977: 95; 1987: 17). The 'copper' stamp seal from Yarim Tepe II appears to be malachite worked as a semi-precious stone, not metal (Merpert and Munchaev 1987: fig. 11:3). Various copper implements and fragments at Arpachiyah were tentatively attributed to this period (Mallowan 1935: 104). A fragment from Tell Shemshara proved on analysis to be a weathered piece of copper pyrite, with no trace of human working (Smith 1970: 123–4). A bead from Chagar Bazar 12 was analysed by Desch: 'No trace whatever could be found of arsenic, nickel, tin, zinc or sulphur. This is the purest specimen of ancient copper that we have had' (Mallowan 1936: 26–7). By approximately this period in Anatolia, to judge by the almost pure copper macehead from Can Hasan, shaft-hole castings were already current (Jesus 1980: 41). It should perhaps still be emphasized in passing that a copper or bronze axehead, a spearhead, a dagger, and an arrowhead from Tell Halaf itself have nothing to do with this stage in the history of metallurgy (Schmidt, H. 1943: pl. CXIV).

Nor is the evidence for the subsequent Ubaid period in Mesopotamia much more revealing. Gawra XVII yielded a copper ring and a rectangular-sectioned awl; level XIII a copper awl; level XII a hemispherical copper button and a flat copper blade with a splayed cutting edge (Tobler 1950: 213, pl. XCVIIIa, 5–6). Analysis of the latter indicated a relatively pure copper with only 0.05 per cent arsenic. A flat copper adze or axe-blade from Arpachiyah falls late in the Ubaid period (Mallowan 1935: 104, pl. XI; Curtis (ed.) 1982: fig. 22 (BM 127757)). Analysis has shown it to be 99 per cent copper, 0.1 per cent arsenic; no tin was detected (down to 0.002 per cent) (Jesus 1980: ii. 207). It may be the

product of a simple smelting technique (P. T. Craddock: personal communication). At Nineveh a copper pin was attributed to 'Nineveh 3' (Campbell Thompson and Mallowan 1933: 145, pl. LXVIII, 5). In the south, at Ur, in a grave placed by Woolley in the Ubaid III horizon (but possibly of the later Protoliterate period) was a solid, tanged spearhead of very pure copper (Woolley 1934: 291; 1956: 21, pl. 30). At Tell el-Oueili in Iraq, no metal has yet been recovered from the Ubaid period settlement; the only exotic goods there are bitumen and obsidian.

In the late Ubaid period at Degirmentepe (Malatya), on the Upper Euphrates in Anatolia, the settlement is reported to have had 'furnaces in the workshops . . . copper slag found lying near a furnace' (*Anatolian Studies*, 35 (1985), 188), suggesting significant developments in the highland zone whence came some at least of the copper used by settlements in Mesopotamia. The use of arsenical copper is evident by at least the late Ubaid period on the Upper Euphrates (Çukur and Kunç 1989: 114, 199).

Where cemeteries of the Ubaid period have been excavated the quantity of metalwork in them varies markedly. In the cemetery at Eridu (193 graves: Safar *et al.* 1981) and in that at Ur (50 graves: Woolley 1956) no metalwork was recorded, but at Susa, in a cemetery of over 2,000 bodies, there were over 70 objects (only those in the Louvre are published in detail) (Susa I: terminal Ubaid; cf. Tallon 1987: i. 311–14). Both the number and the size of these objects are striking. Small personal ornaments and chisels were now associated with many flat axes/adzes and mirrors, the largest perhaps a kilogram in weight. The tools were probably cast in open moulds and then slightly worked with a hammer; analyses (Tallon 1987: i. 159) indicate a possible change in composition from relatively pure copper to a copper with up to 4.2 per cent lead; whether this is native or smelted copper is debatable. It has been attributed to mines at Anarak (Malfoy and Menu 1987: 364). This is possible, but it is too early to say for certain as numerous other potential copper sources in the Zagros mountains have not yet been scientifically finger printed.

The status of copper technology in southern Mesopotamia in the Ubaid period is still sometimes assessed in the light of the argument that the baked clay shaft-hole axeheads and hammer-axes characteristic of the period on many sites, though persisting later, are faithful copies of metal forms (Childe 1952: 116). No metal example has yet been reported from a site in Sumer; but there is an axehead from Susa (Tallon 1987: i, no. 71), which might date to this period since it closely parallels baked clay and stone axeheads of the Ubaid period in Mesopotamia (Tallon 1987: i. 94–5). Tallon suggested that it might have been made in the type of mould found at Ghabristan in Iran (Majidzadeh 1979:

84, fig. 3:2); but these may be later in date than the Susa axehead. Müller-Karpe (1990^a: 192) has suggested that the baked clay axeheads might sometimes have been used as models for sand-casting copper examples.

The kind of information accumulated by craftsmen in the highland regions where the metal was both retrieved and first processed was very different from that generated only by simple, secondary working remote from source zones. As Kohl (1987: 16) has pointed out, 'important technologies often initially developed or were further refined in peripheral areas close to the natural sources of the necessary resources'. The apparently low level of production and very basic skills of metalworkers in Mesopotamia up to the earlier fourth millennium is striking only in comparison with regions in or closer to source zones, notably the remarkable metalwork evident in the Chalcolithic of Palestine; seen in its own context it is not so surprising. Excavation reports have always paid too little attention in Mesopotamia to stone and baked clay tools. It is not always appreciated how vital they were to farmers in Mesopotamia until iron became the utility metal. Certainly, stone and baked clay were the raw materials predominantly used by prehistoric communities of farmers for their tool-kits and weapons, above all in the south.

Copper tools were not needed to increase the efficiency of food production or of carpentry in the relatively small, self-contained villages of this time in Mesopotamia. Indeed, at this stage, stone tools were probably more efficient than copper and were easily made of accessible materials. There was no incentive to increase the potential supply of copper, even if there were the means, nor to improve the range and strength of copper tools. Metal was neither vital for subsistence nor yet valued as a prestige commodity. As distance from sources did not apparently affect supplies of the coloured semi-precious stones that were prestigious, it is unlikely it would have affected copper supplies had they been in demand. In Mesopotamia there had to be major socio-economic developments in the settlements of the area before there could be technological advances in metallurgy and a marked expansion in the use of metals. These developments are evident by the middle and later fourth millennium.

Many copper artefacts were probably by now of smelted copper, imported ready-processed, for casting in open and bivalve moulds, then hot- or cold-worked after casting. Sheet-metal working had been mastered in all its simplest forms. Small-scale lost-wax castings appear early enough in this period to indicate some kind of previous development in Ubaid contexts, either in Mesopotamia or closer to a supply zone. One major archaeological discovery outside Mesopotamia is very relevant to this question, since it shows a remarkable mastery of the art of lost-wax casting, both for relatively

plain, if intricate objects, and for free-standing, three-dimensional ornaments, long before any such thing is evident in Mesopotamia. The enormous hoard of copper and copper alloy tools, weapons, and 'ritual' objects, from a cave in Nahal Mishmar on the western shores of the Dead Sea in Israel, is dated within the second quarter of the fourth millennium (c. 3750–3500 BC) (Bar-Adon 1980). It is a product of the Chalcolithic Beersheba Culture of southern Palestine and, even on relatively conservative dating, would be earlier than Uruk IV in Mesopotamia (Shalev and Northover 1987). Nothing to compare with it has yet been found elsewhere at this date.

The late prehistoric stage of expansion in metal production in Mesopotamia, now embracing both precious and base metals, is still difficult to describe. The key archaeological sites, Uruk in the south, Gawra in the north, are not likely to be typical. At the former the relevant small finds have yet to be properly published, at the latter they are published but their context and date are often very uncertain (cf. Forest 1983). At Gawra, for instance, a bronze kohl-tube, perhaps from an intrusive grave of the Achaemenid period, is attributed to level XI in the late fourth millennium BC (Tobler 1950: pl. 182); whilst the bronze pin attributed to level VIII, usually dated to the early third millennium, can no longer be identified to check its context and analysis (5.62 per cent Sn) (Speiser 1935: 102; cf. Hall and Steadman 1991: 226). An adze-blade attributed to level XI was primarily copper with 1.63 per cent arsenic and 3.34 per cent nickel.

The Uruk excavation reports rarely detail the more mundane copper finds. Between levels C and D of the Anu Ziggurat were an 'astonishing' number of completely oxidized lumps of copper, some as large as a man's fist (Nöldeke *et al.* 1938: 25). Worked copper was also recorded in levels of Eanna XI (Jordan 1932: 30). Objects of copper are noted in levels D and E of the Anu Ziggurat (Nöldeke *et al.* 1937: 53). No details are given of a spear-point analysed as Cu: 99.13 per cent; Fe: 0.27 per cent; Ni: 0.14 per cent; As: 0.17 per cent; Zn: trace (Heinrich 1936: 47). Among the many small finds from the *Riemchengebäude*, in the western corner of the Eanna sanctuary, built soon after the destruction of the *Steinstifttempel* in Uruk IVA, were various copper vessels and spearheads as well as animal horns (Lenzen 1958: 24–5; 1959: 10, pl. 17, 39b). More remarkable are the copper overlays and wire fittings for monumental ringed-poles from the *Steinstifttempel* itself (Boehmer 1990: pls. 1–6) comparable to an Early Dynastic example from Telloh (Parrot 1948: 63, fig. 15, no. 17).

Survey in the Uruk region offered some evidence for sheet-metal vessels in the Uruk period; but the various copper tools and weapons recovered might have been made at any time down to Early Dynastic I (Adams

and Nissen 1972: 205–6). A free-standing lion amulet ($4.7 \times 3.4 \times 1.1$ cm.) is of some significance for the study of cast metal, since it is made of copper with 9 per cent lead (Heinrich 1936: 25, 47, pl. 13a). This high lead content suggests that the craftsman was already aware that its presence facilitated casting (cf. Braun-Holzinger 1984: 3 ff.). However, it is not clear how much control was exercised at this time over alloying. Berthoud and his colleagues (1982: 45–6) have shown how in the centuries on either side of 3000 BC there was a degree of lead-copper alloying not encountered later, notably at Susa (Malfoy and Menu 1987: 362–4). A group of metal cylinder seals of late prehistoric type (Buchanan 1981: xiii) have copper as the main constituent, but with lead percentages ranging up to 20 per cent (L. Gorelick: personal communication). Müller-Karpe (1991: 109, fig. 3) has called attention to an arrow-or harpoon-head from the *Riemchengebäude* at Uruk made of copper with over 25 per cent silver; an alloy found in the third millennium in Syria (Braidwood, R. J. 1960: 302, 315).

As the Ubaid gives way to the Uruk period (Susa II–III) the best evidence is to be found at Susa (Tallon 1987: i. 315–16, fig. 49). There the forms of the shaft-hole, stone, and baked clay tools of the Ubaid period (adzes, hoes, and axes) are first evident cast in copper, with arsenic and lead at about 1 per cent, in the Early Uruk period. This is very likely to be a highland innovation, pioneered in workshops closer to the sources of the copper. A coppersmith's workplace, perhaps contemporary with Susa II–III, was excavated at Tepe Ghabristan, 60 km. south of Qazvin, equipped with benches and hearths. It contained 20 kilos of copper ore (primarily malachite), broken down into hundreds of nut-sized pieces for local smelting. A crucible, with a base slot to facilitate handling when hot, identified the area's function. Open moulds of baked clay for casting bar-ingots and shaft-hole tools comparable to those found at Susa were accompanied by part of a clay *tuyère* (Majidzadeh 1979: figs. 2–3). At Susa (II), as at Uruk, polymetallism is evident and the range of techniques has widened to embrace decorative lost-wax castings, manipulation of sheet metal to make vessels, and experiments with alloying. Evidence from Anatolia, notably the hoard of 22 arsenical copper daggers, spearheads, and an ornament from level VIA at Arslantepe, in the later fourth millennium, also illustrates a more sophisticated metallurgy than is evident generally in Sumer and in Northern Mesopotamia at this time (Frangipane 1985: 220–4); some dagger-hilts were inlaid with silver.

In Mesopotamia for some guide to routine production during the late Protoliterate and into the Early Dynastic I period recourse must be made to Ur. There the evidence comes from a number of graves and levels of occupational debris in Pits W and X. Woolley divided

the graves into three groups, early (A), middle (B), and late (C) (for recent complex and unresolved chronological discussions see Gockel 1982; 1983; Kolbus 1982; Korbel 1984). Of the 54 graves assigned to 'A', fifteen contained metalwork: of lead, eleven tumblers and one dish; of copper, five bowls, one vessel, and one ladle. Of the 130 graves attributed to 'B', 26 contained metal objects: of lead, thirteen tumblers; of copper, fourteen bowls, five pins, one razor, one fishhook, one harpoon. Of 148 graves classified in 'C', 22 contained metal artefacts: of lead, twelve tumblers and one bowl; of copper, three pins, one chisel(?), five bowls and one tumbler, one needle, one ladle, and one mirror; of silver, two pairs of earrings (Woolley 1956: 10 ff.). The copper vessels, allowing for heavy corrosion, had percentages of arsenic varying from 0.3 to 1.3. There was no trace of tin, and nickel readings were low; a copper rod gave the same result (Desch in Woolley 1934: 165). Predictably, it is tools which predominate in the occupational debris: fishhooks, projectile points and spatulae; no vessels were reported there (Woolley 1956: *passim*). Such a pattern is evident elsewhere in this and the subsequent period. Techniques remain simple; arsenical coppers are current. Vessels were hammered, usually in one piece. Metalwork from Jamdat Nasr was meagre, adding nothing to the evidence of Ur (Mackay 1931; Moorey and Schweizer 1972: 180). Before about 3000 BC pure copper or copper with less than 1 per cent arsenic appears to be the utility metal in Mesopotamia.

The excavations of Genouillac at Telloh yielded a little metalwork of the Protoliterate period, though its identification is not without problems. The original publication is very confused and chronological attributions are not always certain. Buchanan provided a critical review of this material, reassembling it into groups (Genouillac 1934: 44 ff.; Buchanan 1967: 535 ff.). Apart from a few gold beads, the finds are predominantly copper pins, mirrors, and sheet-metal vessels, some spouted; but a pin topped by a pair of nude female 'dancers' is an important early example of lost-wax casting (Genouillac 1934: 46, 50, pl. 10.2-5; cf. Braun-Holzinger 1984: 7 ff.) paralleled at Susa (Tallon 1987: i. 238 ff.). A number of copper or copper alloy tools found in level VII of the circular building at Tell Gubba in the Hamrin region, dated from Jamdat Nasr into Early Dynastic I by the excavators, are particularly significant as such finds are still rare in Mesopotamian settlement contexts. Two groups of flat axes, chisels, knife-blades, and awls were in 'foundation deposits' (Ii 1989: fig. 12, pls. 46-8).

Metal temple fittings rarely survive from any period in Mesopotamia so the fragments of copper panelling found in the Late Prehistoric Temple at Tell Brak are all the more remarkable. Some pieces were fluted, some decorated with a linear eye design. They were

originally fixed to a wooden backing with small copper nails (Mallowan 1947: 32, pl. VIII.2, n. 1, pl. XXX.8).

(2) *The early historic period, c.3000-2300 BC*

The earliest known documentary distinction between bronze and copper is in the archaic texts from Ur dated to Early Dynastic I (Burrows 1935: 11), at a time when the new alloy is first evident in artefacts at sites like Kish. Even so, copper or arsenical copper was long to remain the utility metal. Tin was expensive and supplies may well have been intermittent. The extent to which Mesopotamia used tin in the third millennium is the subject of a number of current research projects, which have yet to be fully published. The available results suggest no regular, predictable pattern of use. The range of evidence outside graves at this period in the south is minimal. Very little is known of the metalwork of the Ninevite 5 horizon in the north and, what is, indicates an enduringly conservative tradition.

In the south about the only guide to routine metalwork is in the cemetery at Ubaid, where a few of the graves are late prehistoric, the majority of Early Dynastic II-III (Martin 1982; Hall and Woolley 1927). The metalwork contrasts with that in the earlier 'Jamdat Nasr graves' at Ur. There are no lead vessels. Only eight graves out of about 80 held copper vessels (Hall and Woolley 1927: c.11, 27, 37, 46, 63, 76-7, 9); two copper daggers or knives (ibid.: c.28, 91); four copper pins or kohl-sticks (ibid.: c.3 (EDI), 27, 65, 73); one a copper harpoon-head (ibid.: c.77 (EDI)); and four twisted copper wire earrings (ibid.: c.3 (EDI), 27, 59, 73). A copper flat axe, an adze-blade, and a fishhook loose in the soil do little to alter the overall sample (ibid.: pl. XLVI.2).

The Royal Cemetery at Ur continues to dominate discussions of metalworking in the third millennium in Sumer. In base metal it provides a comprehensive repertory of weapons, tools, vessels, personal ornaments, and miscellaneous fittings from Early Dynastic IIIA to Ur III (Woolley 1934: 284-98) in copper, arsenical copper, and tin-bronze. This cemetery illustrates how the Sumerians primarily used gold for its beauty and copper for its utility; but understanding exactly how they used copper alloys rests upon a much larger number of analyses from known, datable grave-groups than is presently available.

Susa has also provided considerable evidence for routine use of copper and its alloys in the Early Dynastic III period (Tallon 1987: i. 322-36, fig. 52), not least a large hoard ('Vase à la Cachette') comparable to a smaller one found at al-Hiba (Lagash) (Hansen 1973: 69, figs. 12, 13). The contents of the Susa hoard, now in the Louvre, have been analysed (Malfoy and Menu 1987: 368-71). The objects are mostly of pure copper or arsenical copper; four are of bronze with over 5 per cent Sn: three vessels and a flat adze-blade. Elsewhere

at Susa at this time such tin-bronzes are generally weapons or elements from chariots (Tallon 1987: i. 351). Tin percentages rise as high as 13 per cent in a macehead, 15 per cent in a shaft-hole axehead, and 16 per cent in a shaft-hole adzehead by the Akkadian period (Tallon 1987: i. 351 n. 175).

In central Mesopotamia the metalwork of Early Dynastic I-II is still best represented by artefacts from the casually excavated and poorly recorded graves of cemetery Y on Tell Inghara at Kish (Moorey 1978: fiches E09-G03). They are best studied in comparison with the grave sequence at Khafajah in the Diyala region. Here, of 53 graves attributed to the end of the Protoliterate period, only five yielded metal: simple sheet-copper vessels and pins as well as two lead vessels and a lead ornament (Delougaz 1967: 59 ff.; graves 1, 4, 5, 8, 18). Of about 30 graves attributed to Early Dynastic I only three yielded metal: two copper mirrors and a pin (ibid.: graves 66-7, 83). Slightly over 30 graves were allocated to Early Dynastic II; thirteen produced metalwork, with sheet-copper vessels predominating. Isolated mirrors, pins, and a razor appear; but the only clues to a more sophisticated range of metallurgical skills are two vessel-stands, cast and joined (ibid.: graves 86-7, 89, 91-2, 94, 97, 108-10, 113-14, 119A). At Kish Early Dynastic I-II private graves are furnished exactly as at Khafajah, though two cast copper vessel-stands, one set on a frog, the other with elaborate interlaced openwork sides, are more elaborate than those in graves at Khafajah (Watelin 1934: pl. XX.1-2). It is the furnishings of cart burials at Kish that indicate the wider range of metalwork now available to those of wealth and social standing: tools (saws, goads, and awls), weapons (fine daggers and axeheads), and finely cast zoomorphic rein-rings (not yet analysed; cf. Braun-Holzinger 1984: 33 ff.). Although primarily of copper or arsenical copper, isolated tin-bronzes have now been identified by analysis among the vessels (Müller Karpe 1990: 110), the dagger- or knife-blades, and the adzes (Sumerian Metals Project, Philadelphia); but not sufficient analyses are yet available to identify any pattern of use at this early stage of tin-bronze manufacture.

The basic repertory of copper and copper alloy production in Early Dynastic III is illustrated by artefacts from Cemetery A at Kish (Early Dynastic III-Early Akkadian) and at Abu Salabikh. The jewellery includes pins, finger-rings, spiral 'hair-rings', decorative roundels, and cosmetic kits; the weapons are primarily dagger-blades, shaft-hole cast axeheads, and hammered axeheads with folded sockets and arrow or spear (javelin) heads; saw-tooth knives, gravers, chisels, and forked 'goads' of uncertain use (Mackay 1925, 1929; Martin, H. P. 1985) are the routine tools. Copper vessels were now rare in ordinary graves: at Ubaid one grave in eight held one; one in six at Kish and Khafajah

(in Early Dynastic III); one in about twenty at Abu Salabikh (cf. Martin, H. P. 1985: 16).

Although metallurgy has sometimes been taken as a distinctive feature of the 'Ninevite 5' horizon (c.3000-2500 BC.) in Northern Mesopotamia, the evidence provided by artefacts remains meagre and often difficult to date closely, as at Gawra (Muhly and Stech: 1988 manuscript). The metallurgy of Gawra VII did not differ much from the prehistoric tradition, though the number of metal finds increased with time; at present regular use of tin-bronze is not evident in the analytical data. The most marked change comes with Gawra VI (Akkad to Ur III); of the 198 artefacts registered as from this level, 60 have been analysed in Philadelphia: bronze appears for the first time (six objects with over 4 per cent Sn), though in types also produced in arsenical copper, whilst 58 contain arsenic from 0.4 per cent to 2.2 per cent. Two high tin-bronze shaft-hole axeheads (over 10 per cent Sn), one cast and not worked, contrast with the enduring standard local procedure of casting, working, and annealing arsenical coppers. When changes are evident in the tradition at Gawra and elsewhere, as at Chagar Bazar, southern or Sumerian influence seems likely to have stimulated it in an area where the general level of technology was lower. It is, however, still impossible to know at this stage whether copper was in fact not widely available, though many northern settlements lay on routes to Anatolian mining areas, or whether constant recycling and a low level of deposit in ordinary graves explains its relative rarity in excavations before the Akkadian period.

Metal temple furnishings certainly of Early Dynastic I are still unknown; only in the Diyala Valley are such objects available for Early Dynastic II, with one possible exception. In pit W at Ur, at the lower end of the SIS 4-5 were found four hooves of oxen (Woolley 1956: 38, pl. 29. 77), made of thin sheet copper hammered over a wooden core, originally fixed to a stand. Woolley believed them to be much earlier than the comparable Tell al-Ubaid temple metal sculptures. The context, if undisturbed, certainly indicates an Early Dynastic I-II dating; but Frankfort (*et al.* 1932: 16n.) did not accept it. Three vessel-stands cast as bearded male figures, nude save for a girdle, of almost pure copper, with minor casting faults filled in with lead, were found in a context attributed to Early Dynastic II in the Temple Oval at Khafajah (Delougaz 1940: 33-4, 157; cf. Braun-Holzinger 1984: 20 ff.). In the Shara Temple at Tell Agrab, in an early Dynastic II context, was a badly corroded anthropomorphic stand, just like those from Khafajah (Frankfort 1939: 11, pl. 55). Here also were three solid cast copper statuettes, two male, one female (ibid.: 11-12, pl. 56); technically more outstanding is the three-dimensional cast copper model of a one-man chariot, drawn by four equids (ibid.: 12-13,

pl. 58). These objects, and the vessel-support modelled as two wrestlers wearing only girdles, from Nintu Temple V at Khafajah, illustrate the great skill of the Sumerians in making elaborate cast copper statuettes by the lost-wax method by at least Diyala Early Dynastic II (ibid.: 12, pl. 54). In the highest surviving levels of the Shara Temple at Tell Agrab, in Early Dynastic III, were found the fragments of an anthropomorphic stand, considerably larger than those from Khafajah, and the toes of a human foot three-quarters life-size. Other body fragments are hollow-cast with clay cores and look like debris from a faulty casting on a comparable scale (Frankfort 1943: 11, pl. 61, 311–12; cf. Braun-Holzinger 1984: nos. 54, 56).

Although these fragments suggest that complex castings of some size were not beyond the skill and ingenuity of Early Dynastic craftsmen, an elaborate programme of temple decoration in cast statuary of any size would have been costly in terms of metal and craftsmanship. This probably explains why, at sites like Tell al-Ubaid, large free-standing animals and relief panels were made mainly of hammered sheet copper fitted over roughly shaped bitumen or bitumen-coated wooden cores, and secured with rivets, with separately fitted cast-bronze heads (Hall and Woolley 1927; Braun-Holzinger 1984: 26 ff.; J. E. Curtis: personal communication). A number of cast copper (or bronze) animal heads have survived from Early Dynastic III, though only at Tell al-Ubaid is their original destination known (cf. Moortgat 1969: pl. 53; Sarzec and Heuzey 1884–1912: pl. 5 *ter*; Parrot 1960: 186; Glob 1955: 178, fig. I; Hilprecht 1904: 539, fig. on p. 540; Frankfort 1943: pl. 29B; Braun-Holzinger 1984: 31 ff.). At Ur five copper bulls' heads were found together in a hole below a plano-convex brick wall alongside the Neo-Sumerian grave 1850 (Woolley 1934: 212, 594, pl. 143).

The base metal equivalents of the well-known Early Dynastic II/III votive human statuettes in stone (cf. Braun-Holzinger 1984: 10 ff.) are known only through rare survivors without recorded sources. All are lost-wax castings. The Louvre has a bearded male figure in a kilt, standing on a small copper base-plate, described as 'bronze' (Braun-Holzinger 1984: no. 37); the Schimmel Collection contains a copper or copper alloy male worshipper, best paralleled by a stone statuette from Mari, set on an openwork base and inscribed by a scribe with a dedication to the goddess Ninegal (Braun-Holzinger 1984: no. 45); in the Metropolitan Museum, New York, is a copper statuette of a man wearing only a girdle with a box on his head (Muscarella 1988: no. 464; Cu: 95.5 per cent; As: 2.4 per cent; Sn: 0.03 per cent). The dating of two hollow-cast statuettes from Assur within the range c.2500–2000 BC is less clear (Braun-Holzinger 1984: nos. 43–4); but a nude female figure from Mari is Early Dynastic II/III (cf. Braun-Holzinger 1984: no. 42). There is also a sig-

nificant group of cast copper foundation figurines, plain, anthropomorphic, and zoomorphic, many of known source and date (Ellis 1968: 46 ff.; Rashid 1983). One text of this period relevant to the history of metal statuary speaks of a silver statue of the deity Sag-sag made in the second year of Urukagina of Lagash and the craftsmen involved in its production: the master-sculptor, foundrymen, a worker in stone, and jewellers (Spycket 1968: 34–5). This assembly suggests that the sculptor created the original wax model for casting, that its eyes at least were inlaid with stone, and that its surface was further ornamented by jewellers. The size of the statue is not given.

(3) *The Akkadian period, c.2300–2100 BC*

Limet (1972) has provided a useful study of the textual evidence for metals and metalworking in the Akkadian period, emphasizing its limitations. Generally speaking, the archaeological record for the routine repertory of metalsmiths is equally meagre outside the Ur graves of this date (Woolley 1934: *passim*) and the metalwork from Susa (IVB) (Tallon 1987), as so little has been published elsewhere which may confidently be dated to this period. There is nothing to suggest a radical break in the evolution of metallurgy, indeed the contrary, nor any certain indication of a widespread break in the lines of metal supply as had been suggested on the basis of restricted evidence from Ur. Tin continues to be used at Ur and its use appears to be carefully regulated (cf. Craddock 1984). There is one remarkable aspect of metalworking in this period, only obliquely indicated in Early Dynastic III by the fragments of large-scale bronze castings from the Diyala sites. This is the unequivocal evidence for large-scale copper castings of the very highest quality.

The head of an unidentified king from Nineveh (Campbell Thompson and Mallowan 1932: 72, pl. 50; Braun-Holzinger 1984: no. 49, pl. 9) is now renowned, but it has never been published in full metallurgical detail. It is made of cast copper, not of bronze, as was long supposed (cf. Strommenger 1985). The casting core has largely gone, though chaplets survive, leaving the head at least partially hollow, though it is sealed across the base of the neck. A tiny hole here, which may not be ancient, leads into the cavity and there is the ghost of a square peg on the base-plate, either produced by the original casting process or else the remains of the fixture which secured the head to the body, probably in other materials. The detail of the head is remarkably fine and, although some of it may have been improved after casting with chasing tools, it looks as if it was predominantly cut on the original hard-wax model. The head had been intentionally damaged at some point in its history, perhaps when Nineveh was sacked in 612 BC (Nylander 1980).

After half a century of debate an equally remarkable

arsenical copper male head of unknown origin, now in the Metropolitan Museum, New York, is generally ascribed to the Akkadian period (cf. Muscarella 1988: no. 494; Cu: 97.8 per cent; Sn: 0.06 per cent; As: 3.2 per cent). It was cast solid with a cavity in the neck to take a rectangular dowel for fitting to a body; the eyes were originally inlaid as on the Nineveh head. The reported companion piece to the New York head, now in Cincinnati, has not yet been analysed (Pope 1939: IV, pl. 107). It is smaller, has eyes modelled in one with the face, a short beard, and the casting extends down on to the shoulders in a way neither of the other heads do. Its date is a much more open question, and the original association of the heads on the art market means, if anything, no more than a common geographical source in modern times.

The achievement of the Akkadian craftsmen in casting large-scale human statuary was confirmed in 1975 when, at Bassetki near Dohak in north-east Iraq, a bulldozer turned up the lower part of a cast copper crouching nude man, clasping the base of a standard or flag-pole, set on a circular podium bearing an inscription of Naram-Sin. It may originally have been one of a pair of 'guardians of the gate' in a temple (Braun-Holzinger 1984: no. 61, pl. 13). It is a massive, hollow copper casting which still retains some of its clay core with the chaplets still in place. The whole figure, in so far as it survives, is modelled with striking realism and sensitivity, exactly placed within the circle provided by the circumference of the base. The right leg, at a right angle, frames the flag-pole socket, the left is drawn back more sharply to provide room for the panel of inscription. A tasselled girdle provides the only ornament. Like the Nineveh head it would be regarded as a masterpiece of the sculptor's art in metal in any age or place, epitomizing the level of skill available to the Akkadian kings towards the end of the dynasty. Copper is particularly difficult to handle in large castings of this kind, probably done with multiple piece moulds. The technology has not yet been expertly studied; it might be direct casting in divisible refractory piece-moulds.

The relative roles of metals and stone in the later third millennium may be gauged, at least for weapons, by the persisting use of flint arrowheads. At Brak they were found in considerable numbers, though none of metal was recovered by the excavator (Mallowan 1947: 180, pl. XXXVII.). For agricultural tools wood, stone, and baked clay continued to play a crucial role and were only slowly superseded by metal. The current excavations at Brak are for the first time producing small finds, including metalwork, that may safely be dated to the Akkadian period in the north of Mesopotamia (cf. Oates and Oates 1991).

(4) *Ur III to the Neo-Assyrian period: c.2100–1000 BC*

The Ur III period marks the point from which textual

information on copper and bronze-working in Mesopotamia steadily supersedes the evidence of archaeology. In his fundamental textual study of the Ur III metal industry Limet (1960: 198 ff.; cf. Zettler 1991) provided a useful list of the objects made of metal by the Sumerians. Many may not be identified with certainty, but the list demonstrates how restricted the range of surviving material evidence is. This point is again well made three centuries later within the context of an operating metal industry, by Rouault's (1977) study of the activities of Mukannišum, one of the high officials of the Mari palace administration at the time of Zimri-Lim. Fortunately, the surviving documents for his role as controller of metals and metalworkers are the most important and most detailed in his archive (Rouault 1977: 162 ff.). He was the senior official who received and stored consignments of metal, who executed royal orders for their manufacture or disbursement, ordered and stored the artefacts, depending upon expert advice on technical matters. This valuable documentation is complemented by more scattered information on metals and the repertory of objects in the Mari archives (Bottero 1957: 293 ff.; Birot 1960: 310 ff.; Durand 1983, 1990: 160–77; Limet 1985^a). Against this background it is easy to appreciate why, in a region where the archaeological evidence for metalworking is predominantly mortuary, a sharp decline in the amount of metalwork placed in graves increasingly reduces the database for study. When, at the same time, the number and range of excavated graves is also more restricted than before, the problem is still more acute. At present, evidence is virtually confined to Ur in the Ur III period; is sparse and scattered for the Isin-Larsa and Old Babylonian periods; and is negligible for the Kassite and Middle Assyrian periods in publications.

The nature of the contrast in mortuary evidence between the third and second millennium BC is best illustrated at Ur where the graves of the Isin-Larsa period may be compared to those of the earlier Royal Cemetery. Woolley (1976: 195 ff.) lists 168 graves in detail. Apart from personal ornaments, the following copper or bronze items were recorded: 21 graves produced metal vessels (24, 27, 33, 41, 44, 45, 59, 106, 131, 142, 145, 148, 152, 157, 164, 179, 182, 184, 186, 189, 196); three had pins or kohl-sticks (5, 33, 61); four held razors (27, 142, 175, 187); one had what may be an arrowhead (43); one contained a 'chisel' blade (double-ended, 45); three, significantly, were equipped with sets of miniature tools (27, 38, 44); and three had sets of scale-pans (23, 38, 170). This sample of the graves of an urban community, largely small merchants and craftsmen, without any conspicuous signs of wealth or status (only twelve graves contained pieces of gold or silver jewellery) is, where it can be checked on other sites, typical of the period. The situation does not substantially change thereafter. The range of personal

ornaments, weapons, and vessels from graves of the Ur III period at Assur complements the Ur evidence (Haller 1954: 6 ff.).

Jewellery is the only aspect of metalwork for which a continuous, if at times thin, thread of material evidence extends through the second millennium BC (Maxwell-Hyslop 1971: 64–93, 163–79); but, when personal ornaments are in base metal, they do little more than copy, as far as possible, the forms and techniques of gold and silver jewellery. The development of weapons at this time in Mesopotamia is ill documented from controlled excavations. It has been largely reconstructed from scattered artefacts (spearheads, daggers, and axeheads) assembled typologically. In general, the shaft-hole axeheads show increasing variety of form (Maxwell-Hyslop 1946, 1949; Deshayes 1960; Curtis 1983), though Mesopotamian craftsmen do not seem to have favoured relief or incised decoration as much as their colleagues to the east. Daggers, or short swords (the true sword is not evident), developed flanged hilts to replace the tangs of the third millennium BC, perhaps under western influence, and by the end of the millennium had evolved into very efficient bronze weapons, notably some with royal inscriptions (Maxwell-Hyslop 1946; Calmeyer 1969: 59 ff.; Moorey 1971: 71 ff.; Boehmer 1983; Curtis 1983). The evidence for spearheads (Maigret 1976), now generally socketed, and arrowheads (Medvedskaya 1982), flat and tanged, is even more inadequate in Mesopotamia; but what there is does not demonstrate any marked divergence from the mainstream Mesopotamian tradition, nor any significant modification across the millennium. Metal maceheads are known, but have not yet been systematically studied. Nor, for this long period, do pictorial illustrations, save very rarely (cf. Maxwell-Hyslop 1970^a), offer any new information.

The most spectacular surviving votive weapon of the period is a sword in a private collection in Europe (Güterbock 1965). It is 1.09 m. long overall and has a cast hilt riveted on to the blade. The lower part of the hilt flares out towards the junction with the blade and is flanked on each side by an openwork lion rampant, head turned outwards; the blade bears an inscription in cuneiform for 'the Lord (i.e. Nergal) of Hubšalum' and gives the weapon's weight as 12 minas. Charpin (1987) has pointed out that a tablet from Mari refers to the dedication of a sword to the god Nergal of Hubšalum, a town thought to lie south of the Jebel Sinjar. Güterbock had identified the script and spelling of the inscription as Old Assyrian. Charpin prefers a context within the orbit of the *shakkanakkus* of Mari at the very end of the third millennium BC.

It is surprising that excavations on town sites in second-millennium Mesopotamia have not yet revealed more information on the tools of the period. Scattered examples are published in excavation reports, at least

showing that metal was now regularly used for agricultural tools; but it is only by association and context that identification of specialist craft tools is possible. It is unfortunate that neither of the two sets of miniature tools from Ur may be confidently attributed. The first (Woolley 1976: pl. 99: U.16699(1–8)) is of five miniature spearheads, one miniature axehead with bone handle, what might be a miniature ingot, and an enigmatic piece of folded copper. The second (Woolley 1976: pl. 99: U.16773(1–5)) appears to consist more certainly of model specialist tools, 'spatulae', and 'knives'. Deshayes (1960) assembled and typologically classified the base-metal tools of Mesopotamia, but only in two cases, both of the Old Babylonian period, is it possible to identify what have every appearance of being assemblies of tools.

The first is a group excavated by Loftus at Tell Sifr in 1854 (Moorey 1971a; Moorey *et al.* 1988), including axeheads, mattock-heads, adze-blades, hammers, spade-blades, double-edged and single-edged knives, tanged sickle-blades, bill-hook blades, chains, various ring fittings, perhaps clamps for assembling a wooden plough, nose-rings for animals, and some vessels. Unalloyed copper was the material generally used. Tin was used sparingly and, when used in quantity, for tools where the hardness imparted to cutting edges might have been the significant factor; but even then consistency is not evident. These tools illustrate a simple unsophisticated aspect of the metalworker's craft, changing little in the shapes it produced, or in the means of manufacture, until iron became the utility metal in the Neo-Babylonian period. Recycled metal may have been the primary medium and control over alloying minimal.

The Oriental Institute in Chicago holds a more mixed group (A. 9382–9455, 9466–9505) bought in Baghdad in 1930 with an attribution to Ishchali. It includes 'hooks, chisels, nails, spoons, sickles, large rings, hoes, needles, adzes, bowls, platters, tweezers, mirrors, razors, daggers, pins, spatulas, and similar objects reminiscent of the tools and implements mentioned in the Ishchali texts' (Greengus 1979: 12; cf. examples from Khafajah: Hill *et al.* 1990: pls. 63–4). In certain rooms of the Kititum Temple at Ishchali tablets were found recording the loan and use of tools and implements by various individuals.

Copper or bronze statuary is only known from small-scale pieces, with the exception of some bulls' hooves of copper hammered over wood from the Shulgi Mausoleum at Ur (Woolley 1974: 14). Metal peg figurines in foundation deposits are known until the time of Rim-Sin of Larsa (c.1822–1763 BC); thereafter only inscribed stone and metal tablets are reported from such contexts (Ellis 1968; Rashid 1983). Spycket (1981: 227 ff.) and Braun-Holzinger (1984: 43 ff.) have assembled the votive statuary in metal for this period,

none of which shows any marked technical improvement over earlier work, though some examples are rather more elaborate than the small statuary known from the third millennium. Sheet gold continued to be used to plate at least the faces of human figures and animals.

The most various range of base-metal statuettes from a single site are the deities and worshippers from Susa, predominantly of the Middle Elamite period (Tallon *et al.* 1989). Simpler figures were cast solid, finer ones hollow; arsenical copper, so common in the third millennium at Susa, is hardly apparent. Of the 34 statuettes analysed only two had tin above 5 per cent and four approaching 5 per cent. There was considerably more evidence for the use of recycled metal than for deliberate alloying to improve the casting. Large-scale castings of the Middle Elamite period found at Susa (cf. Amiet 1966: figs. 280, 291, 297, 305), which are unique survivors, have not yet been the subject of published metallurgical reports.

In some instances, new aspects of the base-metal repertory may be identified. Although there are isolated examples of what may be sheet-metal plaques for body armour before the middle of the second millennium BC (cf. Boehmer 1972: 102 ff.), it was not until then that both texts and finds in Mesopotamia indicate the currency of metal armour (Kendall 1982; Starr 1939: 475 ff.; 1937, pl. 126A, L; Al-Khalesi 1970: pl. 24). It is not until the second half of the millennium that there is material evidence for metal horse-bits with snaffle action; previously organic materials or nose-rings had been used (Littauer and Crouwel 1979: 60–1). Examples of these early bronze horse-bits have been reported from Assur and Tell al-Haddad (Littauer and Crouwel 1988); but there is, as yet, no archaeological evidence from Mesopotamia for the metal chariot fittings that would also have been a major innovation in the middle of the second millennium BC (Kendall 1975: 230 ff.).

In major buildings metal fittings have rarely survived. The eighteenth-century palace of Mari provided a set of metal parts for a door (Parrot 1959: 87, fig. 66, pl. XXXIII). At Nuzi four centuries later there were metal door-pivots (Starr 1939: 471; 1937: pl. 124B), copper wall 'knobs' (Starr 1937: pl. 127E), and door-studs of bronze, their heads covered with sheet silver (Starr 1939: 142, 473; 1937: pl. 123). Some dome-shaped bronze nails were given gilded heads (*ibid.*: 473). Fifteenth-century Nuzi also yielded other uncommon base-metal objects. One of the rooms adjacent to the palace chapel contained a cylindrical cast-bronze stand with excised sides and with lions *couchant* on the upper edge (Starr 1939: 439 ff.). A cache of bronze objects concealed in a pot (Starr 1939: 75–6) consisted of: 'two sun disks (pl. 127B), two crescents (pl. 127C), nine sickles (pl. 123J, 124C, D), six pins (pl. 125R–T), a bell

(pl. 126Y), a concave plate pierced at the edge and two bracelets (pl. 126N)'. A bitumen mask of a bull was thought to be the core for a statuette of precious metal (Starr 1939: 136; 1937: pl. 103G). Among a conventional repertory of tools and weapons, two spoons were unusual: 'too small for food, too large for an ear spoon' (Starr 1939: 485; 1937, pl. 126U).

Analyses of base-metal objects after the Akkadian period remain relatively uncommon. A sequence for Susa has been published up to the eighteenth century BC (Malfoy and Menu 1987) and select items in the Old Babylonian hoard from Tell Sifr have been sampled (Moorey *et al.* 1988). Thirty objects from excavations on Bahrain, said to date between 2300 and 1800 BC, were reported to be of unalloyed copper without a trace of tin (McKerrell 1977: 167). Fourteen objects from excavations at Tell Rimah and four from Kar-Tukulti-Ninurta, all attributed to the Middle Assyrian period, with one exception were also reported as an unalloyed copper (McKerrell 1977: 167 ff.; table 13; 1978: 21, table 10). The enduring vitality of copper as the metal of utility is about the only generalization that may yet be safely made. There appears to be a marked decline, by comparison with the third millennium, in the use of arsenical copper and a steady increase of tin-bronze, but the changeover may not yet be quantified nor may patterns of alloy-use be defined. Indeed, outside workshops specializing in luxury production, and to a degree probably also there, constant recycling of metal confuses the picture so that the extent to which craftsmen sought to control their alloys remains obscure. It is only by the Late Bronze Age, to judge from evidence available elsewhere in the Near East, that a consistent pattern of tin-bronze production may be said to emerge. However, there is no evidence so far, either in Mesopotamia or in western Iran (cf. Moorey 1971: 29 ff.), for leaded bronzes, which are a significant feature of Late Bronze Age metallurgy in certain parts of Europe. As they are associated with industries where tin may, at the time, have been in short supply and a degree of 'built-in obsolescence' was customary, this is not surprising.

(5) *Neo-Assyrian to the Achaemenid period, c.1000–330 BC*

It was not until the Neo-Babylonian period in the earlier sixth century BC that iron became cheaper than copper/bronze, though long before that it had been adopted as the primary metal, at least for the working parts of tools and weapons. The sources of archaeological evidence for metalwork at this time are surprisingly restricted. The range of evidence from graves is confined to a few sites, such as Assur, Babylon, Kish, and Nippur, and even then only personal ornaments and vessels are commonly represented. The situation is somewhat improved by the vivid presentation of Neo-

Assyrian metalwork on sculptured palace reliefs (cf. Hrouda 1965; Madhloom 1970), and by significant quantities of metalwork excavated from store-rooms in the palaces themselves. But, although the sequence of reliefs begins about the middle of the ninth century BC, the majority of surviving metalwork belongs to the last century or so of the Assyrian Empire. This means that it is not yet possible to write a history of Neo-Assyrian copper or bronze-working in any meaningful way, since developments through time are obscured by the nature of the surviving information.

The paucity of surviving copper and bronzework of this period has led to a persistent underestimation of the Neo-Assyrian metal industries, particularly by contrast with those of Urartu for which evidence is more extensive and varied (cf. Loon 1966; Azarpay 1968; Berghé and de Meyer 1982; Wartke 1990). On the evidence of the texts and sculptured reliefs, Assyrian metalworkers were no less active than their colleagues elsewhere at the time. The requirements of their army alone, not to mention the demands of the kings, constantly building and rebuilding, decorating and redecorating, palaces and temples, were a recurrent stimulus to production. Much of the drive behind Assyrian imperialism came from the quest for guaranteed lines of supply for vital raw materials, metals conspicuous amongst them (Jankowska 1969). With so much booty and tribute entering royal palaces and the well-documented presence of foreign artisans in major Assyrian workshops, caution is needed in the identification of Assyrian as distinct from foreign metalwork, when so much of the known repertory is from palace store-rooms. Unless compelling arguments to the contrary can be sustained, architectural fittings in metal, particularly when they follow long-established Mesopotamian traditions, metal elements from furniture of types regularly shown on Assyrian reliefs, and standard items of military equipment for men and horses may most safely be taken as local products. Where decoration is present distinctions are clearer, as among the imported bowls from Nimrud, especially when reinforced by inscriptions (Barnett 1967).

Curtis (1979; 1988) has surveyed the whole range of Neo-Assyrian metalworking, with particular reference to finds at Nimrud. To judge from developments elsewhere in the Near East, a major iron industry in Assyro-Babylonia is unlikely to have been established before the first centuries of the first millennium BC; during that time a full repertory of iron tools and weapons emerged (see below). Since iron could not be cast, though it might be decorated by swaging and *repoussé* work, copper and bronze long remained pre-eminent for all forms of decorative casting and for all objects or applications requiring sheet metal. The American excavators at Khorsabad (Loud and Altman 1938: 15–16) reported that bronze was found much

more often than any other metal. It was extensively used for tools and implements; architecturally for door-pivots and nails, some with heads covered in sheet silver. Wooden columns were encased in sheet bronze, scaled to resemble a palm tree (Place 1867–70: i. 120–2; iii, pl. 73; Loud 1936: 97 ff.) and embossed plaques decorated doors. Sheet-metal overlays for doors, more fully described below, are one of the better-known aspects of Neo-Assyrian metalworking, notably as exemplified by the sets of decorated doors from the Temple of Mamu at Balawat set up by Assurnasirpal II and Shalmaneser III (King 1915; Barnett 1973). Wall-plaques (cf. BM 22488 from Nimrud), overlays for 'Hands of Ishtar', and brick-stamps (cf. BM 124598; 135465–7) further illustrate the use of bronze in architectural contexts.

Elements of cast and hammered bronze formed an important part of furniture construction and decoration (cf. Salonen, A. 1963: 247–8). The evidence of palace sculptures is particularly valuable in this instance in offering the basis for the reconstruction of furniture from which only displaced metal fittings have survived (cf. Hrouda 1965: pls. 13–16; Dentzer 1982: 48 ff.; Born 1984; Curtis 1988: 85–6, pls. 74–82). Layard (1853: 198 ff. with figures) described his discovery of a royal throne at Nimrud (see p. 272 here).

With the exception of the legs, which appear to have been partly of ivory, it was of wood, cased or overlaid with bronze. . . . The metal was most elaborately engraved and embossed with symbolical figures and ornaments. . . . As the woodwork over which the bronze was fastened by means of small nails of the same material, had rotted away, the throne fell to pieces, but the metal casing was partly preserved. Numerous fragments of it are now in the British Museum, including the joints of the arms, and legs; the rams' or bulls' heads, which adorned the ends of the arms (some still retaining the clay and bitumen with the impression of the carving, showing the substance upon which the embossing had been hammered out), and the ornamental scroll-work of the cross bars, in the form of the Ionic volute. The legs were adorned with lion's paws resting on a pine-shaped ornament, like the thrones of the later Assyrian sculptures, and stood on a bronze base. . . .

In front of the throne was the foot-stool, also of wood overlaid with embossed metal, and adorned with the heads of ram or bulls. The feet ended in lion's paws and pine cones, like those of the throne. . . .

Sheet bronze was also used for cauldrons, cauldron-stands, and a wide range of vessels, some of which may also have been cast (cf. Hrouda 1965: pls. 18–19; Luschey 1939; Layard 1853: 176 ff.); for shields, for helmets, and for body-armour (cf. Hrouda 1965: pl. 23). Bronze was used for the decorative parts of weapons (cf. Hrouda 1965: pls. 21–2) and in the harness-trappings of horses (cf. Hrouda 1965: pls. 26–30). Horses on the reliefs also have elaborate sheet-metal trappings but few such objects have been reported from Assyria itself, though they are well rep-

resented in some neighbouring countries (cf. Winter 1980). Some fine cast bells found by Layard at Nimrud (1853: 177, figure) are probably from horse-harnessing. Some of the finest surviving representatives of the Neo-Assyrian cast metal tradition are lion-shaped weights (Layard 1849: i. 128; BM 91220–35); but they do little more than bear witness to much now lost, judging from the evidence of texts (cf. Braun-Holzinger 1984: 111 ff.). Of large-scale statuary virtually none has survived and the surviving corpus of small-scale Neo-Assyrian statuary is meagre; heads and statuettes of the demon Pazuzu are the commonest (Spycket 1981: 372 ff.; Braun-Holzinger 1984: 74 ff.).

Braun-Holzinger (1988) has assembled what little archaeological evidence there is for bronze-working in Babylonia in the first millennium BC. The repertory of surviving objects includes personal ornaments, small apotropaic figurines, tools and weapons, vessels, and furniture fittings. As this is the range of production common to most of the Near East, distinctive Babylonian features are hardly to be expected save in figurative designs and few have survived. Assyrian tribute lists and scenes on their reliefs of spoils from Babylonia indicate the usual concentration of metal and metalwork in the royal treasuries. On a relief from Sennacherib's Palace at Nineveh, probably carved late in Neo-Assyrian times (c. 630–620 BC), scribes are shown recording booty from a Chaldaean settlement (BM 124955–6; Paterson 1915: pls. 43, 55–6, 94–5; Reade 1983: pl. 61 (colour)). In this scene weapons and furniture appear with metal bowls and cauldrons, two on conical stands; all types commonly encountered elsewhere.

Substantial pieces of Neo-Babylonian bronzework are almost unknown archaeologically, though constantly evident in texts. An isolated survivor is part of a massive bronze door-sill with an inscription of Nebuchadnezzar from Rassam's excavations at Borsippa (BM 90851; Reade 1986^a: 114, 115, pl. XVI). It is embossed with fourteen-petal rosettes. Reade (1986^a: 114–15, fig. 3) has suggested that another massive bronze fragment from the same source may be part of the metal sheathing of a Neo-Babylonian column-base or the top of a pedestal. The widespread use of copper fittings for gateways at Babylon is reflected in the words of Herodotus (i: 179): 'There are a hundred gates in the circuit of the wall, all of bronze with bronze uprights and lintels.'

Copper and its alloys continued to be used in Mesopotamia through the Achaemenid period. The material culture of this time is known almost exclusively from sites in Babylonia, where the base-metal repertory differs little, if at all, from the Neo-Babylonian tradition. The distinctive Achaemenid fashions in metalwork are most evident in precious metal (see above).

(e) Workshops and manufacturing equipment

The confident identification of metal workshops on excavated sites in Mesopotamia is by no means as easy as might be supposed. The literature already contains a number of debatable or demonstrably erroneous attributions. The best-known is the case of the palace at Mari, where archaeological evidence of secondary metalworking is to be expected (Muhly 1973: 212; Rouault 1977: 162 ff.). Here a confusion over the translation of *šuripum* ('ice' not 'copper-ore') led Dossin and Forbes to unwarranted conclusions about smelting, and other metalworking, in specific parts of the Mari palace (cf. *AHW*, s.v. *šuripum*; Muhly 1973: 211; cf. Margueron 1979: 14 ff.). Nor may a case be sustained for a copper workshop in the AH site, of the earlier second millennium BC, at Ur, cited by Leemans (1960: 55) and Muhly (1973: 211), on the basis of a preliminary report by Woolley. In his final excavation report of this part of the site Woolley (1976: 33) wrote: 'In no. 1 Baker's Square the entire house had been remodelled and turned into a workshop and one old room served as a stoke-hole and in another room and in the courtyard were furnaces (pl. 50); judging from a miniature set of model tools in the owner's grave he was a working coppersmith.' This is a reference to grave LG 144, found in the 'chapel' of 1B Baker's Square (Woolley 1976: 158, 199), which contained this set of models (U.16773; Woolley 1976: 244, pl. 98). But, as their appearance (and Woolley's own catalogue entry) indicates, they look more like a leatherworker's tools than a coppersmith's, and there is no reported trace of metalworking debris from the building itself. Indeed, the 'furnaces' are more like ovens, perhaps for baking bread (cf. Barrelet 1974: 270 ff., fig. 15; Mari). The same objections (the absence of diagnostic industrial debris, of working tools, and of characteristic installations) apply to the proposed identification of metal workshops in later prehistoric levels at Uruk (Lenzen 1960: 10, pls. 39, 3b, 4a–d; Nissen 1970: 110 ff., pl. VI) and in Early Dynastic Khafajah (Delougaz 1940: 33; 1967: 176) and in Palace 'A' at Kish (Mackay 1929: 87).

Delougaz identified a 'smithy' in the Akkadian to Ur III house levels at Tell Asmar. This conclusion was based on the fact that 'identical fireplaces are used by metalworkers today in the bazaars of small Iraqi towns', though, even here, the associated small finds do not make the comparison absolutely compelling (J.18.1; Delougaz 1967: 228); no more convincing are workshop identifications in the Northern Palace at Tell Asmar (Delougaz 1967: 198; cf. Margueron 1979).

By far the best identification of a workshop is in a town of the Isin-Larsa period at Tell edh-Dhiba'i (Al-Gailani 1965), which yielded a whole series of small finds indisputably demonstrating its purpose. Sadly, these were recovered under weather conditions that

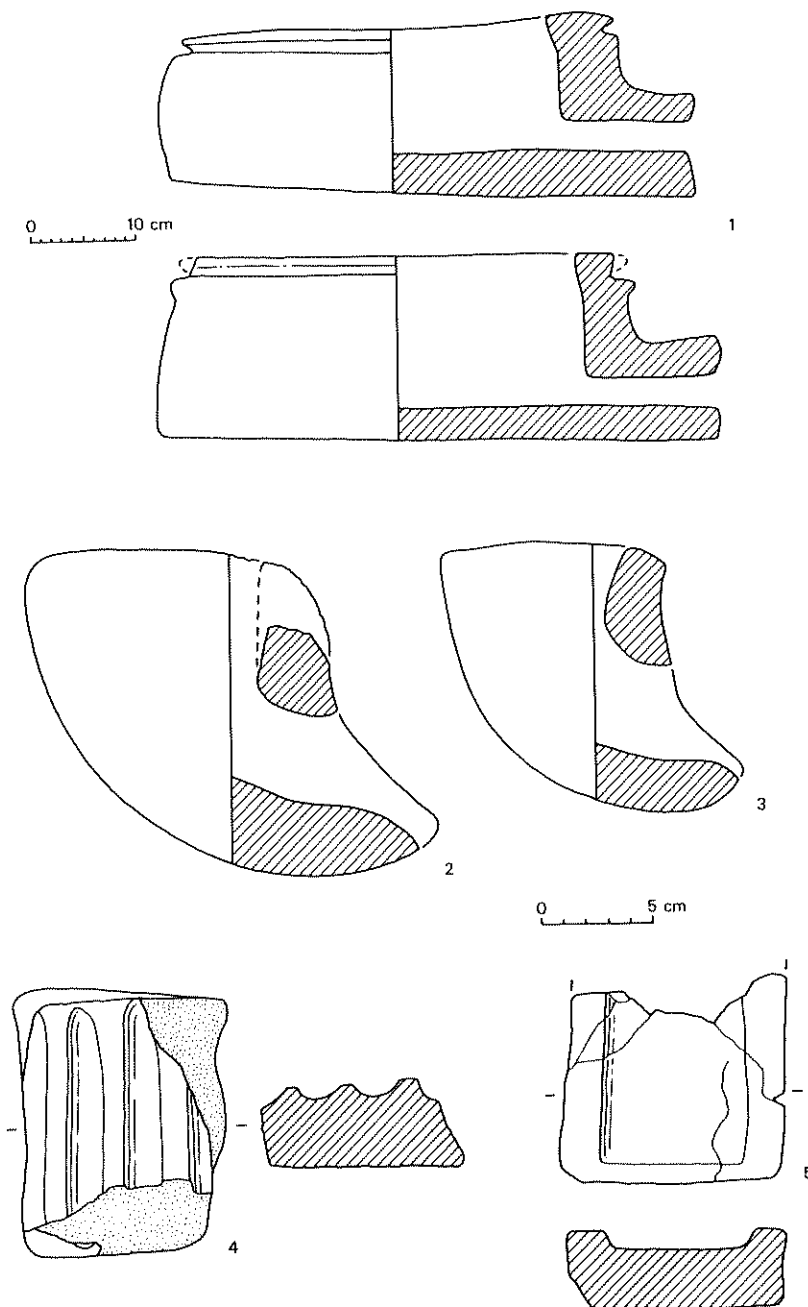


Fig. 16. Industrial debris from a bronze-working place at Tell edh-Dhiba'i, c.1800 BC (after Davey 1983: figs. 2-3):
 1. Two pot-bellows of baked clay.
 2. Baked clay crucible.
 3. Baked clay crucible.
 4. Baked clay open mould for casting long narrow bars, perhaps for working into knife- or dagger-blades.
 5. Baked clay open mould for a flat sheet, perhaps for working into a vessel.

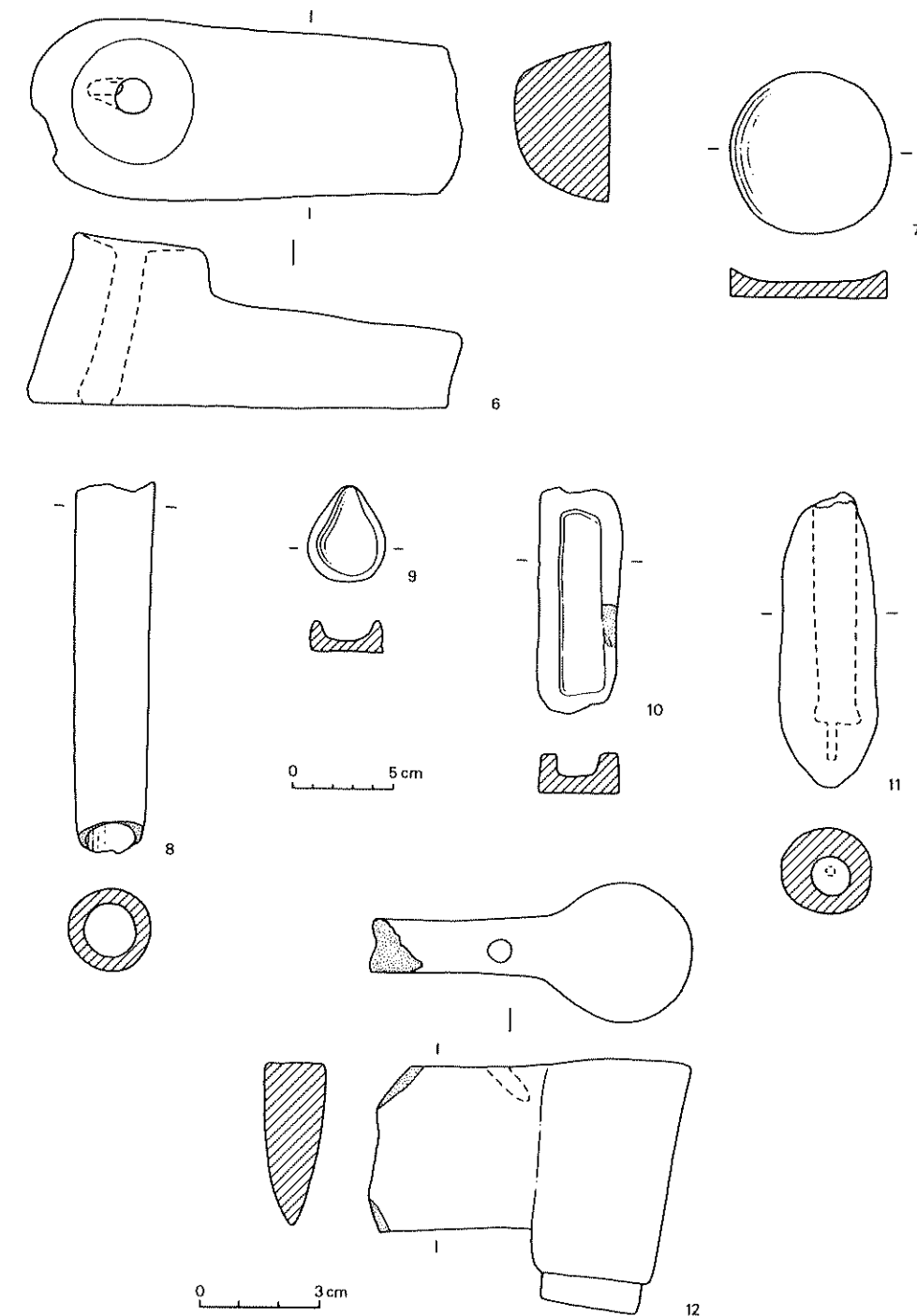


Fig. 17. Industrial debris from a bronze-working place at Tell edh-Dhiba'i, c.1800 BC (after Davey 1983: figs. 4-5):
 6. Baked clay mould cover.
 7. Baked clay 'dish'.
 8. Baked clay pipe.
 9. Baked clay measuring dish.
 10. Baked clay mould (?).
 11. A baked clay bellows or blow-pipe nozzle.
 12. Baked clay model axehead for use in sand-casting.

prevented proper recording. Winton, on the basis of photographs only (Al-Gailani 1965: 37–8, pl. 6), presented a preliminary identification of the finds. More recently Davey (1983; 1988) has offered valuable first-hand studies of them with good illustrations. They include the following items:

1. *Two hand-made baked clay pot-bellows* (Davey 1983: figs 2, pl. 1a; 1988: fig. 6.5) about 0.4 m. in diameter and 0.16 m. high; probably operated by the feet as a pair, on analogy with illustrations in the New Kingdom tomb of Rekmire at Thebes in Egypt (cf. Davey 1979; 1988: 66).

2. *Five crucibles and a fragment of another* (Davey 1983: figs. 2, 3, pl. 1b, c; 1988: figs. 6.1–2) made of a coarse fabric containing silica and traces of straw. X-ray fluorescence of debris in crucible 4 revealed copper, tin, arsenic, with traces of nickel and iron, indicating that bronze had been melted in it. Their capacity has not been reported. Davey (1983) reconstructed their use with the assistance of reliefs showing metalworkers in Egyptian tombs of the Vth Dynasty: 'the reliefs reveal that melting is performed in two crucibles placed back to back and with six men using blow-pipes aimed at the charcoal placed in front of each crucible. After the metal was melted the crucible was taken to the mould, held with the assistance of two stones or lumps of clay and then a blockage in the mouth of the crucible was removed to allow the metal to discharge into the mould' (Davey 1983: 174; cf. also the Egyptian hieroglyphs for copper: Gardiner 1957: 490, 529: this shape is not an 'ingot' but a 'crucible'). Comparable crucibles have been reported from Tell el-Qitar in Syria and from Sinai (Davey 1988: 66, fig. 6.1a).

3. A number of fragmentary *baked clay open moulds* (Davey 1983: figs. 3 and 4, pl. 1d) were recovered. Two, Davey nos. 9 and 14, were probably for casting bar-ingots, perhaps then bent round to form rings for ease of handling. Mould 10 is similar, but is larger and might be a blank to be hammered into a knife- or dagger-blade. Mould 11 produced rectangular plaques of metal, perhaps for hammering into sheet. Mould 18, with thin sides, for a rectangular bar, might be for a metal of lower melting point than copper and its alloys. The use of ingot-moulds is referred to in texts, both practical and literary, where it is a matter of recycling metal by melting it down for reuse: 'like statues poured into an ingot-mould we will be killed' (Cooper and Heimpel 1983: 81–2).

4. *One baked clay mould-cover* (Davey 1983: fig. 4, pl. 11a) and the fragments of another; such covers inhibited oxidization of the surface of the casting, and by allowing the mould to be heated in the furnace, retarded the solidification of the metal, allowing it to flow more freely into the mould.

5. *One mould for casting a pin* by the lost-wax method

(Davey 1983: fig. 5, pl. 11b; 1988: fig. 6:7) made of two different types of clay, the inner of fine yellow clay, the outer shell of coarser buff-coloured clay.

6. *A broken clay model axehead* (Davey 1983: fig. 5, pl. 11c, d; 1988: fig. 6:8) probably used as a pattern in mould-making, and the core for creating a shaft-hole in an axehead. Davey (1983: 178–9) suggested that this was evidence for sand-casting. This is an open question, as the model's purpose is not self-evident (cf. Müller-Karpe 1990^a).

7. *A baked clay ladle* (Winton in Al-Gailani, 1965: 38) or possibly the clay nozzle of a blow-pipe (Davey 1983: no. 13; 1988: fig. 6: 1d, 6).

8. At least one fragment of *tuyère* (cf. Tylecote 1981).

9. A number of *small flat round dishes*, some with green and brown slag indicating they had been subjected to considerable heat.

It is important to notice the absence of stone moulds here (cf. Davey: 1979), the use of baked clay instead and possibly of earth or sand, and the presence of closed crucibles as in Egypt, rather than the open ones of Anatolia, the Levant, and Iran (cf. Davey 1983: 183; Tylecote 1976: 20). Davey (1988: 67–8) has sought to identify two copper-working traditions in the Near East in the Bronze Age on the basis of their equipment and a broad distinction between craftsmen who had ample fuel (Anatolia; Iran) and those who had to be economical with charcoal, as in Mesopotamia, debatably concluding that 'the beginnings of the metallurgy of Sumer, Egypt, and Babylonia are not to be sought in the surroundings mountains, but in the deserts, in places such as Oman, Fenan and western Saudi Arabia, where people are known to have mined and engaged in metallurgy'.

There is no known illustration from Mesopotamia of copper-working. Limet's view (1960: 121) that a scene on an archaic sealing from Susa shows metalworking is mistaken. It is just one in a whole series of contemporary sealings which show pots and potting (Baudot 1979).

Scattered evidence for metalworking is no more common in Mesopotamian excavations; nor have any sets of metalworker's tools been identified. Before bellows, smiths probably used blow-pipes for annealing, brazing, and other low-temperature operations. Sufficiently high temperatures (1063 °C. to melt gold) can be obtained locally with a brazier-type hearth and a blow-pipe blown by human lungs. 'A pair of human lungs can produce an intermittent flow of 40 l./min. but only 10–20 l./min. on a continuous basis. This is more than enough to superheat a hearth to 1000° C over a small area, already brought to a high temperature by a natural draught' (Tylecote 1981: 108). Such pipes, perhaps reeds tipped with clay, will rarely leave recognizable archaeological traces (but see Davey 1988: 6.6).

Pot-bellows are not evident in Mesopotamia before the earlier second millennium BC, when examples are known from Tell edh-Dhiba'i and Tell Asmar (Davey 1979: 106–7). The earliest stone moulds, significantly from northern Iraq at sites like Chagar Bazar (Mallowan 1937: 160, pl. 18B) and Tepe Gawra (Speiser 1935: 104, pl. 47), appear in the later third millennium; a Middle Assyrian group, some for shaft-hole axeheads, have recently been found at Tell Mohammed Arab, in the Eski Mosul region (M. Roaf: personal communication). In central and southern Iraq stone moulds are always likely to have been exceptional, for baked clay and possibly sand would have been the standard medium there, as in the Tell edh-Dhiba'i workshop. Forbes cites, without reference, *tuyères* 'found near a furnace at Telloh (Ur III period, c.2300 BC)'. I have not traced this in the published reports.

In level IV, of the earlier second millennium BC, at Tepe Gawra there was an object reported as 'a hand-made lamp of greenish grey ware with two legs on one side balancing with the base' (Speiser 1935: 59, pl. LXXIV, 201). It was associated with a number of storage jars. In 'ambiente 5' of period IVD at Arslantepe in eastern Anatolia exactly comparable objects used as crucibles were found in direct association with stone moulds for casting copper or bronze artefacts (Palmieri 1973: 109–10, pl. 45, 1–3, 46, 1–3, 5) dated to Early Bronze IIIB, late in the third millennium BC (Palmieri 1981: 102). This is one of the best published examples of a metal workshop in the Near East (Palmieri 1981: figs. 34, 37; cf. Özgüç, T. 1955). The room also contained pestles and mortars and had benches running round the sides. There may be no doubt of the function of these crucibles, for there was metal debris in at least one. A crucible from Amuq 'G' in Syria had been used for bronze (Braidwood R. J. *et al.* 1951); another, of the later third millennium BC, from Tell Sweyhat on the Euphrates, attested to local metalworking (Hedges 1976: 66–7). An isolated crucible was reported from the early second-millennium BC levels at Nuzi (Starr 1937: pl. 57); but there is no clear indication that it was for metal.

(f) Techniques

'The nobler metals provide a fruitful source of evidence for technical methods of manufacture. This, unfortunately, is often denied to us in the case of copper and its alloys, which are ravaged by corrosion to such an extent as to hide all traces of tool-marks unless in exceptional cases' (Plenderleith, in Woolley 1934: 295).

(1) Annealing

Those who argue that native copper is extremely difficult to cold-hammer successfully (Coghlan 1975: 26 ff, 76 ff.) believe annealing to have been an early innovation in the appearance of native copper artefacts in

the Near East. Smith (1967: 28) argued that 'native copper can be worked almost infinitely without cracking' and that the earliest known copper artefacts from Çayönü in Anatolia, and from Ali Kosh and Sialk I in Iran, 'are unmistakably hammered copper made without annealing' (cf. his more cautious statements in Smith, C. S. 1969: 427). More recent work on a greater range of copper objects from Çayönü has shown both 'the cracking due to excessive cold working without annealing' (Muhly 1988: 7, fig. 1: 6–7) and 'evidence of the recrystallization brought about by annealing' (Muhly 1988: fig. 1: 8). Thereafter, as it alone allows for the continuous workability of copper, it is a crucial technique. For *planishing*, a light hammering to toughen and polish the metal, polishing stones may have been used. Research by the Sumerian Metals Project in Philadelphia has shown that in both the Early Dynastic III and the Akkadian period at Ur some tools were left as cast, others were annealed, as were contemporary pins; but not to a consistent extent. By contrast, Gawra in the third millennium showed a much more standard, if less enterprising, tradition of manufacturing.

(2) Casting

Casting involves, at its simplest, pouring liquid metal into a suitably shaped mould of baked clay, stone, metal, or sand. The earliest moulds to survive in archaeological contexts are one-piece, of clay or stone. They remained usual for the manufacture of simple tools, flat weapons such as tanged arrowheads, bar-ingots (cf. Levey 1959: 207: fig. 46), and jewellery. Simple jewellery moulds of stone are more common in excavations than their more complex relatives used for tools and weapons. Wartke (1980) has catalogued and discussed the stone jewellery moulds from Assur, Sinjirli, and Uruk, then in East Berlin; isolated examples have been published from other sites (Opitz 1933: 208 ff.). Even a one-piece mould would have been covered with a flat stone to prevent oxidization.

Two-piece (bivalve) moulds, probably of baked clay at first, were introduced some time in the fourth millennium, if not before, with core pieces for sockets when required, as on axe, adze- and hammer-heads. A few tools and weapons, of the later third millennium BC from Tepe Gawra and Billa, have been the subject of metallurgical study (Levey 1959: 201 ff.). Three tin-bronze axeheads (Sn: 6 per cent; 15.7 per cent; 5 per cent) were the only objects among the ten listed specimens that had apparently not been worked after casting. Of the specimens tested, the flat 'axes' and chisels, all of unalloyed copper, 'show microstructures indicative of cold working and annealing or of hot-working subsequent to casting' (Levey 1959: 204). It was probably common practice to cast the simple tools in open moulds and subsequently hammer them to the desired

shape. Two shaft-hole adzeheads, neither with appreciable amounts of tin, had been 'worked to some extent subsequent to casting although the amount of working is slight'. There appeared to be 'no indication that specimens were heavily cold worked near the edge to harden them. While the smiths must have been aware of the hardening effect of working the metal while cold, they apparently made no attempt to utilize this, in giving a cutting edge that could last longer.'

The only elaborate moulds made of metal so far reported from Mesopotamia are for casting socketed arrowheads of the so-called 'Scythian type' in the seventh to sixth centuries BC; one, said to be from Mosul, is for producing three at a time (Coghlan 1952); the other is from Woolley's excavations at Carchemish (Woolley 1921: pl. 23) and casts singly (PLATE VII A, B). The triple mould consisting of six separate pieces, probably of the seventh century BC, is a beautiful and masterly construction and an isolated indicator of the sophistication of casting technology by this time. Coghlan (1952) argued that it was for the production of actual arrowheads; Underwood (1958) was of the opinion that it was for producing wax arrowheads, then reproduced in metal by lost-wax casting. It has yet to be demonstrated that bronze moulds can be repeatedly used. British Prehistoric metal moulds have lead on their inside surface indicating use in a process of lost-lead casting, so Underwood's suggestion may be more likely for the Mosul mould. By the Neo-Assyrian period parts of metal vessels, if not entire vessels, were being cast; but no metallographic work has yet been done on this problem. It is impossible to tell by eye which of the richly embossed *phialai* (Luschey 1939) are cast, which hammered; but when microscopic surface examination reveals no evidence of working they are usually described as cast. Only cast handles may be so identified (cf. Woolley 1962: pl. 24, top). Finger-rings from the Achaemenid period onwards were cast in moulds of baked clay, stone, and metal (Wartke 1980).

Davey (1983: 178-9) suggested that a fragmentary baked clay model axehead and a shaft-hole core, included among workshop debris from Tell edh-Dhiba'i (see above), might have been used for sand-casting. This technique is rarely mentioned in the current literature on ancient metalworking, since it seems generally to be regarded as an aspect of modern rather than of ancient metallurgy. This may be a matter of definition rather than a reflection of the actual situation. Contemporary practice among Bedouin, cited by Davey (1983: 80), indicates that the use of loose earth for casting in antiquity is probable. Although Coghlan (1975: 50-1; cf. Wulff 1966: 18-19), in his comprehensive discussion of casting techniques, included a full description of sand-casting, 'the most simple method by which non-ferrous castings are sometimes still made today', he did not expand the discussion, as he believed the technique

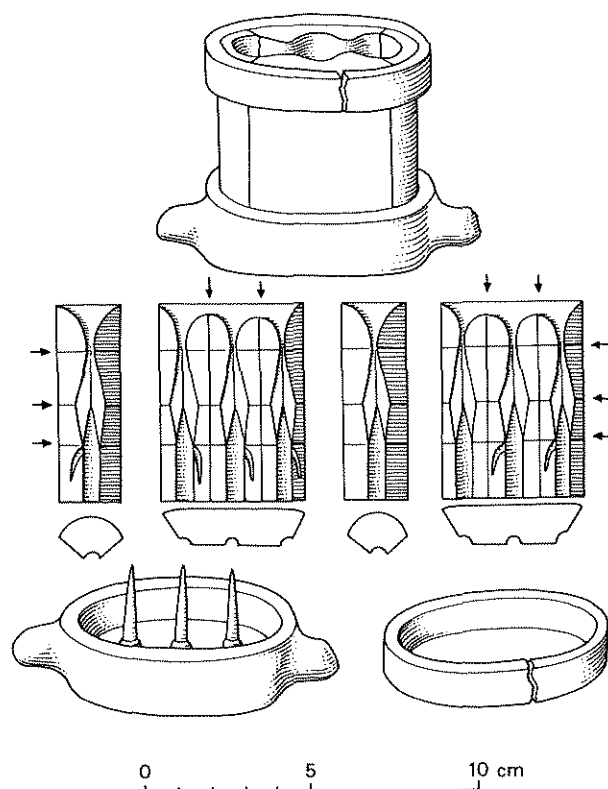


Fig. 18. Detailed drawing of the Neo-Assyrian bronze mould shown closed in plate VIIIA (drawing after H. Maryon, *American Journal of Archaeology*, 65 (1961), pl. 72, fig. 17).

to have been largely unknown in antiquity. Müller-Karpe (1990^a) has illustrated both the use of this technique by a metalworker in the Baghdad *Suq* and experimental reproduction of an Early Dynastic III shaft-hole axehead using a wooden model. He has also pointed out the distinctive surface effect left on the metal surface in sand-casting, identifying it on a silver axehead from PG 250 (Early Dynasty III—Akkadian) in the Royal Cemetery at Ur (Müller-Karpe 1990^b: 191-2, fig. 23). He argues that use of this technique in Sumer may explain the general absence of baked clay and stone moulds from excavations in the region.

Textual references do not necessarily elucidate such matters, but a key phrase in the famous passage in 1 Kings 7: 46, where the manufacture of bronze objects for Solomon's Temple is described, is rendered in the Jerusalem Bible, following the Greek, as 'sand-casting'. Even the more conservative renderings speak of 'in the compactness of the soil' or 'in the clay ground'. The archaeological problem is obvious. A moulding-box filled with sand or loam, or just a negative made in the ground, is not going to survive for recognition in an excavation. It is only an accumulation of stray indi-

cators that will reveal such a procedure. Patterns and cores are one aspect of the matter; objects not cleaned down may be another. Some of the distinctive copper bar-ingots of the later third millennium BC in Palestine (cf. Tufnell 1958: pl. 21, 11-15), like the Ur axehead, look as if they might possibly be sand-castings.

Investment casting, the *cire perdue* or lost-wax method, was used for small-scale work by the fourth millennium BC in Mesopotamia. First, a model of the object to be cast was made in beeswax, then covered with clay or a clay mixture (the investment material to form a mould; see the *Chicago Assyrian Dictionary* under *iškuru* (wax), usage 'b'). This would then be supported in some way and heated. The wax was thus melted and either burnt away or ran out through holes provided in the mould. When the mould was sufficiently baked, metal was poured into the holes whence the wax had escaped. It was allowed to cool. The mould was then broken away and the casting cleaned. The surface was treated as required (cf. Coghlan 1975: 143 ff., pls. XI ff. for illustration of the method). Smith (1981: 134) has commented generally on this remarkable technique: 'There is, of course, no evidence whatever of what "wax" was used. Any easily shapable material that was fusible or volatile, or that left a light removable ash on combustion, would serve—for example, a hard animal fat, beeswax, resin, some of the harder forms of bitumen, and, on occasions, the bodies of insects or a light low-ash wood. With this technique the artist is free from any restraint arising in the negative nature of the mold, for the pattern does not have to be withdrawn and the mold surfaces, however contorted, reflect all the details of the wax and do not have to be accessible to further tooling. The sculptor could, indeed, model things freely as he had done in clay for millennia. At first these castings were solid, but later the art of molding the wax over a sandy clay core was introduced'. The Mari texts provide evidence for the issue of wax to metalworkers (Bardet *et al.* 1984: 303).

The earliest castings of this type known from Mesopotamia are tiny, solid-cast animal amulets, parts of composite statuettes of animals, and zoomorphic handles for seals from the *Sammelfund* found in the latest part of Eanna (level 3) at Uruk (Heinrich 1936: pls. 13a, 14a, 17a-b). Although buried at the very end of the prehistoric period, this hoard is believed to contain objects manufactured earlier in the Uruk IV period (Goff 1963: 265 ff.). In the case of one amulet, a copper lion, analysis revealed 9 per cent lead, indicating that the maker already realized the value of this additive in casting. By at least Early Dynastic I-II more elaborate, larger anthropomorphic and zoomorphic copper artefacts were cast, notably a series of stands for vessels found in temples in the Diyala Valley (Frankfort 1939: 39 ff.; 1943: 11 ff.) and in graves of the 'Y' sounding at Kish (Watelin 1934: pl. XXI.1-2; for dating:

Algaze 1983-4), where they also decorated rein-rings (Watelin 1934: pl. XXV). This work already shows remarkable mastery of the technique, particularly when it seems the medium was copper or arsenical copper rather than leaded tin-bronze.

The use of divisible piece-moulds for such work is best shown by lost-wax castings in precious metals (see above). The most remarkable single work in this category, in base metal, remains the copper quadriga from the Shara Temple at Tell Agrab (Frankfort 1943: 12-13, pls. 58 ff.). The only object of this type to have received a detailed examination is an unprovenanced (dealer's attribution to Tell Sifr) wild-goat stand in the Metropolitan Museum, New York (Muscarella 1988: no. 467), probably dating to Early Dynastic III. Its structure elucidates many points which may only be surmised about the excavated pieces yet to be studied. This stand is made of three separate units: a foot comparable to those on the Kish and Diyala stands, a central standing wild goat, and an upper bracket set on its back. The animal is arsenical copper (Cu: 94.0 per cent; As: 2.6 per cent; Zn: 0.9 per cent; Sn: 0.2 per cent; Pb: 0.3 per cent) cast round a clay core, held in place by chaplets through the shoulders and haunches. The hollow central, circular strut passes through the animal's body and must have been cast around the core. The solid animal head was cast separately and fitted by a 'tongue-in-groove' device to the neck, which is tapered and reaches into the base of the head, where the junction is secured by a pin. Radiographs indicate that the base was a single casting. Tangs below the animal's feet fit into cavities in the base and are secured by 'collars' of extra metal, perhaps cast on by puddling, i.e. by putting molten metal into a fired clay dam at the junctions, probably with the stand inverted. The four-ring upper bracket is a single casting, possibly made in an open mould. The three vertical struts were cast on separately and the whole joined to the animal (Muscarella 1988: 334-5 n. 2: technical report).

That lost-wax casting was early exploited for relatively routine objects is evident from a cast openwork handle for a copper dagger from a Kish grave of Early Dynastic I (Watelin 1934: pl. XVIII.1). It was to be used throughout for small-scale statuary, predominantly solid-cast, examples of which survive only sporadically (Spycket 1981: *passim*; pls. 23, 40, 42, 52, 62, 152, 153, 156-9, 171, 191, 242-5, 252; Braun-Holzinger 1984), and foundation figurines (Ellis 1968; Rashid 1983). Decorative cast fittings of one sort or another are equally elusive in the archaeological record. To the earlier second millennium BC belong an enigmatic series of rollers and frames (Moorey 1977; Calmeyer 1969: 177 ff.) and some standards (Calmeyer 1969: 50 ff.) that may be Babylonian rather than Elamite. In contrast to Iran and Anatolia, Mesopotamia seems never to have developed a taste for weapons with cast

decoration, though isolated examples are reported (cf. Güterbock 1965).

Whether or not cast-metal furniture fittings had been used for furniture before the Neo-Assyrian period is not clear, but by then both reliefs and isolated finds bear ample witness to their currency (Kyrieleis 1969: 6 ff.; Dentzer 1982; Curtis 1988: 85–6). In the 'Room of the Bronzes' (AB) of the North-West Palace at Nimrud, Layard found many scattered fittings from what he identified as a high-backed throne and footstool (Layard 1853: 198–200). Curtis (1988: 85) has reviewed these pieces, correcting Layard's reconstruction, in the light of evidence from reliefs. He argues that 'we may postulate the presence of at least four pieces of furniture, including a backless throne and a table . . . the assembled throne resembles the well-known example on a relief of Ashurnasirpal' (Layard 1849–53: i, pl. 5). A fine hollow-cast bronze 'dragon's head in the Louvre was, perhaps, once the head of a sceptre sacred to Marduk (*Encycl. Photo II*, 1936, pl. 39). Fine zoomorphic castings on a small scale are illustrated in the same period by the bronze lion weights found in Assyrian palaces at Nimrud and Khorsabad (Spycket 1981: 433–4, pl. 284).

For substantially larger castings, and even for some smaller ones, it was important to save metal, and for this cored lost-wax castings were devised. For this a core of clay or clay mixture suitable for rough moulding was shaped to the desired form and covered with wax to an appropriate thickness and consistency, so that all ornament and detail might be cut into it. An outer coating of clay was then applied and the same process of baking and metal pouring used as with smaller work (see above). Most such castings would have needed projecting spikes of copper, bronze, or iron ('chaplets') to secure the core in position. By this method, particularly when skilfully executed, there can be great economy in the use of metal. It is also extremely versatile. Fine detail can be worked on the wax model and exactly reproduced in the casting. Any shape may be produced since, unlike moulds (even piece-moulds), the pattern does not have to be extracted from the mould before casting.

There is already some evidence in the later Early Dynastic period for cast-metal statuary of considerable size (Frankfort 1943: 11, pl. 61) in which the surviving limbs and feet are hollow-cast: 'It may be, of course, that the statue was of some other material with only the face, hands, and the feet cast of copper' (Frankfort 1954: 26). The Akkadian copper head of a king from Nineveh (Braun-Holzinger 1984: no. 49; Strommenger 1985: with analyses) is hollow-cast; a detailed technical examination has yet to be undertaken. The ears are said to be 'connected with one another through a roughly square, almost vertical copper plate' and were inserted into the head. This head illustrates the extent to which

craftsmen had appreciated the potential of cutting the fine details of hair and beard in the wax for reproduction in casting, though the head is heavier than need be. The fragmentary copper casting of a crouching standard-bearer, on a circular base inscribed for Naram-Sin (Al-Fouadi 1976; Braun-Holzinger 1984: no. 61), is no less remarkable and also awaits the full technical study it deserves; chaplets and much of the casting core survive.

It is only at Susa in the Middle Elamite levels that excavators have found large-scale castings of the type that texts indicate would also have been current in other major Mesopotamian cities. The famous bronze *barrières* inscribed for King Shilhak-Inshushinak (c. 1130–1100 BC) are 20 ft. long, 8 in. in diameter and about ½ in. thick; perhaps cast by pouring simultaneously from numerous crucibles through many funnels (Maryon and Plenderleith 1954: 632). The now headless bronze statue of Napir-asu, wife of Untash-Napirisha, is almost bell-shaped; it consists of an outer shell of metal usually about an inch thick, though more at the hands. The core is a solid mass of less compact metal, probably from successive pourings from small crucibles (Amiet 1966: no. 280, pl. 372; 1.29 m. high; 1750 kg. weight). Maryon and Plenderleith (1954: 632) commented that: 'perhaps the additional metal was added to strengthen a crack that formed in the casting when it cooled. It is to avoid this mischance that modern bell founders rake out the core of a large bell as soon as the metal has set, and before it has time to contract strongly.' A fragment of a relief frieze cast in bronze (Braun-Holzinger 1984: no. 359) of the same date from Susa illustrates an aspect of cast bronzework only evident elsewhere at present in small inscribed fragments from Neo-Assyrian royal workshops distributed through the antiquities market (Braun-Holzinger 1984: nos. 356–7). A 'Sumerian' metal relief, published by Börker-Klähn (1974), has yet to be convincingly authenticated.

The most famous text from Mesopotamia relating to large-scale casting in bronze is in Sennacherib's account of the 'Palace without Rival' (Luckenbill 1924: 108–9, duplicate 122). Dalley (1988: 103–5) has provided modern translations of the relevant passages and a commentary on them. She renders one of the key sections thus:

In times past, when the kings my fathers fashioned a bronze image in likeness of their members, to set up in their temples, the labour on them exhausted every workman; in their ignorance and lack of knowledge they caused a scarcity of the materials needed for the work: oil, wax and the 'covering of flocks' (meaning uncertain: ?fleeces; tallow; lanolin).

Here, as in other contexts, Sennacherib appears to indicate personal knowledge of technical processes, which were undertaken away from towns, presumably where

metals, timber for fuel, and prevailing winds suitable for furnace operation were all available.

Dalley renders another instructive passage thus:

I fashioned a work of copper and cunningly wrought it. 4 giant trees and palm trees, the tree of abundance, 12 fierce lion colossi together with 12 mighty bull colossi, which were perfect castings . . . as by divine inspiration I built forms of clay and poured copper into them over and over again; I perfected their forms as (easily as) if they were objects (weighing only) half a shekel each.

Some commentators (e.g. Underwood 1958) have been misled by the reference to shekels into proposing methods based on dies and on coin-striking, when the reference was to three-dimensional, solid bronze weights on the shekel standard made by long-established, if small-scale, techniques of casting in moulds. Maryon and Plenderleith (1954: 632–3) offered a plausible reconstruction of Sennacherib's procedures:

Sennacherib's moulds were of clay; they would be piece-moulds, built up individually against the original models. When removed from the model they would be fitted with a core, and the necessary jets and vents for casting would be provided. Next, the core and mould would be set up near the furnace and fired to enable them to withstand the pressure of the molten metal. Then brick walls would be built round them, strengthened by the 'great posts and crossbars of wood'. These could not have been placed within the moulds themselves, for the heat of the molten metal might have set them alight, with disastrous results; nor could the mould have been baked if they were within.

It appears that Sennacherib's figures were not hollow lost-wax castings, as had been customary before his time, but enormous solid metal figures cast, not with legs free-standing as originally assumed, but 'striding' (as Dalley (1988: 105) points out) in low relief on a solid metal core. In short, they were exact replicas in metal of the massive guardian figures carved in relief on stone blocks with just the head projecting. Dalley (1988: 104) has also calculated that Sennacherib's lions contained nearly two and a half times the metal of those cast by Sargon, though there is the possibility that the given weights apply to two colossi rather than to a single one since they were paired:

Sargon (Luckenbill 1926–7: ii, sections 73, 84)
8 lions, total 4,610 talents, each 576.25 talents.
if heavy talent, 34,920 kg. (35 tons) approx.
if light talent, 17,460 kg. (17 tons) approx.
Sennacherib (Luckenbill 1926–7: II, section 367)
8 lions, total 11,400 talents, each 1,425 talents.
if heavy talent, 86,355 kg. (86 tons) approx.
if light talent, 43,177 kg. (43 tons) approx.

Most surviving Assyrian weights, whether zoomorphic, notably a fine series in bronze, or small, plain ones in geometric shapes, were solid-cast in multiple clay moulds. Perhaps it was this type of casting that

Sennacherib, at least for the first time in living memory, exploited on a monumental scale. It is possible that a relief, from Ashurbanipal's palace at Nineveh, carved about 645 BC, shows the façade of Sennacherib's palace, with its columns standing on cast bronze bases set on the backs of lions *passant*, just as Sennacherib's inscription describes them (Reade 1983: pl. 56).

Very little Neo-Assyrian metal sculpture has survived, although the archive of photographs left by Place includes one captioned 'débris d'une statue de bronze de Kalah-Chergat' (Börker-Klähn 1973: fig. 1). This appears to be a metal version of a type of male caryatid stone statue, of a deity carrying a vase with flowing streams, known from Khorsabad (Strommenger 1970: 23 ff.). Such a column-shaped casting would not have presented the same problems as Sennacherib's colossi. It is in the tradition of the Queen Napir-asu statue. The Louvre in Paris has a damaged, headless inscribed bronze statue of King Assur-dan II (c. 934–12 BC), now 30 cm. high, weighing 2 kg.; it is of simple, cylindrical form (Braun-Holzinger 1984: no. 342). Assyrian soldiers are shown breaking up a statue for its metal in Sargon's depiction of his sack of *Muṣaṣir*, in the later eighth century BC on reliefs at Khorsabad (Botta and Flandin 1849–50: pl. 142–2; Mayer 1979).

(3) Sheet-metal working

Maryon and Plenderleith (1954: 635) resolved the question of whether hot- or cold-forging was used at Ur in antiquity on the basis of the existence, or absence, of efficient tools for holding the work for hammering. For hot-working the hands must be about 8 inches or more from the metal. No hinged tongs are known from the ancient Near East before the mature Iron Age and it is assumed, from Egyptian practices shown on reliefs (Newberry 1900: pl. XVIII), that crossed strips of young or damp wood were used, insulated as necessary with clay. The grip would not have been very secure. 'This beaten work, such as that from Ur, must have been done mostly by cold-forging, a process still employed wherever hand-working is practised. To the craftsman, it has the immense advantage that by holding the work in his hand he had complete control over it' (Maryon and Plenderleith 1954: 636). It is likely that the metal vessels were raised, by means of blows on the outside, rather than by sinking into a suitably cut hollow in a wood or stone block. Maryon (1949: 95 ff., fig. 10) describes the procedure in detail, with particular attention to a range of standard vessel shapes from the Royal Cemetery in which he isolated 'the shapes which the vase would be likely to have taken while passing, under the hammer of the craftsman, from the original flat disk of metal to its completed form'. These techniques had been developed by the fourth millennium and were to undergo no appreciable change (cf. Woolley 1976: 185, pl. 100; 1962: 104, pl. 24,32).

They included tricks for including handles and spouts: 'If desired, the material to produce a lip or spout, or a handle, may be left on the disk from which a jug or saucepan is to be raised. Such material does not get in the way very much during the raising of the body of the work. When that is completed the shaping of the handle or spout may be taken in hand' (Maryon 1949: 99).

Maryon believed, great though the competence of Sumerian sheet-metal workers was, that they lacked the snarling-iron or its bronze equivalent. Hodges (1964: 78) describes this tool as follows: 'a Z-shaped rod, one end of which is held in a clamp and the other, free end of which is rounded. This end is passed through the mouth of the vessel and held against the area to be raised. The middle section of the rod is then struck with a hammer, and as the whole free end of the rod rebounds from the blow so the rounded end in contact with the metal forces it out.' In the British Museum collection from Ur, said to be from the suburb of Diqdiqqah, is a broken bronze tool, originally identified as a 'steelyard' (Woolley 1976: 86, 233), that might have served a comparable purpose (cf. BM: 122186 = U. 12683; Maryon 1949: fig. 12, for illustration of use). Its date is unknown, but the majority of the objects from this area are dated to the first half of the second millennium BC. Yule (P. 1988) has identified a snarling-iron among metalwork of the Harappan period at Chanhudaro in modern Sind, so their use may have been more widespread from an early date in the Bronze Age than is at present apparent. There is no evidence before the Achaemenid period, and then it is equivocal, for the use of a lathe to turn or spin metal vessels (Cooney 1965), though its use in the third millennium BC has been suggested for the manufacture of stone vessels.

Most of the sheet-metal copper or bronze vessels at Ur were beaten up from one piece of sheet metal, though riveting was used for larger pieces, notably type 77 (Woolley 1934: 302, pl. 237), 'which was made in three pieces, the edge of the base being bent so as to fit round the bottom of the sides'. In making raised bases, 'the general method has been to bend the bottom edge of the walls inwards and upwards and then to splay it out so as to make a ring-ledge to which the base, a disk cut separately, is fixed by soldering: in some cases, e.g. Type 9, a disk has been soldered or sweated directly on to the hammered base so as to strengthen it where the metal was thinnest'. With one exception (type 17; Woolley 1934: pl. 233), handles were separately fixed on, as occasionally were legs (type 24; Woolley 1934: pl. 233). Collon (1982) has examined the distinctive and unusual double-tubes of metal, fixed to the vessels by rivets, through which wire loop-handles were passed.

More sophisticated joining methods had already been

developed by the middle of the third millennium BC. If copper or any of its alloys is heated, a film of copper oxides forms on the surface so that neither a flux nor hammering will unite two surfaces. Unlike iron, copper cannot be welded together by heating or hammering; a solder is required (see p. 216 for distinction of 'soft' and 'hard' solder). The stag's antlers on the Ubaid copper relief are square copper bars and the joints between the main stem and the tines were made with soft solder, though of what type is not specified (Maryon 1949: 114). Tin was used as a solder at Ur on a copper bowl with silver lugs from the Royal Cemetery (Craddock, in Collon 1982: 101; Craddock 1984). Hard-soldering (brazing) with a low-melting-point silver-copper-tin alloy has been recognized on an Early Dynastic III 'bronze' axehead from Ur (BM 121574; Roberts 1974: figs. 12-13).

None of the base-metal vessels from the Royal Cemetery at Ur was, apparently, decorated though some were inscribed. The main copper object to exhibit a developed mastery of *repoussé* decoration is a fragmentary plaque from RT 789, which Woolley believed might have decorated a shield (Woolley 1934: 69, pl. 169b; U.10475). This is a rectangular strip, decorated with an addorsed pair of lions *passant* above recumbent men, probably corpses, in some way associated with a rosette. It is generally argued that a true cutting tool (a graver or scorper) of bronze could not be used on bronze (Maryon 1949: 117 ff.; Lowery *et al.* 1971) so all linear work before an advanced date is likely to have been chased rather than engraved. Caution, however, remains in order. 'We have found a bronze tracer very much less convenient to use on bronze than a steel one, frequently needing re-shaping of the edge, though hammers and styles of use different from those customary with steel tracers reduce the differences . . . we are not yet certain how far' (Lowery *et al.* 1971: 170).

From subsequent periods embossed work in copper or bronze has very rarely survived. In the Neo-Assyrian period, apart from the work on a larger scale considered below, high *repoussé* is known from an isolated piece in the Boston Museum of Fine Arts, which may again have been from a shield (Porada 1950), and on fragments from what may be overlays for boxes, some from Nimrud (Organ 1963: 129, fig. 2). Some fragments without known source, now in the Louvre (Parrot 1958), were published as Neo-Assyrian, but may be from western Iran; all are decorated with animals or with scenes of animal combat and hunting. The most remarkable examples of the technique at this time, sheet-metal vessels in the shape of animal heads, were made in Mesopotamia and in neighbouring countries (Calmeyer 1979; Kepinski and Lecomte 1985: 55) following a tradition that went back at least a millennium. It is possible that a series of drinking goblets, decorated

with *repoussé* and chased scenes, dated mainly to the tenth century BC, illustrate an aspect of Middle Babylonian metalwork. They are reported predominantly from clandestine excavations in Western Iran; but a few inscribed examples bear witness to a strong Babylonian connection (Calmeyer 1973).

As elaborate programmes of temple decoration in cast statuary of any size would have placed a heavy burden on Mesopotamian metal resources, it is hardly surprising that the Sumerians developed methods for producing substitutes. It may not have been until the Neo-Assyrian period, when copper came so readily as tribute or booty, that rulers were able to contemplate and execute schemes like that undertaken in cast metal by Sargon II and Sennacherib (see above). Statues of hammered sheet copper or bronze fixed to roughly shaped bitumen or bitumen-coated wooden cores of the shapes desired were current by the earlier third millennium BC. Composite statuary, combining parts of stone, wood, and metal, though evident from textual sources, is not so readily illustrated from the archaeological record, where the original destination of fragments is not certain. That the Sumerians had a taste for such creations is clear from the outset of the sculptural record, notably where animals are concerned (Spycket 1981: pl. 31). The two rampant he-goat supports from RT 1237 at Ur remain the best examples of the genre (Woolley 1934: pl. 87), although in them precious materials are the visible components and the scale is small.

The outstanding archaeological instance of wrought statuary from Mesopotamia is that from the Early Dynastic III temple at Tell al-Ubaid, excavated in turn by Hall and Woolley (1927). This temple had been dismantled, possibly in the Ur III period, for extensive restoration. The fittings had been removed and assembled at the base of one of the access ramps for burial in the new terrace or platform. This had preserved them remarkably well but with little indication of their original disposition, presumably within the temple building. Various early analyses (Hall and Woolley 1927: 36 ff.) showed that the sheet metal of the bodies was copper with no clear evidence of alloying: 'all being wonderfully pure copper', as was said at the time (*ibid.*: 38). Maryon (Maryon and Plenderleith 1954: 639-40) has given the most concise description of the technique used to make one of the standing bulls at Ubaid:

Their construction is worthy of consideration. A piece of wood, measuring about 18 x 6 x 3", was roughly shaped with an axe to the general form of the bull's body. To it were fitted, by mortise and tenon joints, further pieces for the head and legs. The whole wooden core was then covered with sheets of thin copper: head and legs first, then body, horns, etc., each piece being fixed in place by large-headed nails. Each leg was constructed from one

piece of metal. Now, though a piece of copper could be bent round the core to form a kind of leg, much work would be needed before it assumed its final shape. Thus the formation of the concave anterior border of a hind leg would entail much hammering near the back edges of the folded sheet to stretch the metal over the hock, and this demanded frequent annealings. Then the smith, after a final annealing, tacked the long edge onto a bitumen-covered core. He would warm the metal so that the bitumen would flow closely against it to form a support during the chasing of the surface modelling. The last task would be to fold over the free edge so that it overlapped that already nailed to the core and to drive in a row of large-headed nails, which held all together.

Detail was worked on the surface of the metal with tracers and some of the design is in *repoussé*. Maryon may not be correct in all his deductions. The heads of the lions and leopards appear to be of cast tin-bronze, not of hammered sheet copper, with bitumen poured in after casting to reinforce them and support the eye inlays and the stone tongue-tips, which project from the open mouths. The few cast heads that have been properly examined are said to show traces of the multiple piece-moulds in which they were cast after an original wax model (Hall and Woolley 1927: 55). In some cases the horns were made separately and fitted on; the joints between the main antlers and the tines on the stag's head were soft-soldered (Maryon 1949: 114).

Later examples of the same technique were found in clearing the temple of Dagan at Mari, where the terrace had been guarded by lions, or the foreparts of lions, made of copper or bronze plaques hammered over wooden cores, probably in the reign of Zimri-Lim (c.1800 BC). Little save inlaid eyes remained of the external ones, but two from inside had survived intact (Spycket 1981: 290-1).

Some types of religious furniture were made of sheet metal over wood. As early as Uruk IV 'ringed gateposts', familiar from scenes on cylinder seals, were being made of wood with copper overlays and coiled wire loops at Uruk (Boehmer 1990). An example of Early Dynastic III from Telloh (*Girsu*) was of hammered copper over a wooden core, with a bitumen terminal on the top, perhaps also originally plated (Sarzec and Heuzey 1884-1912: pl. 57:1; Parrot 1948: 106, fig. 26c). That this tradition endured is evident at Assur, where in one of the rooms of a substantial Neo-Assyrian house was found the copper or bronze cladding for a standard of some kind, in this case a radiate rosette set on a shaft (Preusser 1954: 41, 44 ff., pl. 19). Hammered metal fittings, and silhouettes cut out of bronze sheet, were important components of elaborate pieces of ceremonial Neo-Assyrian furniture, as on the throne found at Nimrud by Layard (1853: 198 ff.; see p. 272 here), and earlier evident in texts (Salonen, A. 1963).

By far the best-known instance of sheet-metal decoration on a monumental scale is provided by the Neo-

Assyrian examples of decorated bronze inlays or overlays for palace and temple doors (cf. Lackenbacher 1982: 91 ff. for textual references). They are first referred to under Adad-nirari I (c. 1305–1274 BC), sporadically mentioned down to Assurnasirpal II, and thereafter more regularly. Sennacherib claims responsibility for a change in the manufacture of such bands:

I had a gate made of red bronze . . . (executed) in the workmanship of (the god) Ninagal according to my own clever idea . . . I am capable of undertaking the casting of objects in silver, gold and bronze . . . melting from more than 1000 talents to (as little as) 1 shekel, fusing(?) them together, fashioning them skilfully. If you do not believe the account of smelting that bronze, I swear by the king of the gods, Ashur, my creator, that I myself had smelted the casting of the place where this inscription is written and the emplacement where the reliefs of Ashur and the great gods who went into battle with him into the midst of Tiamat are drawn. For future generations, in order that it may be known, I increased the tin in (that cast). Know through this that I myself had that cast smelted.

(Walker 1988: 116)

Layard found fragments of bronze overlays in Chamber I of the North-West Palace at Nimrud; Place located pieces in the Adad Temple at Khorsabad; Loud recovered some from the Nabu Temple there, and further pieces were found in the throne room. At Assur the door of the Anu-Adad Temple and the Tabira Gate offered some examples, as did the temple of Nergal at Tell Hadad (Sirara), in the Hamrin, built or restored by Ashurbanipal (cf. Curtis (ed.) 1982: 118; 1988: 87–8). But the best-known and most elaborate are the gate-coverings set up by Shalmaneser III, discovered by Rassam and Mallowan at Balawat. They are of sheet bronze, with about 10 per cent tin. Maryon and Plenderleith (1954: 646) report that 'the bands (i.e. of decoration) were in *repoussé*, worked mainly from the front, where the tilting downwards of the background toward the outlines of the figures, and the marks of chasing tools and tracers, are clearly visible in the original'. Elaborate scenes, miniature renderings of the activities more familiar from monumental Neo-Assyrian palace stone sculptures, were first traced in outline on the surface with a graver. Insufficient work has been done to define the earliest appearance of engraving in this period, but Maryon and Plenderleith (1954: 649) believed that the inscriptions on the Balawat Gates 'are probably the earliest examples of true engraving on metal, the technique of cutting inscriptions on stone with steel tools having been transplanted to a new material—bronze'.

Bronze wall-plaques or overlays for terracotta plaques were found by Layard at Nimrud, one inscribed for Assurnasirpal II (Albenda 1991: 44); what appear to be Neo-Assyrian bronze wall-plaques were found at Tell Deim in northern Iraq (Al-Tikriti 1960: 107, fig.

9; in Arabic section). Both at Nimrud and Nineveh some 'hands of Ishtar' (see p. 314) had metal overlays (Curtis 1988: 88). Columns were also overlaid with sheet metal decorated either in imitation of the bark of palm trees (Place 1867–70: i. 120–2) or with friezes in *repoussé* like those placed on gates (Loud 1936: 104 ff.; Marfoe 1982: fig. 37).

(g) The use of metal tools

In recent years increasing attention has been paid by archaeologists to the manner in which ancient tools were used. Two distinct approaches have emerged, the one based on the study of wear on stone tools (Semenov 1964), the other on the idea that it is possible to identify the material of the tool from surviving tool-marks on stone artefacts. Since corrosion destroys the surface of metal work, the second approach is the one most likely to yield information on how and when tools of copper and its alloys superseded those of stone, and how and when in turn iron tools were widely preferred (cf. Nylander 1970: 50 ff.). Such research on Mesopotamian artefacts is in its infancy. Gwinnett and Gorelick (1979) have made a start with cylinder seals, seeking to establish the relative use of wood, stone, and metal tools in their manufacture, on the assumption that 'standards' for ancient tool-marks may be developed and the marks themselves faithfully duplicated by experiment. Their work has done much to confirm the existence of rotating metal cutting-disks by 3000 BC. They are also able to recognize the emergence of metal tool-marks, as distinct from those of wood or stone, in the seal-cutter's repertory in the third millennium BC; indeed, for hard stones, drills of copper may already have been used in the previous millennium BC.

(h) Check-list of published analyses by site

This list is only intended as a rapid guide to the analyses upon which the conclusions in this section are based. A more detailed version was published in Moorey 1985: 51–68. This is not republished here, since analyses done before about 1980 now have little more than a historical value. Major new analytical projects have been undertaken in France (Laboratoire de Recherche des Musées de France), Germany (*Frühe Metalle in Mesopotamien* (FMM): the Institut für Ur- und Frühgeschichte (Hauptmann and Müller-Karpe) and the Max-Planck-Institut für Kernphysik (Pernicka and Lutz), Heidelberg), and the United States (*Sumerian Metals Project* of the University of Pennsylvania at Philadelphia: Dyson; Fleming; Muhly; Pigott and Stech). The individual results, even those so far published, are far too numerous to be listed appropriately here. Much of the data has not yet been made available in print.

1. *Arpachiyah*: Ubaid 3: Craddock, in Jesus 1980: 207.

2. *Asherah*: ? Early Dynastic: Th. Danguin *et al.* 1924: 292.
3. *Tell Asmar*: Early Dynastic: Frankfort *et al.* 1934: 58–9; Dayton 1978: 159; Berthoud 1979: Lab. no. 6534 (IM 24319).
4. *Balawat*: Neo-Assyrian: Sebelien 1924: 13–14.
5. *Bassetki*: Akkadian: al-Fouadi 1976: 66.
6. *Billah*: Third millennium to Neo-Assyrian: Levey 1959: 209, fig. 39; *Sumerian Metals Project* of the University of Pennsylvania: B001–035.
7. *Brak*: 'Late Prehistoric': Desch and Barr in Mallowan 1947: 58; Akkad to Old Babylonian: Moorey and Schweizer 1972: 186.
8. *Chagar Bazar*: Prehistoric: Mallowan 1936: 27. Second millennium BC: Moorey and Schweizer 1972: 187.
9. *Eridu*: Undated: Campbell Thompson 1920: 144; Woolley and Hall 1927: 39.
10. *Fara*: Late Prehistoric to Ur III: *Sumerian Metals Project* of the University of Pennsylvania: F001–022.
11. *Gawra*: Late Prehistoric to First Millennium BC: Speiser 1935: 102; Tobler 1950: 212; Levey 1959: 209; *Sumerian Metals Project* of the University of Pennsylvania: G001–G118; Berthoud 1979: Lab. no. 6533 (IM 22398).
12. *Jamdat Nasr*: Late Prehistoric: Moorey and Schweizer 1972: 180.
13. *Kar-Tukulti-Ninurta*: Middle Assyrian: McKerrell 1977: 167: table 13 (not Assur as published).
14. *Khafajah*: Early Dynastic: Frankfort *et al.* 1932: 78; Delougaz 1940: 151–2; *Sumerian Metals Project* of the University of Pennsylvania: Kh001–0100; Berthoud 1979: Lab. no. 6535 (IM 15489).
15. *Kheit Qassem*: Early Dynastic I: Berthoud 1979: Lab. nos. 6601–4, 6607–9, 6611, 6613, 6617–9.
16. *Khorsabad*: Neo-Assyrian: Berthelot 1906: 219–28.
17. *Kish*: Undated: Peake 1928: 453–4; Woolley 1934: 291 (table II). Early Dynastic: Moorey and Schweizer 1972: 182–4; *Sumerian Metals Project* of the University of Pennsylvania: K001–056; Berthoud 1979: Lab. nos. 6526 (IM 2354).
18. *Maghzaliya*: Aceramic Neolithic: Ryndina and Yakhontova 1985.
19. *Nimrud*: Neo-Assyrian: Layard 1853: 670 ff.; Hughes *et al.* 1981: 143 n. 5; 1988; Lang *et al.* 1986; Muscarella 1988: no. 444; Craddock, in N. M. Giumlia-Mair 1992: tables 5–6.
20. *Nineveh*: Neo-Assyrian: cited by Partington 1935: 250; Akkadian: Campbell Thompson and Mallowan 1933: 72 n. 2; Strommenger 1985.
21. *Nippur*: Undated: cited in Partington 1935: 247. Ur III to Old Babylonian: *Sumerian Metals Project* of the University of Pennsylvania: N001–014. Foundation Figurines (Ur III): Schlossman *et al.* 1976: 21; Muscarella 1988: 311 (see also no. 437 with analysis).
22. *Tell Rimah*: Middle Assyrian: McKerrell 1977: 167, table 13. See under Yarim Tepe.
23. *Tell es-Sawwan*: Old Babylonian: Iraq, 34 (1972), 2, n. only; Moorey *et al.* 1988.
24. *Tell Sifr*: Prehistoric to eighteenth century BC: Malfoy and Menu 1987.
25. *Susa*: Early Dynastic to Isin-Larsa: Berthelot 1906: 76–80.
26. *Telloh (Girsu)*: Early Dynastic: Hall and Woolley 1927: 37; Woolley 1934: 291, table II; Moorey *et al.* 1988 (ingot).
27. *Tell al-Ubaid*: Undated: Campbell Thompson 1920: 144. Ubaid period: Woolley 1934: 291; 1956: 164–5. Early Dynastic III—Akkadian: Woolley 1934: 290, table II; Moorey and Schweizer 1972: 184; Dayton 1978: 158–9; Craddock 1984 (with Ur numbers and dating in Moorey 1985: 66–8); *Sumerian Metals Project* of the University of Pennsylvania: U001–100; Berthoud 1979: Lab. nos. 6510–
28. *Ur*: Undated: Peake 1928: 453–4; Woolley 1934: 291 (table II). Early Dynastic: Moorey and

- 25, 6527–32, 6536 (Baghdad Museum).
29. *Uruk*: Late Prehistoric: Heinrich 1936: 47.
30. *Yarim Tepe*: Neolithic: Merpert *et al.* 1977^a: 160, table on pp. 64–5.
31. *Zerghul* (Sirwan): Gudea: Sollberger 1975: 178.

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(iv) IRON

Strictly speaking, *iron* (Fe) is the pure metal (the chemical element *Fe*) never encountered in antiquity. The manufactured iron with which this survey is concerned was an alloy of carbon and iron. Carbon atoms find spaces between the layers of atoms in the iron crystals so they move through the hot metal even when it is solid, far below its melting point (1537°C). On cooling the metal is increased in hardness and strength in proportion to the amount of carbon dissolved. No similar effect occurs in the smelting of copper, lead, or tin since carbon is insoluble in them. As iron was smelted from the ore using charcoal (which contains about 80 per cent carbon) as fuel, the iron dissolved the carbon invisibly deep inside the furnace, unknown to the smelters. Although the nature of this chemical process was not explained until modern times, blacksmiths from an early date appreciated that the properties of workable iron, so different from those of copper and its alloys, depended not only on the metal, but also on the duration and the succession of heating and cooling, not least the operating temperature of the smelting furnace. Among common metals iron is further distinguished by two things in particular: pieces of it will weld perfectly if they are simply hammered together when hot; when hot the metal is soft enough to be easily shaped, then on cooling to room temperature it develops high strength (in general, see Rostoker and Bronson 1990).

Wrought iron contains little or no carbon (up to about 0.5 per cent) and is soft and malleable. Steel has a carbon content between about 0.5 per cent and 1.5 per cent, and its properties vary accordingly. Unless wrought iron is 'steelled' by the addition of carbon, hardened by quenching, and heat-treated by tempering to reduce brittleness and induce strength, it is not generally superior to work-hardened bronze in those qualities that make acceptable tools and weapons: hardness; strength; ability to take and hold a good cutting edge. Broadly speaking, within these limits, the higher the carbon content, the harder the steel. For all cutting

edges a hard steel is required, but the rest of the blade should ideally be ductile with a degree of elasticity. Cast iron contains between 1.5 per cent and 5 per cent carbon. It is hard and brittle. Inevitably, perhaps often, cast iron would have been made by accident in smelting hearths that were producing wrought iron. Its role in the ancient Near East, if any, is obscure.

The smelting and metallurgy of iron are considerably more complicated than those of the other metals regularly employed by craftsmen in Mesopotamia. Wrought iron, steel, and cast iron are in almost every sense three distinct materials, each needing a different treatment, each best adapted to different purposes. Although iron was subsequently regarded as the utilitarian metal *par excellence*, in its early history it played an important role as an ornamental material and from an early date smelted iron (wrought and steel) was cold-worked for decorative purposes with techniques already long employed in gold and silverwork: chasing, raising, and tracing.

Fully satisfactory investigation of iron artefacts involves destructive techniques of sampling, so very much less scientific research has been done, particularly on early iron, than on non-ferrous metals in the Near East. Attempts have been made to study Neo-Assyrian ironworking through minimal sampling. This has inevitably meant that the technology of manufacture may still remain unclear, though this is not always explicit in primary reports and is rarely obvious from secondary accounts.

(a) Types and sources

(1) Meteoritic

(Although 'meteoritic' is strictly speaking the correct term, 'meteoric iron' is used here, as it commonly is, for clarity's sake.) Native iron is rare, found chiefly in meteorites; but not all meteorites contain iron in readily available form. Only siderites are made almost wholly of iron; aerolites are largely stone, and siderolites are a mixture of iron and stone, with the metal like raisins in a cake. By hammering with stone tools or cutting with copper chisels small flakes of iron may be detached for use (cf. Bjorkman 1973). A role for meteoric iron in the ancient Near East has long been taken for granted, particularly in the pioneering stage of iron metallurgy; but it is much more difficult to demonstrate than has previously been assumed. Moreover, now that it has been shown that early iron may derive from copper smelting (see below) an alternative explanation is available for apparently precocious pieces of ironwork. In reality the observation of the fall of meteorites, coupled with the finding of such pieces, is by no means as common as many arguments about the early vocabulary for iron appear to take for granted.

Philological evidence has in the past done much to

shape the meteoric hypothesis. Vaiman (1982) argued that there are references to meteoric iron (AN) in Sumerian texts from late in the fourth through to the third millennium BC and that the appearance of the terminology AN.BAR/*parzillu*, first documented at the end of this period, coincided with the appearance of smelted iron. However, present evidence for iron terminology both in ancient Egyptian (Harris 1961: 60) and in Hittite (Košak 1982: 199; 1986: 125–6) indicates that specific references to 'iron from heaven' and 'iron of (or from) the sky' do not appear until the second half of the second millennium BC, in the Late Bronze Age, by which time iron from copper or lead smelting or smelted intentionally from iron ores was already current. Even if some of Vaiman's early references indicate iron in Sumerian, and some at least are unacceptable on philological grounds (cf. Muhly *et al.* 1985: 175), it is more likely to be a generic term leaving the question of origin open. A passage from the Sumerian Lugalbanda Epic, in a copy of the Old Babylonian period (c.1850–1650 BC), is read in a recent translation by Hallo (1983: 176) as distinguishing an axe of meteoric iron from a thigh- or hip-dagger of terrestrial iron. However, the first phrase turns on a restoration in the text which, as it stands, refers only to precious metal generically not specifically; indeed, if Hallo's restoration is correct it could be referring to *annaku* (tin/lead). The second phrase speaks simply of 'iron' (J. A. Black: personal communication). At present the history of terms for iron in Sumerian and Akkadian does not firmly indicate whether a special terminology for 'iron from heaven' preceded or succeeded the regular smelting of iron ores.

Desch (1928) identified fragments of early iron from Mesopotamia as of celestial origin through bulk chemical analysis of their corrosion products on the assumption that a high nickel content, comparable with that in actual meteorites, was alone a safe distinction between iron of celestial and iron of terrestrial origin. This is now known not to be so. Moreover, surface indications of nickel are likely to be misleading, since corrosion will alter the Fe/Ni ratio. Today determination of the origin of nickel-rich iron, whether celestial or terrestrial, depends on a variety of analytical and metallographic techniques to determine the structure of the metal as well as its body composition. The presence of nickel, which will anyway be reduced in the process of smelting nickel-rich terrestrial iron ores, in an iron artefact can only imply a meteoric origin if the original Widmanstätten structure is also present (cf. Photos 1989; Rostoker and Bronson 1990: 201–3), as in an iron ball or pellet from level II at Tepe Sialk in Iran, in the fifth millennium BC (Ghirshman 1939: 206).

The occurrences of early iron objects in Mesopotamia said to be of meteoric origin on the basis of high

nickel content now need to be re-examined. They are a fragment found between levels D and E of the Anu Ziggurat at Uruk, late fourth millennium BC (Heinrich, in Nöldeke *et al.* 1937: 53), rusted fragments of uncertain purpose (?dagger/knife) from RT 580 at Ur (Woolley 1934: 49, 542 = Desch 1928: 440: 10.9 per cent nickel) and pieces from Tell al-Ubaid (cf. Woolley 1934: 293; analyses by Neumann: 10.9 per cent nickel), of the mid-third millennium BC.

Piaskowski (1988) has argued that the famous Chalybean iron, produced in northern Anatolia from iron-bearing river sands, which looked more beautiful than other iron and did not get rusty, according to Pseudo-Aristotle (*De mirabilibus auscultationibus*, xlviii. 833b), was a high-nickel iron. Piaskowski has consequently suggested that 'most ancient iron implements considered until now by the historians of metallurgy as made of meteorites, were really produced in the iron smelted from the ore as early as in 3000–2000 BC by the tribe of Chalibes . . .' (Piaskowski 1988: 45). This challenging hypothesis needs to be substantiated by wider investigation of the high-nickel iron ores of Turkey. The only substantial object so far scientifically tested that might well be made of high-nickel iron from an Anatolian source is the Late Bronze Age iron blade (2.5 per cent nickel) of an axehead with a zoomorphic bronze shaft-hole found at Ras Shamra, Ugarit (cf. Waldbaum 1980: 76 nn. 7, 22; Richardson 1943).

(2) As a by-product of copper smelting

As it is possible under certain conditions to produce iron when smelting copper, it is increasingly thought likely that a significant proportion of the iron current in the Near East, at least before the Late Bronze Age, might have been produced in the process of smelting copper, or possibly lead. As Wertime (in Wertime and Muhly (eds.) 1980: 16) pointed out 'the earliest smelting must not be seen as a conscious selection of a pure ore but as the experimental employment of an ore mix which could alternatively yield lead, copper, or iron, or a mixture of all three'. If iron oxide in any one of its three forms (haematite; limonite; magnetite) was accidentally or deliberately added to the furnace charge as a fluxing agent, in smelting copper or lead, the iron would combine with the silica in the ore to form slag that would melt and eventually run off. In circumstances of high temperature and extreme reducing atmosphere, small bits of relatively pure iron would have been produced (cf. Cooke and Aschenbrenner 1975; Gale *et al.* 1990).

Avery (1982: 206) reported that his laboratory experiments showed that the agglomeration of iron into larger pieces would be greatly accelerated by the fluctuating temperatures encountered in an intermittently blown early furnace, whilst Charles (in Wertime and

Muhly (eds.) 1980: 164–7) has argued that more efficient use of fluxes and a greater control over furnace firing in the course of the Bronze Age might have increased the chance of metallic iron occurring in copper smelting. Tholander (1982) tested the possibility that iron might have been extracted from the ancient copper slag excavated at Hala Sultan Tekke in Cyprus and Timna in Israel in Late Bronze Age contexts. He found that 'copper slag . . . would have made possible an iron production of the order of half a kilogram of soft iron per week per smelting unit. The slag from Timna would have given only about one third of a kilogram under similar conditions.' It is clear that such a production technology would only produce small quantities of iron of status value (on Timna, cf. Gale *et al.* 1990).

There are other possibilities. Some of the copper deposits exploited in the Near East in antiquity are notably heterogeneous. Within these deposits the great bulk of the copper exists as the copper-iron sulphide chalcopryrite. It has long been assumed that the first exploitation of the sulphide, as distinct from the oxide, copper ores was a major technological change involving 'matte smelting', which can be a complex multi-operation. Recent experiments (Rostoker *et al.* 1989) have indicated, however, that chalcopryrite copper can react with copper oxides to produce copper metal in a single smelting step. Under the conditions postulated for this process, metallic iron would sometimes have been unintentionally produced. In certain circumstances small nodules of iron could have been separated from the contents of the copper-smelting furnace.

It is possibilities of this kind that emphasize the importance of seeking to distinguish those pioneer ironsmiths whose level of production and varied repertory of artefacts suggest that they were using iron smelted directly from its ores from those using iron produced in copper or lead smelting. If Maxwell-Hyslop's (1972) interpretation of the philological evidence is correct, texts from *Karum Kanesh* (Kultepe) in Anatolia distinguish bloom-iron explicitly by the beginning of the second millennium BC.

(3) Iron ores and smelting

It is not known which ores were preferred in the early stages of iron production in the Near East. Ethnographical parallels, particularly in Africa, suggest the possibility of significant variations in the ores used and the types of furnace, though the bloomery process is assumed to have been universal. Pioneer ironworkers may well have used smaller, less rich ore deposits than geologists today might identify as of economic grade, perhaps favouring low-grade ores with enough calcium to make self-fluxing possible without adversely affecting the smelting procedure by clogging the furnace. However, as time went on, it would seem equally likely that pure minerals and rich ores came to play as impor-

tant a role as they did with copper. Indeed, classical references to regions of Turkey renowned for the quality of the iron they produced indicate this, pinpointing magnetite sands as the source (Tylecote 1981^a; Muhly *et al.* 1985: 74). From rich ores, by controlling such factors as the rate of blast to the furnace and the fuel to ore ratio, experienced smelters might well have produced either a ferritic bloom or a steely one ('natural steel') at will. 'Production of a natural steel in this manner would have been possible during any period of ancient iron production. Certainly the steely bracelets of the Transjordan (cf. McGovern 1986: 274) represent some of the earliest, though unintentional, production of steel' (Clough 1988).

In many areas terrestrial iron ores are far more readily available than copper ores; indeed, they are among the most common on earth. Many lie so close to the surface that they are readily recoverable. Nor is a more or less pure mineral required for workable iron, since many rocks of high iron content can be smelted. Red oxide (haematite) and the hydrated form (limonite) both contain a high proportion of iron and, as they are relatively free from sulphur and phosphorus, are easily worked to give good iron. The magnetic oxide (magnetite/lodestone) and the carbonate (siderite/chalybite or spathic ore) are also easily worked. The sulphide ores (pyrites or marcasite and pyrrhotite) are more problematic, since any sulphur left in the metal affects its working properties and use. Most ironstones contain one of the oxides of iron, but with siliceous, argillaceous, or even partly calcareous matter, so the yield of metal is very low by comparison with the purer minerals. Iron ores usually contain 30–40 per cent of unwanted materials.

As no scientific work has been done on sourcing the iron used for manufacture in Mesopotamia, arguments of probability on the basis of known deposits remain the only source of information, supplemented by meagre textual references. In considering possible sources of iron it is important to bear in mind that the rulers of Mesopotamia before the full expansion of the Assyrian Empire did not have direct access to major iron-producing regions and would have been obliged to acquire processed iron by trade or force, as iron was almost certainly smelted at or near the site of the mine.

In view of the prevalence of iron ores across the Near East, source location is not so crucial a problem in the study of early ironworking in Mesopotamia as it is with some other metals. So far there is neither documentary nor archaeological evidence to indicate exploitation of local iron ores in antiquity, though it is a possibility in Assyria. Layard (1849: 225) explored iron mines in Kurdistan, in the Bawari Valley north-east of Amadiya, and also in the Tiyyari Mountains. Al-Hashimi and Skoczek (1982) have recently called attention to iron mines in the Wadi Hassainiyat, north-east of Rutba, in

western Iraq; but they may not have been exploited in antiquity. Iron ores are to be found in Anatolia, as well as in Caucasia and Transcaucasia (Maxwell-Hyslop 1974: map on pl. XX), in Iran (Harrison 1968: 496 ff., fig. 113) and in Syro-Palestine (Stech-Wheeler *et al.* 1981: 259), which is referred to in Deuteronomy (8: 9) as 'a land whose stones are iron-ore'.

Tylecote (1981^a) has investigated the possibility that the iron sands of the Black Sea region in Turkey might have been a useful source of iron from the outset of the local Iron Age (cf. Bryer 1982). Belli (1986) surveyed the area south and south-west of Lake Van identifying surface evidence for ancient ironworking. The reported pottery is said to be Achaemenid in date. This is a region likely to have been vital both to Assyria and to Urartu for iron.

In his study of the Urartian ironwork from Toprak-kale Piaskowski (and Wartke 1989; cf. Wartke 1990: 23–4) identified three types of iron in use there, some, if not all of which, is likely to have come from local sources:

- A. Low in phosphorus (0.019–0.183 per cent), primary carburization with up to 0.8 per cent carbon (large mattock; spear and arrowheads; bracelet?; 'bar' fragment).
- B. Very soft with low phosphorus (0.020 per cent) and clear ferrite structure (macehead).
- C. High phosphorus (0.45 per cent) with a little, non-uniform carburization (traces up to 0.1 per cent) (bracelet?).

The 'ingots' (*Spitzbarren*) from Khorsabad (see below) belong to the type with low phosphorus and non-uniform carburization (Piaskowski and Wartke 1989: 110, after Pleiner 1979; not given in Curtis *et al.* 1979, table 1). Generally, much more attention has been given to the carbon content of early iron than to the phosphorus in it, but it is now appreciated more and more that the phosphorus content of the iron needs to be determined if the way in which early smiths were using the metal is to be fully understood. One of the effects of phosphorus is to slow down the diffusion of carbon into metallic iron, thereby making carburization of the metal much more difficult, although not impossible.

In a concise survey of Assyrian iron sources Maxwell-Hyslop (1974) compared the ancient textual evidence with modern information on the distribution of iron ores, first for the Middle Assyrian, then for the Neo-Assyrian, period. As there is no documentary evidence so far for Mitannian access to iron sources, it is not known whether they, or their political successors in *Hanigalbat* (geographically across Assyrian routes to iron sources in Anatolia), affected iron supplies to the Middle Assyrian court. Tiglath-Pileser I (c.1114–1076 BC) obtained iron ore (unspecified) and haematite

from *Nairi*, west and south of Lake Van (Grayson 1976: 18), but iron is not specifically mentioned in booty or tribute lists until the Neo-Assyrian period.

Iron features conspicuously in royal records of the Neo-Assyrian period listing booty and tribute. Despite certain known exaggerations, and uneven records, the information they offer is instructive. Iron was generally named as a raw material, sometimes with a quantity given in talents, but rarely as artefacts. Jankowska (1969: 263) summarized the evidence as follows (through references to Luckenbill 1926–7):

Though iron was the most important strategic material, it is mentioned much less frequently than other metals. It is recorded in the joint tribute of several areas of Asia Minor, Syria and the Mediterranean coast (I: 722, 801), in Damascus (I: 740: 150 tons), *Hattina* (I: 585; II: 477: 3 tons), Carchemish (I: 601: 3 tons; II: 476: 7.5 tons), *Que* (I: 588), *Bit-Halape* (I: 443), *Bit-Zamani* (I: 405; I: 406 and I: 501: 9 tons), *Shubria* (I: 502), the Chaldean area (I: 625), and in the *Laqe of Hammath* (I: 412: 30kg.). But to a great extent this lack of data on iron can be explained by the nature of our sources, referring for the most part to treasuries.

Pleiner and Bjorkman (1974: 291 ff.) attempted to plot this information as a diachronic distribution graph, but the peculiar nature of the available textual information and its uneven spread compromises its validity. In the majority of cases iron came from the west and north-west: Modern Anatolia and Syria; some also came from the north (ancient Urartu). Regions in Iran do not feature in the tribute lists as sources of iron. Maxwell-Hyslop (1974) discussed in detail the following potential sources of Neo-Assyrian iron: the Middle Euphrates and Khabur region (*Laqe*); Carchemish, Marash, and the Amanus; the Elazig region (*Iruwa*); the Gurun and Malatya areas; the Divrigi deposits, between Sivas and Erzincan, the largest and most important iron-producing area in modern Anatolia; Damascus, perhaps only a distribution centre for manufactured iron; and *Tabal* (Anti-Taurus region) and *Que* (Cilicia), both in modern Anatolia. In all cases evidence is circumstantial rather than direct.

Oppenheim (1967: 240 ff.) published two texts from Uruk, of the mid-sixth century BC, referring to iron 'from Yamana' and from 'Lebanon'. The first probably describes a region on the western or southern coast of Anatolia, whilst the latter may indicate native Syrian iron, since the region had previously sent enormous quantities of the metal to Assyria. Other Neo-Babylonian documents from Sippar and Uruk cited by Oppenheim (1967: 241) refer to iron from *Hume*, a variant writing of *Que* (Cilicia). Iron also came from an unlocated region known as *Simir*, which produced wine and may have been in eastern Anatolia. Again iron does not appear to have come from Iran.

It will be clear from this survey of potential sources

that the ironworkers of Mesopotamia had little, if any, experience of smelting. They worked for the most part, if not exclusively, with blooms of iron received from smelters adjacent to the mines in the highland zone. The absence of archaeological information on iron-smelting furnaces in the Near East before the classical period continues to frustrate the proper study of this aspect of the subject. Procedures have been reconstructed from a blend of analogy with primitive furnaces, both ancient and modern, elsewhere and from the indications provided by metallographic examination of early iron artefacts (cf. Tylecote, in Wertime and Muhly 1980). Actual smelting operations must have taken place where ample supplies of fuel were readily available, as it takes about 8 tons of charcoal to smelt 1 ton of iron ore; though this is considerably less than the 20:1 ratio for copper (Horne 1982).

Valuable evidence may be drawn from accounts of travellers in the nineteenth century who observed a technology which had changed little in the previous three thousand years. One of the more relevant is Hamilton's description of iron smelting near Trebizond in Turkey:

I had brought no interpreter with me, and it was some time before they could be made to understand that I wished to see the mines from whence the iron-ore was extracted. To this they replied that there were no mines, but that ore was found everywhere about the hills near the surface. This they proved by scraping up the soil near their hut with a mattock, and collecting small nodular masses, which I understood was the form in which it is universally found in this district . . . The ore is poor, and the miners . . . must lead a hard and laborious life; they are at the same time charcoal burners, for their own use, removing their huts and forges to a more productive spot, as soon as they have exhausted the ore and consumed the wood in their immediate vicinity.

The mode of extracting the iron is however very slow and laborious; the ore is smelted in a common blacksmith's forge, in which 180 okes of the rude material produce three batmans or pigs of metal, weighing six okes or thirteen pounds and a half each; consequently the ore only yields ten per cent of metal, and to procure this small quantity 300 okes of charcoal are requisite. The blast of the furnace is kept up for 24 hours, during which time the mass must be constantly stirred, and the scum and scoria raked off, after which the melted iron is found at the bottom, which, from the specimen I saw, appeared of a very good quality . . . we passed the remains of several forges in places where the ore had been completely worked out, and where the ground was strewn with ashes . . .

(Hamilton 1842: i. 275 ff.)

Tylecote (in Wertime and Muhly 1980: 209 ff.) has described the smelting process as it is most likely to have been practised in the highlands of the Near East adjacent to mines, whence came the iron ores. To produce sponge iron from the ore, charcoal was layered with chunks of iron ore in a furnace, at first probably no more than a hole in the ground or in rock ('bowl

furnace'). Air-blast from bellows of unknown type was used to raise the temperature. Under firing conditions the charcoal oxidized, forming carbon monoxide, which rose through the ore and reduced it. As reduction took place at about 1200 °C, well below the melting point of iron, the melt did not liquefy, as does copper, but emerged as a spongy mass in which unreduced ore and fuel fragments were caught up (*bloom iron*).

Unfortunately, neither the exact date nor the proper reconstruction of the early iron-smelting furnaces excavated in Transcaucasia/Armenia has been established (Khakhutaishvili 1976; cf. Pigott 1989: 70, fig. 5); but they remain the best point of reference. It is now thought likely that they date either to the twelfth century or later, not to the fourteenth century BC as first argued. The published examples are all deep bowl furnaces in which the original positions of the *tuyères* are not reported (Khakhutaishvili 1976: figs. 4, 8–9). In published reconstructions (ibid.: fig. 10; Pigott 1989: fig. 5) layers of iron ore alternating with layers of charcoal fill the pit. Interlocking *tuyères* (nozzles) extend from the bellows at the surface down one side of the pit to vent at the base of the furnace charge. If this is correct, it might allow for direct steel production during smelting, as Pleiner (1968) found in experiments. Parts of the bloom protected from the direct oxidizing blast of the mouth of the *tuyère* might have had increased carbon content sufficient to characterize them as true steel, whilst those directed towards the mouth of the *tuyère* yielded low carbon wrought iron.

Rehder (personal communication) has recently called attention to the difficulty of smelting iron, particularly in contrast to copper, to help explain why iron technology took so long to mature. At the heart of his argument is the fact that if a smelter is to produce iron that possesses a particular range of hardness and strength, the operating temperature of the smelting furnace must be controlled to the appropriate level and within a specific range of variation. The real situation in pioneering, primitive conditions involved inevitable variations in the composition and bulk densities of the materials used. It is therefore very difficult to transfer an iron-smelting operation that was successful in one location to another, since the number of variables, in ore and fuel, as much as in furnace size and structure, will critically affect the process of smelting in a way not encountered with copper. With copper the same ore, flux, and charcoal in the same ratios in a given furnace will generally produce copper of the same properties through time. Furnace temperature did not, as it did with iron, effectively and relatively closely control the kind of metal produced.

At all times the smelter of iron was threatened with the extremes of producing either little metal in a large quantity of slag or an extremely hard, brittle, and unworkable lump of metal. The desirable bloom he

aimed for lay between such extremes. But, under the circumstances in which he worked, even the carbon range of the acceptable blooms he produced inevitably varied widely. Much, perhaps most, ancient iron in the western world contained about 0.3 to 0.6 per cent carbon, as existing analyses from the Near East confirm. 'Unless the speaker is absolutely certain that an object he is talking of (particularly if it is early or pre-Roman) is true steel, he should avoid the use of the term "steel", for the sake of accuracy . . . It is far more accurate to term the products dating from about 1000–200 BC as being carburized iron or, if one is certain of his ground, as being case-hardened, or semi-steel. As for iron products before 1000 BC or better still, 1400 BC, unless the sample has been analyzed, it is safest to refer to it as iron or wrought iron' (Congdon 1971: 27). 'Appropriately' might well be added before 'analyzed' in Congdon's final sentence to draw out the full force of this caution.

(b) *Manufacture of smelted iron*

From the furnace the ironsmith took a mass of spongy iron, reheated it, and squeezed out the combination of ferrous oxide and silica gangue (fayalite) by hammering it. At the same time he consolidated the iron by welding cavities shut and by shaping it into a form convenient for commerce. The earliest such shapes reported from the Near East are the bi-pyramidal bars found at Khor-sabad in Assyria, Susa in Khuzistan (Iran), and Karmir Blur in Urartu, of eighth- to seventh-century BC date, which commonly have holes in them slightly off-centre (Curtis *et al.* 1979: 371 ff.). This form of bloom ('ingot'), varying from the more stumpy (*Stumpfbarren*) to the more pointed (*Spitzbarren*), was also used in Europe. As he proceeded, the smith would have applied simple practical tests such as the degree of bending without breaking, the resistance under the hammer, and the appearance of fresh breaks, to assess the quality of the iron. This low-carbon bloomery iron was heterogeneous, with very limited regions of high carbon content. Already at the smelting area the smaller blooms or bars might have been welded together to make larger ones by heating and hammering. If the selection was not careful, as often seems to have been the case, such a composite bar might vary considerably in its qualities along its length (cf. Rehder 1991: 16–17).

In any attempt to establish the technological reasons why iron became the metal of utility in the first millennium BC in preference to copper and its alloys, it is important to assess those of its mechanical properties likely to have made it preferable to materials used previously. In the case of ploughshares, for instance, this involves wood and stone as much as bronze. Questions of metal supply will be considered later. Numerous properties are considered in selecting steel for modern engineering processes, but four in particular are rel-

evant to iron in antiquity: strength and toughness; forgeability; hardness; and hardenability.

In the light of the restricted research so far done on the strength of early iron in the Near East it is likely that the introduction of iron was by no means necessarily an advantage in respect of the ability to produce a sharp blade that kept its edge for a reasonable time. No figures exist for average hardness of Late Bronze Age tools made in the Near East, but European evidence for comparable copper-tin alloys provides an average of 200 VPN (Vickers Pyramid Number). At Topprakale in Urartu iron spear- and arrowheads gave readings of 131–72, 155, 217, 225 VPN; a mattock 130 VPN; two bracelet fragments (?) 185 and 232 VPN (Piaskowski and Wartke 1989: 93, table 4). In so far as toughness is concerned, iron has distinct advantages. Bronze, though not a very brittle metal, has only a limited capacity for plastic deformation before it breaks and cannot be repaired fast and effectively. Iron tends to bend and notch rather than break and can be straightened and resharpened fairly rapidly. There is, then, a distinct advantage in having the tough, but slightly less sharp, iron blade. The effort involved in forging an object of iron would probably not be much more than that involved in making it in bronze, taking into consideration all the preparation needed for casting, whilst major repair is easier. Moreover, an iron object may easily be changed from one form to another, whereas a bronze one would have to be recycled and recast. Bronze comes into its own with the need for multiple castings, since mass-production of wrought iron is a labour-intensive business.

By the Middle Bronze Age, in the earlier second millennium BC, bronzesmiths had mastered the art of obtaining maximum effective hardness through alloying and cold-working. The blacksmith had far less control over the composition of his metal, affected as it was by its carbon and phosphorus content. A hard edge could be made on a copper or bronze tool or weapon by cold work-hardening with a hammer; with nearly pure copper the maximum hardness attainable is 110 VPN, whereas 6–10 per cent tin-bronze can be work-hardened to 275–300 VPN. Presumably early ironworkers soon recognized that iron air-cooled ('normalized') from forging heat was harder and stronger than cast bronze, but not as hard as work-hardened bronze. They would then have found that cold work-hardening iron would produce iron considerably harder than the best work-hardened bronze, whilst quenching, plunging iron red-hot from the forge into water to cool it for handling, also produced an extremely hard metal. The choice of hardening method was controlled by the fact that quench-hardening might produce warping and cracking; to edge-quench a shape like a sword without distortion requires special precautions. Cold work-hardened edges corrode more

rapidly than the body of the object and may well be difficult to detect microscopically. There is metallographic evidence of cold-work deformation along the edge of an iron sword-blade from ninth century Hasanlu in Iran (Rehder 1991). The earliest report of quench-hardening is equivocal, since the context and function of the iron in question is uncertain. It is a corroded piece of quench-hardened steel (0.8 per cent carbon) from a tomb at Pella in Jordan with Middle Bronze Age deposits, but 'we cannot be absolutely certain whether the steel blade was part of the grave goods or had come in with the wash' (Smith R. H. *et al.* 1984: 236) and is much later in date, as seems likely from the published stratigraphy.

Forging depends largely on acquired skills and experience. The incidence of intentional carburization in ancient iron from the Near East, as elsewhere, is still obscure. Much of the early iron available for study is badly rusted, making it difficult to be certain that the few remaining spots of steel are intentional rather than the result of using heterogeneous blooms of iron. Did the smiths carburize iron tools before 1200 BC; if not, from what date? At present it is assumed that this may have been the major technological development of the last centuries of the second millennium BC.

Rehder (1989) has recently argued, against a common description in studies of archaeometallurgy, that iron cannot be carburized simply by insertion into a charcoal fire nor is it carburized through repeated heating for forging. He points out that for iron to be carburized it must be enclosed within a source of carbon so that all or nearly all products of combustion are excluded. Temperatures over 750°C are necessary for carburization to occur and over 900°C is required to produce a useful thickness of carburized skin. The ancient smith, as always, would have assessed the process pragmatically, gauging the heat of the fire from its colour and experimenting with the length of time needed to provide the required finished product. Congdon (1971: 27 n. 74) describes a method well within the range of possibility in ancient Mesopotamia: 'the technique of steeling a butcher's knife in the American colonial period was through rubbing the blade with tallow, then heating it evenly, adding more tallow, reheating, etc., numerous times. The burnt tallow would provide the carbon source, the heat would drive the fat (and carbon) deep into the pores of the iron and effectively case-harden it.'

Lamination or piling is perhaps the most reliable demonstration of deliberate carburization. However, not all high-carbon iron was produced after smelting. Since there could be considerable natural variations in the carbon content of the original bloom, it can still be difficult to decide at times whether intentional piling had taken place or whether the various high and low carbon regions in the bloom had been stretched by forg-

ing to produce a pattern very similar to piling. With primitive methods of ironworking the penetration of carburization would have been slight, sufficient for thin, slender artefacts like knife-blades, but not for heavier objects like axeheads. It was for such artefacts that the laminated, piled, or compacted structure was devised. Plates of iron of varying carbon content were bonded together, commonly with a high carbon layer on the surface. This takes advantage of the fact that pieces of iron will weld perfectly to each other if simply hammered together when hot. The iron sheets were each carburized separately before being piled and forge-welded together so that there would be a reasonable diffusion of carbon through its mass.

The history of lamination in the Near East is skeletal, extending on present evidence from knife-blades of the earliest Iron Age in Cyprus, through examples of uncertain pre-Achaemenid date in Anatolia, to more recurrent examples from the fifth century BC (cf. Maddin *et al.* 1983^a). Its earliest clear appearance in Mesopotamia may well not be relevant to local skills. It has been identified on iron tripods (Coghlan 1956: 137, 180, 202; pl. I, fig. 2) found by Layard in palace store-rooms at Nimrud sacked about 614 BC, though in some cases containing objects at least a century older. As much of the associated material is booty or tribute from Syro-Palestine, these tripods may also have been made there.

As has already been noted, quenching served two purposes in the process of manufacture: the rapid cooling of a finished hot-forged artefact; the hardening of steel. The first is not particular as to the temperature of the object, but the second requires the smith to have some feeling for the degree of carburization previously obtained, as well as the correct temperature. Whereas quenching would be a common process for rapid cooling, it is likely to have been less so for metallurgical heat-treatment, since the smith had first to make or buy steel and then ensure that he did not decarburize it by forging or welding. Quenching a low-carbon steel at too low a temperature is useless, whilst quenching a very high-carbon steel at the right temperature may make it brittle. Then tempering will be necessary to make it usable.

Deliberate quenching is even more difficult to identify for certain than intentional carburization in ancient iron objects. About the only independent clue to its early development is in Homer's *Odyssey* (ix. 389-94); but water quenching might have been done simply to cool a forged object quickly. The key layer of an object for resolving whether or not it has been quenched is the martensite outer surface which is the area most subject to rusting and damage. Although there may be some indication of deliberate quenching in iron objects from Nimrud (Curtis *et al.* 1979: 382), firmer evidence is offered by the blade of an iron chisel from Al Mina, in Turkey, of the fourth century BC, which appeared to

have had the cutting edge coated with clay to prevent quenching cracks (Maddin *et al.* 1977: 130 ff.; Wheeler *et al.* 1976: 110-11).

Direct evidence for the activities of Babylonian blacksmiths is unknown, that for Assyrian blacksmiths is negligible. Pleiner and Bjorkman (1974: 303 ff.) have assembled the few documentary references there are. The same workshops were active in the production both of copper and its alloys and of iron, for at times the two metals had to be combined in the same object when the casting properties of bronze rendered it indispensable. Assyrian texts distinguish between coppersmiths and ironsmiths, but texts as well as surviving objects attest to the overlapping of their functions. As so little detailed scientific study of Assyrian ironwork is available, and none of Babylonian, even the most general statements are necessarily tentative. Experts are divided on the interpretation of what little has been done. Piaskowski (and Wartke 1989: 110-11) argues that the Neo-Assyrian ironwork previously believed to show evidence for the welding of iron and steel and deliberate secondary or case carburization (cf. Curtis *et al.* 1979) is just made from iron of non-uniform carburization as received from smelting regions. Consequently, Neo-Assyrian and Urartian blacksmiths (Piaskowski and Wartke 1989) are judged to have had even less knowledge of the effective ways to manipulate their raw material than had previously been accepted. Whatever the differences of interpretation, there is a consensus that 'there is no evidence that Neo-Assyrian smiths (or those who were supplying the Assyrian palaces) were skilled in effective ironworking' (Curtis *et al.* 1979: 389).

(c) *The problem of cast iron*

Whether or not cast iron was ever used in the ancient Near East remains an open question. The possibility has been recurrently considered, since the potential for smelting iron ore to a molten cast iron is inherent even in a small charcoal furnace. The Chinese already used smelting devices capable of producing iron as a high-carbon liquid in the second half of the first millennium BC, if not earlier. Manufacture of some of the iron artefacts mentioned in Hittite texts (cf. Kosák 1986) might be more readily explained by use of cast rather than of wrought iron; but for the moment no philological or material evidence supports any such conjecture. Carbon-14 dating has shown that a potentially early piece of cast iron from Burton-Brown's excavations at Geoy Tepe, near Lake Urmia, in north-west Iran, is in fact modern (Moorey 1991: 8).

(d) *Bimetallism*

The combination of iron and bronze (bimetallism), which had appeared early in the history of iron and was well established by the Late Bronze Age (Richardson

1943), became a significant aspect of metalworking in the first millennium BC, since it allowed for the exploitation of the complementary virtues of each metal. Copper or copper alloy shaft-holes or decorative elements were cast on to iron cutting edges. This technique attracted the attention of Layard and his colleagues after early excavations in Assyria (Layard 1853: 670). It is particularly well represented among the metalwork found in the destruction level of Hasanlu IV in north-west Iran, (cf. Pigott 1981: table 10). Considerable numbers of bimetallic swords, spearheads, and maceheads were recovered in addition to those made entirely of iron or of copper alloys. The material evidence from Assyria is far more meagre and incoherent and, in the case of maceheads and tripods, rather equivocal, as a number of the published examples have West Semitic inscriptions clearly indicating an origin outside Assyria (cf. Barnett 1967). But there are sufficient surviving artefacts to indicate that this technique, almost certainly long established among the Anatolian industries working more directly with iron, had a role in Assyrian workshops by at least the ninth century BC, when much of the Hasanlu IV metalwork was probably manufactured.

No technological study of this technique comparable to that by Drescher (1958) for Europe yet exists for the Near East, though many of his conclusions apply equally to the technology found there (cf. Hodges 1962: 132). A dagger from Nimrud (Ashmolean Museum 1951.60; PLATE VIII A) has a bronze hilt, directly imitating a bone prototype, cast on to an iron blade. This weapon illustrates how, when ornamental detail was required, copper alloys still remained the metalsmith's first choice, despite adventurous experiments with ornamental ironwork in western Iran (cf. Moorey 1991). Such also was the case with Neo-Assyrian maceheads, which commonly have bronze cast over iron cores. The earliest, dated by an inscription of Shalmaneser III (c.858-824 BC), has a faceted stone head mounted on an iron shaft-hole capped with bronze (Curtis and Grayson 1982). By placing a baked clay piece-mould, possibly taken direct from a carved stone macehead, over an iron shaft-hole, smiths were able to cast-on a copper or bronze head decorated in a manner far less easily achieved, if not unattainable, at the time in iron.

Other groups of artefacts illustrate the range and potential of this combination. On tripod stands for sheet-metal vessels bronze was cast round the junctions of iron struts to secure a joint in a rigid sleeve of metal, presumably made by pouring the liquid alloy into an appropriate clay mould encasing the iron parts (cf. Coghlan 1956: 180, pl. I, fig. 2; Barnett 1967). Bimetallism continued into the Achaemenid period. Two chariot linch-pins from Uruk have upper parts modelled as human bodies in bronze cast-on to iron

shanks (Schmidt, J. 1978: 40–2, pls. 19–22). Comparable linch-pins are shown in place on chariot wheels depicted on the reliefs at Persepolis in Iran (Schmidt, J. 1978: pl. 22b). An example of a decorated Neo-Assyrian linch-pin from Nimrud is entirely of bronze (Mallowan 1966: pl. 142; cf. Calmeyer 1980).

(e) *The development of ironworking in Mesopotamia*

The three phases of development in the use of iron proposed by Snodgrass (1980: 336–7) provide a useful basis for discussion of its emergence in most socio-political contexts, though they may not help to explain it:

'In stage 1, iron may be employed with some frequency, but it is not true working iron . . . In the main, its employment is for ornament, as is appropriate for the expensive commodity which we know it to have been in many cases . . .

In stage 2, working iron is present but is used less than bronze for implements of practical use.

In stage 3, iron predominates over bronze as a working metal, although it need not, and usually does not, completely displace bronze even in this role'.

It is important to emphasize, as Snodgrass (1980: 368) did, that 'to understand the spread of early iron-working one must distinguish between the essentially *technological* factors, such as those that brought the initiation of stage 1 and the transition to stage 2, and the essentially *economic* factors that must lie behind the change from stage 2 to stage 3'. In exploring the emergence of iron as a utility metal it is always important to distinguish those areas where smelting and manufacture could proceed in association, most notably in parts of Anatolia, from those where iron arrived as blooms, as in Mesopotamia, and the skill of blacksmiths had necessarily developed in isolation from direct experience of retrieving the metal from its ores; a process more critical for the working quality of iron than of copper.

In seeking explanations for the emergence of iron as the basic utility metal, technological factors need to be separated from socio-economic considerations, though, in the event, it was interaction of the two that controlled the pace of change in any particular region, be it a producer and manufacturer of iron or simply a manufacturer of imported blooms. Two key technological considerations inhibited rapid adoption of iron: the difficulty of achieving consistent results both in smelting and in manufacture, and the appreciable amount of time involved in hand-forging every single iron artefact, particularly by comparison with casting the same types in copper and its alloys. To be able to produce an iron tool or weapon with a cutting edge of a quality equal or superior to that of a fully work-hardened medium tin-bronze (up to 10 per cent or 12 per cent Sn), the smith had to have mastered a variety of hazards not

familiar to the coppersmith. He had to forge a blank of heterogeneous carbon distribution to a thin-sectioned blade; he had to harden the cutting edge of the blade to an evenly distributed and appropriate hardness; and, in finishing, any edge had to be ground to a maximum cutting potential. Such tasks demanded many man-hours, much skill, and wide experience of smithing. With the technical evidence at present to hand, it is hard to argue that it was the superior quality of iron that influenced its adoption in Mesopotamia.

Even for the eastern Mediterranean it is now doubted whether disruptions in the lines of supply of copper and of tin particularly, following the collapse of local palace economies in the political crisis that affected much of the region late in the thirteenth and in the twelfth century BC, were really severe enough to promote systematic exploitation of iron instead (Waldbaum 1989). This hypothesis had never seemed so plausible in Mesopotamia or Iran, or even in Transjordan, where production of copper alloys flourished at this time (cf. Moorey 1971: 296; McGovern 1986). The case would be further weakened if it could be firmly established that tin was available from Anatolia and need not be assumed to have come only from unknown regions in Iran or further east in Afghanistan (see Tin). Nor is the necessary evidence available to test Wertime's idea that deforestation was so severe as to encourage exploitation of a metal whose recovery from its ores did not consume so much fuel as copper did (Waldbaum 1989: 118–19). Here again what might be true of the east Mediterranean need not apply to such metal-producing areas as eastern Anatolia and Iran, where textual evidence indicates no crisis in supplies of timber at the critical time.

In so far as Assyria was concerned, the vital factors may have been more political than technological in the strict sense; nothing is known of the situation in Babylonia at the relevant period. Regions under the control of the Hittites in Anatolia and Syria, where iron ores were available, had a degree of iron production in the Late Bronze Age which, in ways not yet apparent in the material record, appears to have survived the collapse of the Hittite Empire, not only in Anatolia itself but more probably in her client states in Syria. Assyrian contacts with these states, both in the Middle Assyrian period and more particularly through military campaigns from the earlier ninth century BC, would have increased contact with iron and its production, whilst at the same time offering opportunities to capture experienced smiths as well as ample supplies of iron itself. It is possible that the increasing commitments of the Assyrian army from the ninth century required an investment in tools and weapons on a scale not contemplated before, thus placing new strains on the always uncertain supplies of tin. Iron would then have been not so much a substitute for copper and its alloys as

an additional resource, regarded as adequate for the purpose, however far the quality of the metal may have fallen below accepted modern standards. It allowed all available copper and tin to be used for other purposes by providing basic tools and weapons for the army and its support services. The Assyrian state, moreover, in the Neo-Assyrian period, had the capacity to set up the necessary industrial infrastructure for the extensive exploitation of iron. This requires comparatively complex organization to be effective even under primitive conditions (cf. Pigott 1981: 217 ff.); the more so, if economic production on any scale is required.

(1) *Stage 1 (before 3000 BC to 1250 BC)*

It is likely that the search for pigments first familiarized man with the main iron ores. Haematite, for instance, is red ochre (Schmandt-Besserat 1980). Now that it is accepted that pieces of iron may have appeared as a by-product of copper smelting, there is a viable alternative to the suggestion that all early iron was meteoric in origin (see above). The problem for the metalsmith was how to produce useful metallic iron from the bits of spongy bloom which resulted from such accidental smelting. This might be the origin of the four-sided instrument of iron from grave A at Samarra, commonly dated to the Halaf period (Herzfeld 1930: 5, fig. f, pl. 47; with report by Desch 'not meteoric'; cf. Perkins 1949: 7–8, nn. 69, 72). In a subsequent publication, however, Herzfeld (1933: 29) argued that all the metal he had originally published with the prehistoric painted pottery from Samarra was intrusive from the Islamic levels immediately above (for early iron in general, see Waldbaum 1980).

It may not be taken for granted that early scientific identifications of meteoric iron are reliable nor that Vaiman (1982) is always correct in reading 'iron' in archaic texts and, when correct, in identifying it as meteoric (see above). Sporadic finds of iron in early contexts are best regarded as by-products of copper smelting until otherwise established. In an inventory list of Uruk III from Uruk itself Vaiman (1982: 33; Heinrich 1935: pl. 32c) identifies iron objects among vessels and weapons of gold, electrum, silver, and what he believes may possibly be bronze. 'Meteoric' iron was found between levels D and E of the Anu Ziggurat at Uruk (Heinrich, in Nöldeke *et al.* 1937: 53) and iron is reported at Jebel Aruda on the Euphrates in Syria, a settlement of Uruk IV type (Driel *et al.* 1979: 19). A piece of iron was included in a jar hoard of beads (gold, cornelian, lapis lazuli, faience, frit, black stone) attributed to level IX, late fourth millennium BC, at Tepe Gawra, but in a context too disturbed for confident attribution to this early horizon (Judy Bjorkman: personal communication).

Pieces of smelted iron, or traces of it, are reported from third-millennium BC contexts at Tell Asmar

(Frankfort 1950) and Chagar Bazar (Mallowan 1936: 11, 26–7, 58; grave 67 in level 5), both possibly fragments of dagger-blades. Unanalysed pieces are also recorded from Chagar Bazar (Mallowan 1937: 151–2), Tell Asmar (Delougaz 1967: 198, 244), Khafajah (cited in Waldbaum 1980: 70), and Kish (Mackay 1929: 97, 123–4, pl. 36:2). 'Meteoric' iron (rusted fragments) occurred in RT 580 at Ur (Woolley 1934: 49, 542). Some iron fragments from Mari may well be later than was claimed when they were first excavated (Parrot 1956: 180–1).

Apart from the fact that both 'meteoric' and 'smelted' iron were current by at least the third millennium in tiny quantities for objects of high value and status, nothing is known of the metallurgy involved, nor whence the metal came to Mesopotamia. In view of the range of finds from Anatolia, and the local availability of iron, that seems the most likely source (cf. Waldbaum 1980: 70–2; Muhly *et al.* 1985: 70–1). The situation in Iran, apart from the meteoric iron in Sialk II (see above), is obscure both in the material and the textual record until late in the third millennium, when textual references include one to an 'iron dagger from Anshan' (Sollberger 1963: 177; 1966: 99 ff.). Iron is occasionally referred to in contemporary texts from Mesopotamia (Limet 1984).

Iron fragments are rarely reported from Mesopotamian sites in the early second millennium, in common with the Near East as a whole, and without the textual record its role might well be significantly underestimated. At Ur an iron peg, in a shapeless mass of copper, was reported from the *Enunmah* with tablets of Rim-Sin (Woolley 1974: 51). Limet (1984) has reviewed the evidence for iron in the palace archives at Mari, where it was used for personal ornaments, inlays, simple fittings, vessels, and weapons (see also Durand 1983: 222–3; Limet 1986: nos. 117–8, 121, 329, 397–8, 420, 601, 604). Limet points out that it was exceptional, but not such a rarity as is commonly assumed. It has the status of a precious metal, indicated by its value (perhaps 10 : 1 on a gold : iron ratio, 90 : 1 on a silver : iron ratio, if the meagre evidence is correctly interpreted) (Powell 1990: 95 n. 84, 96 n. 88; Bjorkman 1989). Interestingly, the standard Akkadian word for iron, *parzillu*, is sometimes replaced by *barzil*, a form Limet connects with the Hebrew *barzel* (iron) and Ugaritic *brdl*, indicating that iron in the eighteenth century BC was associated by people living on the middle Euphrates with 'les régions occidentales et la côte méditerranéenne' (Limet 1984: 195). This is not surprising in view of continuing textual evidence for a degree of iron production in Anatolia at this period, though the material evidence is minimal (Waldbaum 1980: 74).

In the eighteenth-century palace at Acemhöyük the excavators found an ivory box decorated with studs of

gold, iron, and lapis lazuli (Özgüç, N. 1976). A Hittite text, now thought to date in its surviving form no later than the sixteenth century BC, reports that some centuries earlier the ruler of *Purushkhanda* (?Acemhöyük) gave King Anittas of a neighbouring state centred on *Karum Kanesh* (Kültepe) 'a throne of iron and a sceptre (?) of iron as gifts' (Neu 1974: 15, 36); the former was presumably a wooden structure ornamented with iron inlays or overlays. As early as the middle of the sixteenth century BC in texts of King Hattusilis I, 'iron' is already used metaphorically in land grants, with reference to the words of the king, to express permanence or indestructibility (cf. Oppenheim 1955: 91). Unfortunately, philological uncertainty over the exact meaning of such terms as KU.AN, *amuttu*, and *asi'u* in the Old Assyrian texts from *Karum Kanesh* (Kültepe) c.1900–1700 BC obscure a critical phase in the development of iron production in Anatolia. If *amuttu* is to be rendered 'bloom iron', at forty times the price of silver, then it would be the earliest textual reference to smelted iron (cf. Maxwell-Hyslop 1972; on values see Bjorkman 1989; Powell 1990: 95). An Old Assyrian letter from Kültepe records an offer to purchase 'iron' at a rate of 8:1 (gold:iron) turned down as too low (Powell 1990: 96).

Two cautionary points need to be made here. There is no evidence for a significant quantity of iron recorded in the tablets from level VII at Tell Atchana (Alalakh) in the Middle Bronze Age; the claim rested on a misreading (Brinkman 1987). Nor is it certain that a fragment of iron from a cave burial at Pella in Jordan, identified as quenched steel, is Middle Bronze Age; intrusion cannot be ruled out, as the original report makes clear (Smith *et al.* 1984).

Evidence for iron in the Late Bronze Age in Mesopotamia remains meagre. A spherical bead of iron and a bronze dagger with iron inlays set into the hilt were found in Nuzi stratum II, c.1400–1350 BC (Starr 1939: 94, 470, 475; 1937: pl. 125KK); but the supposed textual evidence for iron armour-scales in the same level is based on a misreading (Brinkman 1987). A macehead from Aqar Quf may also be inlaid with iron (Baqir 1945: 13). An iron ring was recorded in a Middle Assyrian grave at Assur (Haller 1954: 63; grave 746) and there are iron finger-rings in the Middle Assyrian cemetery at Mari (Beyer 1982: 187 n. 1). An iron toggle-pin fragment is reported from a context of the thirteenth century BC at Tell Zubeidi (Boehmer and Dämmer 1985: 6, pl. 151:674).

Textual evidence indicates that Mesopotamia was on the eastern periphery of the areas where iron was becoming steadily more significant in the second half of the second millennium BC. The correspondence between the King of Mittani and Amenophis III of Egypt bears witness to the continuing role of iron daggers, spearheads, and maceheads in royal gift exchange,

though the place of manufacture is not known (Knudtzon 1915: as *parzillu*: nos. 22, I.8, II.16; 25, II.22(?), 28; as *hapalkinnu*: no. 22, III.7). In Syria the Qatna inventories of the fifteenth century (Vrolleaud 1928: 92) reveal its use as a precious metal; a text at Ugarit refers to an iron dagger, probably sent from a Hittite dignitary (Nougayrol 1970: no. 6). Egyptian texts note the Asiatic (Syrian: *Rtnw*) origin of most iron reaching the Egyptian court in the New Kingdom (Harris 1961: 59), when already by the fifteenth century 'iron' was used metaphorically for strength and hardness in inscriptions (Courayer 1965). The material evidence includes the famous bimetallic axehead from Ugarit (Ras Shamra) and various fragments (cf. Waldbaum 1980: 76), but particular interest attaches to the small iron objects (ring; pin) and traces of ironworking in the palace workshops at Kamid el-Loz (ancient *Kamidu*), at the southern end of the Beq'a Valley in the Lebanon (Frisch *et al.* 1985).

It is not yet known whether iron ores available in Syria and the Lebanon were already being exploited or whether the manufacture of iron in the palace workshops of Syria was an aspect of the Hittite domination of the region for much of the Late Bronze Age, using iron blooms imported from Anatolia, where textual evidence indicates a remarkable repertory in iron hardly evident at all in the surviving material record (cf. Waldbaum 1980: 76 ff.; Muhly *et al.* 1985). Kosák (1982; 1986) and Siegelová (1984) have assembled the textual evidence from Boghazköy for ironwork. It not only documents a remarkable variety of cult furniture, partially or completely of iron, but also iron tools and weapons. Many of these may have been prestige objects for ceremonial use, but production also embraced a repertory of those more mundane objects fundamental to the rapid development of iron industries in the Near East after 1200 BC. It is in these Hittite administrative texts that a distinction is first made between 'ironsmiths' and makers of utensils and jewellery using precious metals and copper (Muhly *et al.* 1985: 80; Zaccagnini 1989: 500). It is unfortunate that nothing decisive is yet known of the metallurgical techniques used by Hittite ironworkers. It may be fair to say that 'we cannot at this time attribute to the Hittites any greater technical knowledge of iron working than how to smelt iron' (Muhly *et al.* 1985: 79), but that apparently minimal achievement *might* have embraced a degree of skill and a range of expertise with carburization not evident elsewhere until an advanced date in the Iron Age. Indeed, some of the iron objects described in the Hittite inventory lists invite speculation as to whether they might even have been able to cast iron (see above).

(2) Stage 2 (c.1250–850 BC)

A famous letter from the archives at Boghazköy relating to iron production in Anatolia provides a useful, if

necessarily arbitrary, introduction to the second phase in the history of iron in Mesopotamia. This letter, from the Hittite ruler Hattusilis III (c.1289–1265 BC), was most probably addressed to the Assyrian king Shalmaneser I (c.1273–1244 BC.) (K Bo I: 14; Goetze 1949). The region of *Kizzuwatna*, to which it refers, lay about the axis of Taurus–Comana, an important source of iron ore. Muhly (Muhly *et al.* 1985: 79) translates the key passage thus:

As for the good iron about which you wrote to me, there is no good iron in my storehouse in *Kizzuwatna*. The iron (ore) is (of) too low (a grade) for smelting. I have given orders and they are (now) smelting good iron (ore), but up until now they have not finished (the iron). When they have finished I shall send (it) to you. Meanwhile I am sending to you a blade of iron for a dagger.

This letter has many points of interest, but it does not indicate, as has sometimes been assumed, a Hittite monopoly of iron production. Indeed, it is entirely in accord with contemporary conventions for royal gift exchange. It indicates the continuing status value of a single iron dagger-blade, perhaps illustrated by that found in the tomb of Tutankhamun with a gold hilt of Egyptian manufacture (Carter, H. 1927: 205, pl. 87b), and that Anatolian iron blooms were reaching the Assyrian court, where they would presumably have been made into artefacts. As with all aspects of Late Bronze Age palace economies, firm control over quality and distribution was exercised from the centre.

Shalmaneser I, in his own records, lists iron among the materials placed as foundation deposits at Assur (Grayson 1972: 84) and a contemporary administrative text, also from Assur, includes one dagger of iron and a spearhead of *hapalkinnu*, perhaps a specific type of iron (Postgate 1973: 13–14). Ninurta-Tukulti-Assur, in the mid-twelfth century, records a blacksmith at his court, but the range of his duties is not specified (Weidner 1935–6: 19). Tiglath-Pileser I (c.1114–1076 BC) used iron arrowheads to hunt wild bulls (Grayson 1976: 16), but his army hewed its way through woodland with axes of bronze. By the earlier ninth century iron was becoming more common, since Tukulti-Ninurta II (c.890–884 BC) recorded that his army cleared a path with iron axes(?). He also received one hundred iron daggers from *Lake*, a region in Syria, as tribute and iron from the *Nairi*-lands in eastern Anatolia (Grayson 1976: 100, 103–4). It is notable, in view of the huge quantities listed by later Neo-Assyrian kings, that 30–60 kg. of iron was still regarded as worthy of mention in royal annals in the early ninth century BC.

There are no iron objects of any note from Assyrian sites that may be dated before the late eighth century BC. Throughout, textual and material evidence from Babylonia is even more sparse. It may only be assumed from the remarkable range of bronze, iron, and bimetallic metalwork recovered from the destruction of level

IV at Hasanlu in north-west Iran, a site with marked Assyrian connections, that an increasingly varied repertory of iron tools and weapons was now available, even if the metallurgy was unsophisticated (Pigott 1981; 1982; 1989). Already at Hasanlu iron was used both as a utility metal and in new ways for decoration. Iran also provides a glimpse of an eleventh-century iron industry, whose origin is unknown, in the repertory of decorated wrought-iron swords associated with Luristan. On these a complex design was achieved on the pommel and hilt with separately forged pieces, joined mechanically, to the body of the weapon. They were air-cooled at a temperature of c.700–800 °C, not quenched; dies, swages, and carving were used to achieve decoration in a process that is virtually mass-production (cf. Moorey 1991; Rehder 1991). Nothing is known of ironworking in Anatolia at this time, but the iron industries of Syro-Palestine are increasingly well represented in the material record (cf. Stech-Wheeler *et al.* 1981) and steel is evident during Iron IA (c.1200–1050 BC) from Cyprus to Transjordan (cf. McGovern 1986: 276–7).

In seeking to establish the time at which iron became the primary utility metal, any documentary evidence is singularly valuable. In Babylonia in the third quarter of the eleventh century iron was still a relatively valuable metal, since an iron dagger was worth two full-grown rams (2 shekels of silver: cf. Brinkman 1988: 157 n. 63); three centuries later a very large amount of iron (about 545 kg.) had been collected by a single Babylonian citizen (Brinkman 1988: 158 n. 63).

In regions where the material evidence is more extensive, attempts have been made to quantify the relative use of copper alloys and iron in the centuries after 1200 BC, when iron steadily becomes the metal of utility. However, ironwork is notoriously difficult to identify in the corroded condition in which much of it is found. It has therefore often been discarded or, when published, reduced to an absolute minimum of identifiable pieces on Near Eastern sites. Arguments based on such statistical evidence have to be handled with particular care. 'In Timna I have published 7 or 8 fragments. There are 700 fragments which have no meaning at all, so we couldn't publish them. This is 13th century. I also have all the iron objects from the excavations at Iron Age Arad, about 10–9th century. I have perhaps 200 iron fragments which mean nothing and I might publish 4 or 5 which have some shape . . . [at] Lachish, they have published hardly any iron and yet have found boxes full of fragments' (Rothenberg, in Muhly *et al.* (eds.) 1982: 295).

(3) Stage 3 (c.850–350 BC)

In the absence of artefacts made in Assyria before the late eighth century (Pleiner and Bjorkman 1974; Curtis *et al.* 1979), it is not yet possible to establish when iron

manufacture was first extended to cover the majority of tools and weapons nor the level of technical expertise at this early stage. Even for the later eighth and seventh centuries BC the geographical distribution of the best evidence is limited to the royal palaces at Khorsabad, Nimrud, and Nineveh, and the published evidence is only a fraction of what was recovered. It was probably in the course of the ninth century in Assyria that iron became relatively common, almost certainly imported as blooms, and was used more extensively for tools and weapons. Under Assurnasirpal II (c.883–859 BC) and Shalmaneser III (c.858–824 BC) iron came as booty and tribute to royal storehouses and workshops from regions adjacent to the Upper Euphrates. Under Shalmaneser III, for the first time, iron was listed amongst metals obtained 'without number' and thereafter, until available records cease in the earlier seventh century BC, very considerable quantities of iron are recorded. Shalmaneser III was the king who ordered: 'sharpen the iron swords that subjugate the foe' (Lambert, W. G. 1961: 150–1). To what extent, and when, iron sources in Kurdistan were exploited, and how much iron metallurgy went on in private rather than in public organizations in Mesopotamia, is wholly obscure at this time.

It has already been noted that the surviving material evidence is predominantly of seventh-century BC date, or slightly earlier. This means that the use of simple proportion to separate stages 2 and 3 in Assyria is not possible, since the available artefacts all fall into so brief a period and that came after the transition to judge from the documentary evidence. At Nineveh stratigraphic confusions greatly reduce the chronological relevance of the ironwork excavated there; relatively little ironwork, and that not easy to date closely, was reported from graves at Assur; whilst at Nimrud, though the site yielded masses of ironwork, little of it is likely to be much earlier than the seventh century BC (Curtis *et al.* 1979: 370). At Khorsabad one store-room (84), excavated by Place, was described as a huge iron wall including 160 tons (c.5,600 talents) of the metal, and that was only part of the ironwork found there (cf. Pleiner and Bjorkman 1974: 293). Several hundred blooms ('ingots') were packed into this store-room, together with pickaxes and hammers, grappling irons and chains, and ploughshares. Scattered finds of iron objects from other sites in Assyria and Babylonia down through into the Achaemenid period do not conspicuously add to the body of well-dated evidence. Unfortunately, an important group of iron tools excavated by Petrie at Thebes in Egypt and dated by him 'to the Assyrian invasion' of the earlier seventh century BC are likely to be Ptolemaic or Roman in date (cf. Williams and Maxwell-Hyslop 1976).

Curtis (in Curtis *et al.* 1979: 383 ff.) has provided a simple statistical survey of some of the archaeological

evidence for iron artefacts. All known ploughshares, sickle-blades, hoes, and knives are of iron in the later eighth and seventh centuries BC. Saws were also made of iron (Layard 1853: 195; Curtis *et al.* 1979: fig. 31a–c). Adzes, axe-adzes, and axes were commonly, if not exclusively, of iron. Weapons offer equally striking confirmation that Assyria was now well into stage 3. Of the spearheads and swords listed by Curtis all are of iron; of 17 daggers, only one is entirely of bronze and another has a bronze hilt cast onto an iron blade. Surviving leaf-shaped arrowheads are overwhelmingly of iron; the trefoil, flanged bronze arrowheads of the seventh century BC were an innovation brought by the Scythians and their confederates. Wrought iron, from which the leaf-shaped arrowheads had to be individually hand-forged, is not adaptable to methods of mass-production for which the new type of arrowhead was particularly well suited. Its currency is a technological phenomenon and in no way indicates any failure of iron supplies. Caution is always necessary in assessing the archaeological record for iron. Helmets both of bronze and of iron survive; the former would have been lighter, the latter more protective. An Assyrian iron helmet weighed about 3,049 g. as against 862 or 700 g. respectively for two bronze helmets reported to be from Iran (Curtis *et al.* 1979: 385). The weight, the rusting, and the heat of iron armour-scales in the intense sun would also have been a vital consideration, though iron scales offer better protection against arrowheads and were more easily repaired by army blacksmiths. Consequently, there was a parallel production of both (cf. Dezsö and Curtis 1991).

The material survivors from the Neo-Babylonian period are still too rare for meaningful comparisons, but Brinkman (1988: 140–1) has analysed the textual record relevant to the use of iron in comparison with copper and its alloys. Again iron predominates for axes and adzes, daggers, knives, shears, and sickles, as well as branding-irons and fetters, nails, and tools for digging. Brinkman noted in particular, 'about the turn of the millennium', a decline in the number of references in texts to bronze daggers as common objects and their virtual replacement in everyday life by iron daggers, so long the pre-eminent status symbol in the iron repertoire. Powell (1990: 78; cf. Zaccagnini 1989: 502) has reviewed iron prices in Neo-Babylonian texts. The silver: iron ratio for iron from *Labanu* (Lebanon) was about 1:361, from *Yamana* (?Anatolia/Cyprus) was 1:240. It is difficult to tell whether the minimum (1:229) and the maximum (1:831) for the period are influenced more by quality than solely by factors of supply and demand. Powell makes an educated guess 'that sixth century Babylonian merchants reckoned 1 shekel silver = 4 minas of iron (1:240) as a more or less "reasonable" price for an "expensive" iron and 1 shekel = 14 minas (1:840) a "reasonable" price for a

relatively "cheap" iron. One shekel per 9 minas (1:540) is the median between 4 and 14 minas and may be closer to the true mean of all iron changing hands than the value 1:378 calculated from the total weights in silver and iron of our five meager Neo-Babylonian attestations for the value of iron.'

(f) The repertoire of iron objects

(1) Blooms ('ingots')

There is a category of iron object from Khorsabad and Nimrud (Pleiner and Bjorkman 1974: 295; Curtis *et al.* 1979: 371 ff.), rather fish-like in shape when seen in profile, and generally pierced with a small hole towards the end. They are almost rectangular in section at the middle and have tapering ends hammered into broad flat terminals at 90° to one another. Place reported finding considerable numbers of them in Room 84 of Sargon's palace at Khorsabad (1867–70: 84–7; ii. 264; iii, pl. fr. 5–7; cf. Loud and Altman 1938: 213–7, pl. 62). They vary in length between 39.5 and 51.5 cm. and weigh between 3.7 and 8.7 kg. (Pleiner and Bjorkman 1974: 295 n. 17; Place gives as high as 12 kg.). Analysis and metallographic study (Pleiner 1979; Curtis *et al.* 1979: 371 ff.) have shown them to be 'essentially pure iron with only minor amounts of impurities'. Carburization was not consistent in the tested samples, appearing sometimes on the working edge, sometimes on the shaft-hole. These semi-forged iron objects are still an enigma. In some cases the hole contains traces of wood, in others it is not even cut right through. It has been argued that a few appropriately shaped examples might have been miners' pickaxes, with shafts of ash or larch, whose spring would increase the impact, as in more recent tools (Maddin, in Curtis *et al.* 1979: 389 ff.). But many of the extant examples could not have been mounted to serve in this way and, for the moment, they are best regarded as iron blooms with the hole to facilitate handling (Pleiner 1979: 90). The context at Khorsabad is more appropriate to the storage of ingots than mining tools. Although they are assumed to be Assyrian, if they are blooms they might well be imports from a mining region outside Assyria proper.

(2) Tools and implements

Pleiner and Bjorkman (1974: 296 ff.) have succinctly assembled the textual and archaeological evidence for iron tools. Iron axes, adzes, and pickaxes were standard equipment by at least the ninth century. Hoes, sickles, ploughshares, and probably iron spade-blades were current in the farmer's tool-kit; iron chisels and saws in that of the carpenter. Knives of iron were widely used. If the group of tools from Egyptian Thebes may indeed be attributed to Assyrian military craftsmen of the seventh century BC, and that is very doubtful, then it embraces a punch, a carpenter's chisel, a file, a rasp, an adze, a twist-edged scoop, a cutter, centre bits, and

crank pieces (Williams and Maxwell-Hyslop 1976: fig. 3).

Various seventh-century iron tools from Nimrud have been metallographically studied: a sickle-blade, a knife, a hoe, and two chisels, which might be post-Assyrian in date (Curtis *et al.* 1979: 377 ff.). Carburization was not extensive and may not have been deliberate; but hammering or forging was evident. The implication of these observations is that Neo-Assyrian smiths did not know how to manipulate in the most effective ways the operations in which iron attains the greatest strength' (ibid.: 381). The Theban group has been similarly studied, but in view of its uncertain date and place of origin may not be cited as 'Assyrian' for the purposes of technological study (Williams and Maxwell-Hyslop 1976: 303; for Urartu see Wartke 1990; Piaskowski and Wartke 1989).

Pleiner and Bjorkman (1974: 298 ff.) reviewed the textual and archaeological evidence for iron foot-fetters, pokers and tongs, chains and hooks, bell-clappers, nails, some personal ornaments, and for various structural elements such as door-fittings. Iron was used for the struts of tripod-stands for cauldrons, jointed and shod with cast bronze (Layard 1853: 178, 191, 671: report by Percy). Coghlan (1956: 4, 137, 180, 202) examined a fragment of one such tripod strut and found 'a piled structure which would indicate that the tripod iron was made from piled wrought material'. But many, if not all, of these tripods may be imports, as some bear West Semitic inscriptions (Barnett 1967). From the Nabu Temple at Khorsabad were recovered three iron wheels (c.22 cm. in diameter) from a ceremonial wagon. On them iron spokes were inserted into naves of cast bronze and two iron rims and tyres were possibly riveted together (Loud and Altman 1938: 62, pl. 24e). No certainly identifiable fragments of full-scale wheels, or other iron parts of the numerous chariots used in Assyria, have yet been reported; bronze linch-pins are attested (Ellis 1966: pl. VIII, la–b), as are linch-pins of iron and bronze (see above).

(3) Weapons and armour

The whole range of personal arms, daggers, swords, spear heads, and arrowheads was regularly produced in iron to patterns closely following those of their bronze precursors. Some have received metallographic examination (Curtis *et al.* 1979: 377 ff.); a dagger-tip was carburized and an arrowhead made of hammered, mildly carburized iron. Maceheads present a rather more varied technology, already considered, as has been the use of iron for armour and helmets (see above). Layard vividly described a find of iron scale-armour at Nimrud (1849: i. 341; cf. Stronach 1958); but only two armour scales from Mallowan's Nimrud excavations have been metallurgically examined (Curtis *et al.* 1979: 378–9). They were of mildly carburized

iron, hammered at about 600 °C into a stone mould to give a central rib. Such a method would have saved time and ensured uniformity for an object needed in some quantity. Iron helmets gradually replaced bronze helmets, at least among élite Assyrian troops, in the second half of the eighth century, as iron scale-armour also became more common. Élite Assyrian troops wore fine iron helmets made out of a single piece of metal often inlaid with bronze decoration, whilst ordinary troops had helmets, perhaps easier to mass-produce, made from separate pieces of iron (Dezsö and Curtis 1991). Shields when made of sheet bronze had iron handles riveted on to the inside (Layard 1853: 194). Amongst the iron implements he found, Layard noted 'a large blunt spearhead, such as we find from the Sculptures were used during sieges to force stones from the walls of besieged cities' (Layard 1853: 195; cf. 1853(a): pl. 66).

(4) Horse-harness

To what extent iron was used to manufacture horse-bits it is hard to say, as very few Assyrian horse-bits have been recognized in excavations (cf. Stronach 1958: 175, pl. XXXV.1). To judge from the very much richer contemporary evidence in western Iran, cast bronze was preferred (Potratz 1966: 117) until at least the eighth century BC. In Hasanlu IVB 43 per cent (18 out of 43) of the horse-bits, of what may be a western type, were of iron (Medvedskaya 1991). Other horse-harness trappings were of cast or sheet bronze.

(5) Ornamental work in, or on, iron

Evidence for the ornamental use of iron in Mesopotamia is still awaited. There is no evidence for swaged and engraved decoration, as on bracelets and swords of iron from Luristan (Moorey 1991), nor for *repoussé* decoration as on iron plaques from Hasanlu IVB in north-west Iran (Pigott 1980: 430). Layard, in reporting a number of iron helmets, which disintegrated during excavation, remarked that 'the rings which ornament the lower part, and end in a semicircle in front, were inlaid with copper' (Layard 1849: ii. 339; cf. i. 341). X-rays have revealed inlaid copper or bronze decoration on other helmets of iron from Nimrud (Barnett 1953; Dezsö and Curtis 1991).

(6) Vessels

Although iron vessels were produced in Urartian workshops, they do not yet seem to have been recognized in Neo-Assyrian contexts (cf. Böhme 1979).

In the broad spectrum of evidence for ironworking before the Graeco-Roman period now available, the smiths of Assyria, unlike those of the East Mediterranean and the Greek world, do not seem to have been able to control the quality of the metal used. There is

no clear evidence for the selection of carbon-poor or carbon-rich pieces for deliberate construction of working edges. Nor is there any certain indication of the regular quenching or tempering of blades.

No metallurgical research has yet been done on iron-work of the brief Neo-Babylonian period, though it is represented amongst finds from sites like Babylon and Ur. Only one type of iron weapon, typical of the Achaemenid military repertory, has been subject to such examination. Smith (C. S. 1971: 43, no. 101, fig. 2. 2d, 2:18) showed that an unprovenanced iron *akinakes* or short sword, was forged from a single piece of steel save for the pommel, which was a separate piece pierced at the centre, to fit a small tenon on top of the grip. Coghlan (1956: 137–9, fig. 44) published a technical report on an iron spearhead of the Achaemenid period from a cemetery at Deve Hüyük, near Carchemish (Moorey 1980: no. 170):

The material of this spear is forged carburized steel made from reduced sponge iron. Average carbon content is 0.18 per cent, but in places as high as 0.6 per cent. The high nickel content of 0.32 per cent is unusual. The spear has been forged from about fifty plates or layers of sponge iron piled into a block . . . the majority of the plates have been surface-carburized during heating for forging, the compacted structure resulting in a highly developed water-marked pattern somewhat similar to damascene steel blades produced from cast steel. A noteworthy feature is that the tubular taper socket, which was forged from a 'tagged' end, has been brazed and forged together with impure copper. Hardness ranged from 108 Vickers in the low carbon zones to 152 Vickers in the higher carbon bands. There is no indication of hardening and tempering.

(v) LEAD

Native lead (Pb) is even rarer than native silver. The principal ore of lead is galena (lead sulphide), which, when it occurs in hydro-thermal veins, is frequently associated with silver ore minerals. Cerussite (lead carbonate) is an important, widely distributed secondary ore mineral of lead formed by the action of carbonated waters on galena. Two reasons probably account for the early use of lead ores (see below). They are very shiny, metallic-looking, and so attract attention, whilst the metal is very easily obtained from the ore. Tylecote has shown that lead can be smelted from galena in a fire burning charcoal or dry wood at temperatures below 800 °C (cited in Gale and Stos-Gale 1981^b: 181).

(a) Recovery

Lead is easily recovered through roasting galena to remove the sulphides or through heating cerussite with charcoal to remove the oxygen so that it passes off as gas. It is also easy to work and, because of its weight, useful for stabilizing objects, for making weights and anchors. It was generally used in the condition it came

from the furnace. Archaeological and documentary evidence (*CAD*, s.v. *abāru*) reveal that it was employed in Mesopotamia for vessels, for pipes, large and small (in medical contexts), and as covering in sheets, both for artefacts and parts of buildings. Cast lead formed the cores of statues, particularly of their bases, and of metal weights. It stabilized door-sockets and was used to plug casting faults in copper or bronze statuary. Rivets and clamps of lead provided reinforcement in buildings and in repairing stone vessels. Cast in stone moulds it was made into trinkets and statuettes. It was added to copper alloys for three possible reasons: to ease the filling of complex moulds; to lower the temperature to assist with casting in lengthy or slender moulds, or to assist the casting of several objects from one melt; and to increase the weight of metal available. Lead was also used in the production of glass and glazes (though not so commonly as is often assumed), in cosmetics, and in pigments. It may be alloyed with tin as pewter; but this is not yet evident from any analytical data at present available for Mesopotamia and is rare elsewhere before late Roman times (cf. Bjorkman 1987; see p. 296 for Urartu).

(b) Sources

(1) Texts and geological distribution

After the consideration given to argentiferous lead ores in discussing silver (pp. 234 ff. here), there is little more that may usefully be said about lead sources and their distribution in the Near East. Jesus (1980: maps 12–13) comprehensively summarized the evidence for Anatolia and there may be little doubt, for ancient texts from time to time confirm it, that this was the primary source of the lead used in Mesopotamia. After Egyptian conquests in Western Asia in the Late Bronze Age, Egyptian historical texts reveal that lead was imported from *Djahi*, *Retenu*, and *Isy*: regions in Syria adjacent to Anatolian source zones (Lucas 1962: 244). Lead was commonly collected from peoples of southern Anatolia by the Assyrian kings from Tukulti-Ninurta I (c. 1243–1207 BC) onwards (Jankowska 1969). Emphasis has commonly been put on sources accessible from Diyerbakir (cf. Yener *et al.* 1991) and what is said to be a considerable outcrop in the Tiyari mountains, north of Nineveh (Layard 1849: 223). Lead ores also occur widely in Iran (Allan 1979: 28 ff.; Harrison 1968: 505 ff.); an Old Babylonian text refers to the river Tigris bringing lead from a place which may be Susa (*CAD* 'S': 1466: *sangû*). In a Sumerian liturgy to Ninisinna, goddess of healing, it is noted that 'Elam has indeed produced for her kohl' (Stol 1989: 165–6), which in the ancient Near East was more often a lead than an antimony product. Stol cites an eighteenth-century AD reference to the import of a lead ore from Iran for the manufacture of kohl in Syria. Afghanistan (Chmyriov

et al. 1973) and Oman (Tosi 1975) are also potential, if relatively unlikely, sources for the lead used in Mesopotamia.

No lead ingots have yet been published from a site in Mesopotamia. Elsewhere they are unusually common in the Late Bronze Age, as in Cyprus and Syria, where at Ras Ibn Hani at least sixteen have been found, weighing up to 40 kg. (Lagarce *et al.* 1987: 282–3, figs. 6–7; cf. Muhly 1988).

(2) Scientific determination: lead-isotope analysis:

Ordinary chemical analyses of objects made from copper or its alloys may reveal something about how the metal was extracted from its ore (p. 248), but with lead such analyses are of restricted use for demonstrating the kind of ore used, or the location of the mines, as the processes of smelting and cupellation considerably disrupt the pattern of major, minor, and trace elements characteristic of the parent ore. In the case of lead an alternative is offered by isotope analysis. As only tiny samples are required, the lead contained in variable concentrations in nearly all early metal objects, of copper and its alloys, of gold and silver, also suffices for such testing. The isotopic compositions of lead samples remain essentially constant no matter what is done, *short of mixing together leads from different sources*.

The basis of the technique is relatively simple, even if interpretation of its results is at times contentious. Natural lead has four stable isotopes: Pb 204, 206, 207, 208, which represent atoms weighing, respectively, 204, 206, 207, and 208 atomic mass units. In the case of the great majority of chemical elements the relative proportions of their isotopes are the same, regardless of where the elements are found. But lead is unusual in that the relative proportions of its isotopes vary somewhat among ores occurring in different geological regions. The variations arise from the different geological ages of the ore deposits and stem from the fact that Pb 204, 206, 207, and 208 are found as end-products of the radioactive decay series of uranium and thorium.

Lead-isotope research depends ultimately on a fully comprehensive database of isotopic determinations for lead ores from mines across the Near East. Unfortunately, at present, virtually nothing is known in this respect of mines in Iran and its eastern neighbours and relatively little yet of mines in Anatolia (the best-researched region) or Syro-Palestine. Tests have shown that there is no evidence that the ores exploited in antiquity in a specific mining area were isotopically any different from those accessible there today (Begemann *et al.* 1989: 276). This contrasts strikingly with chemical composition and trace-element patterns in slags and raw copper which have changed in the course of time due to the use of different fluxes and changes of technology.

By determining the isotopic composition of lead

extracted from ancient objects it becomes possible in some instances to match these compositions with those of ores from known mining regions. But, as ratios may not be unique to a deposit, conclusions are predominantly of a negative kind, and even then must be used with caution, as there is a continuing debate over whether or not ambiguities may be resolved by statistical analysis and, if so, how. When an artefact or an ingot has a lead-isotope composition that falls within the isotopic field of a particular ore deposit, it may only be said that the lead in the object is consistent with derivation from that ore source. Even when direct connections cannot be made with specific regions (as is often the case at present for the Near East), such data may serve to group ancient artefacts which contain the same kinds of lead and which, therefore, might have had a common origin.

Isotopic research has proliferated since the later 1970s, after pioneering work by Brill and Wampler (1967; Brill 1978, with bibliography on p. 30 n. 17), to the point where significant trends become visible, yet confident conclusions remain hazardous. Lead-isotope ratios demand meticulously careful and thorough statistical processing, as well as careful attention to all relevant archaeological data, to the mineralogical character of the ore deposits involved (many of them multimetallic) and to the extractive metallurgy used (cf. Gale *et al.* 1992). Data steadily increase for the isotopic identification of specific lead sources in Anatolia and the East Mediterranean region, but little or nothing isotopic is yet known of other Near Eastern lead sources (Yener *et al.* 1991). It has been shown, for instance, that the lead compositions for the Timna deposits and for Feinan in Jordan are very different from those for Cyprus (Gale and Stos-Gale 1985). Gale *et al.* (1981) also demonstrated that the copper deposits in the ophiolite sequence in Oman have lead-isotopic fields quite distinct from that of Cyprus. This is an example of deposits of similar geological ages having easily separable lead-isotopic compositions.

(3) Historical survey of use

Lead was one of the first metals to be exploited by man and might well have been the first metal obtained by smelting an ore, since it is so easily recovered by the simple heating of galena. Some doubts have been raised as to whether the lead beads from level IX at Chatal Hüyük in Anatolia are of the mineral galena or metallic lead; if so, they would be one of the earliest examples of smelted lead (Mellaart 1967: 217–9, pl. 104 r.). The evidence of a single lead 'bead', of the seventh millennium BC, at Jarmo remains equivocal, as there was some doubt about its context (Braidwood, R. J., *et al.* 1983: 542, fig. 136: 19). Lead occurs in manufactured form in Mesopotamia as a bracelet in Yarim Tepe

I, in the sixth millennium BC (Merpert *et al.* 1977: 84, pl. XII.2). In TT6 at Arpachiyah, of the Halaf period, a small conical piece of lead was found in the 'Burnt House' (Mallowan 1935: 104). That lead facilitated copper casting was apparently recognized by the later prehistoric period to judge from a free-standing copper lion amulet ($4.7 \times 3.4 \times 1.1$ cm.) from Uruk containing 9 per cent lead (Heinrich 1936: 25, 47, pl. 13a). Lead was used for vessels ('bowls, tumblers, trays') in the later phases of the prehistoric period at Ur and into Early Dynastic I (Woolley 1956: 104 ff.), and in the Diyala area (Delougaz 1967: 58 ff.), to an extent unparalleled in the archaeological record of any other period. In the so-called 'Jamdat Nasr' cemetery at Ur, extending in time well into the Early Dynastic period, out of a total of 84 metal objects catalogued four were of silver (two pairs of earrings), 42 of copper, and 38 of lead, a remarkably high percentage of the total (Woolley 1956: 104 ff.). A similar pattern of use, particularly for vessels, is evident at Susa (Tallon 1987: i. 318).

There is some scattered evidence from analyses to suggest that at a time when lead was unusually common for vessels it was also being experimented with in binary copper alloys (Berthoud *et al.* 1982: 45 ff.; Tallon 1987: i. 362–4). In the Uruk amulet, cited above, its purpose seems clear, but its presence, up to 15 per cent in a pin from Susa or 20 per cent in cylinder seals, is difficult to explain save as an aberration at a time of general experimentation with copper alloys. What little analytical evidence is at present available for the third millennium does not indicate recognition of the special properties of lead-copper alloys; indeed, lead is markedly absent from the few statues so far analysed. Nor do isolated references in Ur III texts indicate that it was then deliberately alloyed with copper (Limet 1960: 54–5). Metalworkers in Iran worked with copper and lead in the same workshop on various sites; but, it would seem, for distinct purposes (Berthoud *et al.* 1982: 45).

A fragment of sheet lead from level 5(?) of the deep sounding at Nineveh is of the earlier third millennium BC (Campbell Thompson and Mallowan 1933: 146). At Ur it was used as a cover for pottery vessels (Woolley 1956: 220: U.20073; Brill and Wampler 1967: pl. 5). In Early Dynastic I it was also used, very skilfully, at Kish to repair stone vessels (Moorey 1978: fiche 4: 33) as also, somewhat later, in House D at Khafajah, Room XVI (Room 1 in final report) (Frankfort *et al.* 1932: 100), and, no doubt, elsewhere. At this period it also appears concealing casting faults in base-metal statuary. The copper support in the shape of a nude male figure from the Temple Oval at Khafajah is almost pure copper (Cu: 99 per cent; Sn: 0.63 per cent; Pb and Fe: traces; Ni: nil); 'faults such as show in the back of the right calf of no.

181 (pl. 101A) were filled out with lead' (Frankfort 1939: 42).

By Early Dynastic III mortuary evidence indicates a marked decline in the popularity of lead for vessels; they do not appear at Khafajah, Ubaid, or Ur in graves of this period and only two examples were reported from Cemetery A at Kish (Mackay 1925: pl. XX.2: graves 9 and 12), though Mackay did report that 'melted fragments (of lead) were found in several parts of Kish in buildings of the earlier type of plano-convex brick' (*ibid.*: 17). Only one occurrence is recorded in the Royal Cemetery at Ur: PG 55 yielded 'some sheet lead . . . shapeless and pierced with holes due to decay' (Woolley 1934: 148). In the metal statuary of Early Dynastic IIIB at Tell al-Ubaid 'the antlers (of remarkable size and number of tines) were wrought and hammered, and soldered into their sockets with lead. This lead had so expanded as to burst the heads . . .' (Hall and Woolley 1927: 29). The use of lead in casting is not as apparent as might be expected; it is not, for example, reported in the cast copper statue inscribed for Naram-Sin from Bassetki (Al-Fouadi 1976: 65–6); but Berthelot (1906: 79) reported that a copper foundation figurine of Amar-Sin (c.2046–2038 BC) contained between 17 per cent and 18 per cent lead. In the later third-millennium levels at Nuzi lead was only occasionally reported, as needles and pins (Starr 1939: 384). A bracelet of interlocking lead rings is reported from an Ur III context at Nippur (Gibson 1987–8: 24, plate).

One of the distinctive aspects of the material culture of the Anatolian sites of Alishar and Kültepe in the 'Colony Period', in the first quarter of the second millennium BC, was the production of figurines and trinkets of lead in special stone moulds, a number of which have survived (Opitz 1933; Canby 1965; Emre 1971). They were also used at this time across north Syria and Mesopotamia, perhaps as an aspect of the commercial contact at that time between Assur and eastern Anatolia (Canby 1965; cf. Atchana: Woolley 1955: 273, fig. 73, r.; Chagar Bazar: Mallowan 1937: pl. XVII; Brak: Maxwell-Hyslop 1971: pl. 28; cf. Mallowan 1947: 170, pl. XXXII.1 (lead trinket); Assur: Andrae 1922: pl. 29p; Rimah: Oates, D. 1967: 289). One such mould, now in the British Museum, is said to be from as far south as Sippar (Abu Habba) (Opitz 1933: 189, pl. VII: 7). Texts refer to such lead trinkets and statuettes as an 'open hand of lead' and 'figure of the dead (made) of lead' (*CAD*, s.v. *abāru*). Small lead figurines occurred in graves of the Ur III to Old Assyrian periods at Assur (Haller 1954: 9 ff.). A lump of lead formed part of a large hoard of Old Babylonian copper and bronze agricultural implements at Tell Sifr (Loftus 1857: 268–9; Moorey 1971a: 62). Small lead plaques appeared in two graves of the Isin-Larsa period at Ur (Woolley 1976: graves 125, 134). Lead wire was used in the construction of sheet-silver brace-

lets from tombs of the Old Babylonian period at Tell ed-Der (Lerberghe 1984: 106), where other small lead objects were found.

No site so far excavated in Mesopotamia has illustrated the varied uses of lead so well as Assur, where large circular plates of it formed the bases of stone pivots (Andrae 1913: 26, fig. 17, weighing 90 kg.: Shalmaneser III); large inscribed plaques were placed in foundation deposits by Tukulti-Ninurta I (c.1243–1207 BC) in the Ishtar Temple (Andrae 1935: 42 ff., pls. 21–2; Galter and Marzahn 1985) and numerous small lead objects were also encountered, primarily in the Ishtar Temple, in the so-called 'New Palace' of Tukulti-Ninurta I, and at a point on the north-east fortifications (Andrae 1923^a). In recent years a peasant found a hoard of lead objects, model tools, and tokens stamped with rosettes, at Kar-Tukulti-Ninurta (now in Assur Museum; M. Roaf: personal communication). The Ishtar Temple roundels have been published in detail (Andrae 1935: 102 ff.). Whether they were just personal ornaments, tokens, or some form of money was once much discussed (Smith, S. 1922; Andrae 1923^a). In addition to the roundels, Smith also called particular attention to many 'lumps of lead, bearing stamped impressions, now invisible', varying considerably in size, and to small pieces of folded lead that could have been threaded (Smith 1922: figure, no. 102). The latter need be no more than weights for fishing-nets. The known use of AN.NA (*annaku*) as money in Middle Assyrian texts, and its unanimous translation as lead rather than tin in 1923, inspired the view that here were actual examples of the manner in which lead was cast for use as coinage. This is now widely discounted (on this see here under Silver); but there remains a major problem in interpreting the elaborate Middle Assyrian system of 'cheap money' (cf. Powell 1990: 86–7).

Despite Landsberger's magisterial discussion (1965), ambiguity still surrounds the terminology for lead and tin in Akkadian, notably in the second half of the second millennium BC (see also Tin here). In a Middle Assyrian text (VAT 18062: Freydank 1982; Müller, M. 1982: 272) a distinction is made between AN.NA BAB-BAR (*pesū*) and AN.NA *abāru*. The first is fifteen times more valuable than the latter. AN.NA without qualification is also used and has a low value comparable to AN.NA *abāru*. In this context the expensive metal is taken to be tin, the cheap one lead. This also seems to be the case in Middle Assyrian legal texts, where fines are given in terms of AN.NA (*annaku*), and its silver value ratio runs as low as from 180:1 to 240:1, when in the Old Assyrian period it had run as high as between 10:1 and 14:1 (Muhly 1980: 38 ff.; Freydank 1982: 74 n. 27; Müller 1982: 272). There are also Middle Assyrian cases where bronze is twice as expensive as *annaku*. Yet still, in the Middle Assyrian

period, as before and after, in texts describing the manufacture of bronze AN.NA (*annaku*) is most unlikely to be lead rather than tin (Müller 1982: 277 n. 40). Then again, when quantities of *annaku* are as large as they are in some Middle Assyrian texts from Tell Rimah, as much as 50 mana on some occasions (Wiseman 1968: 175–6), it is not easy to understand why a merchant should deal in such large quantities of lead (rather than tin) in a relatively small rural town. AN.NA. BABBAR has been translated by some scholars as 'good-quality' tin (Landsberger 1965: 295; Muhly 1980: 32–4). As 'white tin' it has been suggested it might be metallic tin; but then *annaku* would always represent the oxide (cassiterite), which seems unlikely (cf. Muhly 1980). In Müller's (M. 1982: 272) words, 'the adventures of the vocable *annaku* haben . . . noch kein Ende gefunden'.

At Nuzi in the fifteenth century BC 'lead is relatively rare in comparison with bronze and copper, and is found only in needles and long headless pins' (Starr 1939: 470). A T-shaped ingot or clamp of lead was found in a level of the temple courtyard at Tell Rimah dated to the earlier thirteenth century BC (Oates, D. 1965: 75). What is meant at Assur by textual references to the 'lead courtyard' in the temple of the god Assur is not clear, though excavation revealed nothing to indicate that it was paved with the metal (*CAD*, s.v. *abāru*; Landsberger 1965: 287 n. 12).

In the Neo-Assyrian period lead is only sporadically reported in excavations. At Nimrud Layard (1853: 357) found 'a mass of lead melted by the fire, for embedded in it was the iron head of a hatchet'. At Khorsabad the American excavators refer only to 'plain fragments of lead, impossible of identification' (Loud and Altman 1938: 16); but one of the inscribed foundation plaques found by Place was lead (Ellis 1968: 194). The British Museum has a bronze gate-socket set in solid lead, from Birs Nimrud, probably of the Neo-Babylonian period (BM 104419; Reade 1986^a: 110). Lead was sometimes used in adjusting the weight of bronze lion-shaped weights, bearing the names of Assyrian kings. One example (BM 91223) has a rectangular cavity in the base filled with lead, whilst others do not (BM 91222, 91224). A Neo-Assyrian dedication, either by or for a king, now in the British Museum, is cut on four faces of a broken strip of lead (18 mm. high; 4.5 mm; 36 mm. long as extant) differing in shape from the usual foundation plaques (Lambert, W. G. 1968–9).

The role of lead in buildings where baked brick was the primary medium, and in a region where bitumen was readily available, was naturally restricted. Even in Assyria, where advanced stone construction was not uncommon, architectural uses of lead are not yet as evident as might be expected, though it was used in fixing sculptured slabs together. Nylander (1970: 63 ff.) has examined the history of clamps in Mesopotamian

stonework. The simple dovetail clamp, working horizontally, was mostly not of molten lead, but rather of wood or else prefabricated lead, bronze, or stone inserted into a cutting, as at Babylon (Buddensieg 1912: fig. 3; cf. also Nylander 1970: 64 n. 160 with references to Nimrud, Assur, and Khorsabad). A clamp combining vertical with horizontal effect is only evident in a developed form, of molten lead, at Khorsabad, where it may have been one of the architectural features introduced into Mesopotamia from Syro-Anatolia in the ninth to eighth centuries BC (Nylander 1970: 65 n. 162). A new type, the double clamp, reached the Near East from western Anatolia in the sixth century BC and became part of Achaemenid clamping techniques. Nylander (1970: 66 n. 165) has commented critically on certain, regularly quoted, classical references:

Herodotus (I: 186) and Diodorus (II: 8) mention the use of clamps, embedded in lead, in the Euphrates bridge in Babylon of the latter half of the seventh century BC (R. Koldewey, *Das Wiederaufgestellte Babylon*, 193 ff.). Nothing has been found of the stone materials of this bridge. It is thus hard to know whether this was true or whether the Greek writers make anachronistic references to a construction practice common in their own day (see Thucydides I: 93, 5). Nebuchadnezzar used clamps, though wooden, in the north wall of the Kasr in Babylon (*MDO-G* 48 (1912), 10 ff., fig. 3).

A most unusual use of lead, to create a composite statuette, is illustrated by finds at Toprak Kale near Van in Urartu. For this lead was cast in sheet with a network of tiny square cavities to take inlays of glass or faience and ivory to serve as the garments, whilst other pieces are partitioned into wavy strands and circular curls (Barnett 1950: 16; pl. XIII:3; Mitchell 1983). It is essentially a lead-tin alloy (Enderly and Lane 1985). Lead as a medium for writing tablets was used in the Neo-Hittite states of Syria (Bossert 1951); whether this was also the case in Mesopotamia is a more open question (cf. Lambert 1968–9: 64).

(4) Select analyses

The extent to which ancient metallurgists were able to extract silver from lead is still uncertain. By the Hellenistic and Roman periods at least they were capable of extracting silver from lead down to a level of about 0.01 per cent residual silver. As there were galena deposits worked in antiquity that had natural silver contents of less than 0.01 per cent, it is not valid to argue that all ancient lead objects containing little silver (of the order of 0.00x per cent) must necessarily have been de-silvered. Aitchison (1960: i. 185) cites the following approximate standards for de-silvering: Roman period: 0.01 per cent; later Medieval period: 0.008 per cent; modern practice: 0.002 per cent.

1. *Ur: Late Prehistoric/Early Dynastic I:*

Padgham (Woolley 1934: 295) undertook 'two

assays of a leaden tumbler from a grave of Jamdat Nasr date, which each gave a quantity of silver amounting to 0.07 per cent'. Reported in Woolley 1956: 165, as '100 grams lead gave 0.0255 grams silver, approximately 9 oz silver to the ton'.

2. *Ur: Early Dynastic III:* 'some sheet lead . . . shapeless and pierced with holes due to decay' (Woolley 1934: 148). Desch analysed it as: Pb: 98.29 per cent; Cu: nil; Sn: 1.30 per cent; Fe: 0.41 per cent; Ag: trace; Au: nil; (Woolley 1934: 293). Padgham (Woolley 1934: 295) reported that a '50-gramme sample of lead of the Cemetery period, from PG 55, contained an unweighable amount of silver'.
3. *Tell al-Ubaid: Temple: Early Dynastic III:* Lead from stag's head: Scott reported (Hall and Woolley 1927: 38): 'the lead . . . from the setting of the base of the antlers was pure lead, analysis indicating at least 99.8 per cent . . . No silver or copper could be detected'; but Friend and Thorneycroft (1929) reported it as containing 0.0131 per cent of silver.
4. *Tell ed-Der: Old Babylonian:* Plaque: Cu: n.d.; Sn: n.d.; Pb: 99.5 per cent; Sb: 0.1 per cent. Disk: Cu: n.d.; Sn: n.d.; Pb: 99.3 per cent; Sb: n.d. Lerberghe 1984: 117.
5. *Assur: Foundation plaque (Ass. 22804) of Tukulti-Ninurta I (c. 1243–1207 BC) from the Ishtar Temple at Assur (Andrae 1935: 45).* Pb: 99.60 per cent; Cu: 0.14 per cent; Sn: 0.15 per cent; Fe: 0.06 per cent; traces of antimony and arsenic.
6. Friend and Thorneycroft 1929: 105: reported *Neo-Assyrian* lead as having 0.11 per cent silver.

The publication of lead-isotope determinations for Near Eastern artefacts and ores has just begun in earnest, particularly linking Mesopotamian artefacts to lead sources in Anatolia. Until details are agreed and methods of presentation of results has been standardized, it is only appropriate to refer the reader to the emerging bibliography of report and discussion (cf. Yener *et al.* 1991; Sayre *et al.* 1992; Gale, N. H., *et al.* 1992).

(vi) NICKEL

Nickel (Ni), like zinc, was unknown as a metal in antiquity. It was first discovered and separated in Europe in the middle of the eighteenth century AD (Aitchison 1960: ii. 482–4). Nickel occurs as a trace element in objects manufactured in Mesopotamia; what little evidence there is at present indicates higher levels in artefacts from the south than from the north. As it was so frequently detected in the 1920s and 1930s in the

third-millennium BC artefacts analysed by the Sumer Copper Committee, they assumed a copper ore containing nickel as the source of the raw material and devoted considerable research to identifying it. They accumulated a wide range of useful data and eventually suggested that the Jebel Ma'aden deposit, inland from Sohar, in the Wadi Ahin, Oman, had been the primary source of Sumerian copper in the third millennium (Peake 1928). Generally speaking, renewed research into this problem in the last ten years has endorsed this view (see p. 247). As addition of 1 per cent nickel to copper improves the alloy's basic strength by a factor of two and increases the work-hardening rate of the alloy, it is possible ancient craftsmen had appreciated empirically the value of ores with significant nickel inclusions.

The role of nickel in the identification of meteoric iron has been a matter of debate in recent years. It occurs in terrestrial iron ores to a degree sufficient to confuse any distinction made on the basis of nickel percentages alone (see Iron here).

(vii) TIN

(a) *The metal and its uses:*

Tin (Sn) does not occur in nature in metallic form, but in the combined state as a mineral, either the oxide (cassiterite or tin stone) or the much less common sulphide, combined with sulphides of copper and iron (stannite or tin pyrites). Tin minerals are only formed *in situ* where the mineralization is genetically related to granite or to the granite family of rocks, though not all such deposits contain tin. The oxide occurs both in veins and lodes occasionally in association with copper, and alluvially as debris from disintegrated rocks bearing vein ore. Stream tin was always a particularly rich source of the ore when veins of tin running through granite may well have been inaccessible to miners and prospectors. In his review of the ancient Near Eastern terminology for tin, Muhly (1973: 178) noted 'that tin has no connection with mines, mining, or with any verb that refers to a mining operation'. Alluvial tin normally appears as clean grains or pebbles free from any gangue. Only its weight, not its form or colour, suggests that it is a metallic compound. It may have been initially discovered as part of gold-panning operations (Lucas 1962: 255), though, in Mesopotamia at least, gold was used before there is any evidence of the local use of tin. Even if a stream once bearing tin has been exhausted of the mineral, the pegmatites of the source should still be there for modern geological identification. They are the main key in modern searches for potential ancient tin sources in such likely regions as Turkey, Iran, and Afghanistan.

The complex problem of the meaning of the Akkadian word *annaku* was considered in a paper of funda-

mental importance by Landsberger (1965) and, more recently, in response to misleading metallurgical arguments, by Muhly and Wertime (1973). Although 'tin' was its primary meaning, the possibility that it was from time to time applied to 'lead', is further considered here on p. 295. In so far as this section is concerned, any reference to textual evidence for tin is to the word *annaku* (CAD A(II): 126; AHw 49).

In Mesopotamia, as elsewhere in antiquity, tin was used primarily for alloying with copper to make bronze. At times it was used alone or, passing by weight, as currency, whilst texts refer to tin 'utensils', tin foundation tablets, tin beads and bracelets. As a pure metal tin has drawbacks, since objects cast with it have a tendency to break and it has to be worked slowly to avoid cracking. Tin's earliest regularly recorded appearance in the form of the alloy bronze falls in Mesopotamia some time in the first half of the third millennium BC at the time of the 'Y' Cemetery at Kish (Early Dynastic) (see also Bronze). By the middle of the third millennium copper bowls, found at Tell Asmar, were being dipped in tin, presumably for decorative effect (Muhly *et al.* 1980: 254) and tin was being used as a solder for silver lugs on a copper bowl at Ur (Collon 1982; Craddock 1984). It is quite a good solder for silver, copper, and its alloys. Craddock has suggested this might have been its earliest use, before alloying with copper.

(b) *The pattern of trade and the identification of sources*

(1) *Ancient textual references*

Few questions in the economic history of the ancient Near East have been so much debated as the ultimate origin of the tin used by local bronze industries. Since Muhly (1973; 1976) thoroughly reviewed the textual evidence no decisive new documentary evidence has been published. The 'archaic' texts of the early third millennium BC from Ur distinguish copper from bronze for the first time. In the Ebla texts of the third quarter of the third millennium BC tin is recorded passing through *Dilmun* (Waetzoldt 1981: 366–7). Gudea, c.2100 BC, identified *Meluhha* as the source of his tin (Falkenstein 1966: i. 48; Cylinder B: XIV). Mention of tin in the epic poem 'Enki and the World Order', cited by Muhly (1973: 309), appears not in fact to refer to *Meluhha* as a tin source. A Sumerian hymn to the god Ninurta mentions the copper and tin of *Magan* (Cohen, M. 1975: 28, line 144). Whether poetic descriptions of *Aratta* stating that 'its soil is tin-stone' indicate a source region is unclear (Cohen, S. 1973: 11, 17–19). A text of Shu-Sin (c.2037–29 BC) refers to tin captured as booty in a campaign against *Zabshali*, a neighbour of Elam somewhere deep into Iran (Sollberger and Kupper 1971: 152; III A4e), and perhaps also to tin from *Anshan* (Davidovic 1984: 186ff., 200). References

to various 'tin mountains' in Sumerian literature, generally to the east of Mesopotamia, are too vague to offer any reliable information on sources (cf. Muhly 1973: 288 ff.). Yet, if assessed in the light of evidence from the Mari texts of the earlier second millennium BC, they do not entirely lack credence.

Tin procurement at Mari was highly organized (Dossin 1970; Villard 1984: nos. 555–6). It travelled in the form of ingots weighing about 5 kg. each. It reached Mari by donkey caravan from Susa (Susiana) and Anshan (Elam) through Eshnunna (Tell Asmar). The relevant records contain the names of Elamite rulers and Elamite agents (Heltzer 1989). Tin was transmitted westwards, both as an item of royal gift-exchange and as a trade commodity. No documents yet published indicate that tin was available in Syria in the third or earlier second millennium BC from sources close to hand.

This is the written evidence that reinforces the view that some at least of the tin reaching Sumer came from a considerable distance to the east, either by land through southern Iran or by sea up the Gulf. In view of the recurrent hostilities between Elam and Sumer in the third millennium BC, the land route may well not always have been open. As tin is so far rarely reported in analyses of base-metal objects from highland Iran in the third millennium BC, though it is well attested at Susa at this time (Berthoud and Francaix 1980; Malfoy and Menu 1987: 360–2), it may well often have travelled by sea up the Gulf from distribution centres in the Indus Valley. In the Old Babylonian period tin was shipped through *Dilmun* (Leemans 1960: 35), as it had been a millennium earlier to judge by references in the Ebla texts.

The pattern of the tin trade west of the Zagros in the earlier second millennium BC is reasonably clear from texts. Tin, reaching Assur from somewhere in the east, was traded into Anatolia in the Old Assyrian period:

What we can say with certainty is the following: the texts available (i.e. from Kültepe (*Karum Kanesh*)) refer to exports from Assur to Kanesh of ca. 17,500 pieces of textile and about 13.5 tons of tin. This documentation accordingly covers part of the total exports over a period of some 40–50 years. A very conservative estimate of the total would be at least 100,000 textiles and 100 tons of tin.

(Larsen 1982: 40)

Veenhof (1988: 256) has summarized the information on tin prices in the Old Assyrian trading records, but comparisons are difficult (see below).

In the Old Babylonian period Sippar was re-exporting tin received from Susa, either by way of Der or Eshnunna (Tell Asmar), or Larsa, to Mari (see above). Tin is also known to have been passing through Tell Shemshara (ancient *Shusharra*), which controlled the Sungasur gorge leading into the Rania Plain from north-west Iran (Laessøe 1959). Thence it is likely to

have passed through Erbil and Kirkuk into the Diyala Basin. For the Middle Assyrian period there is textual evidence from various sites in the north (Assur, Tell Billa, Tell Rimah) and in the east (Nuzi), all indicating a relative abundance of tin at that time (cf. Muhly 1973: 290; Saggs 1968). Only the texts from Tell Rimah give any indication of the metal's source: 'brought from *Nairi*' (TR 3019; Wiseman 1968: 183). This name embraces the region between the Upper Euphrates and Lake Van (perhaps extending further east towards Lake Urmia), later known as Urartu. Hittite inventory texts of the thirteenth century BC record tin from *Kiz-zuwatna* (Cilicia) (Kořak 1982: 195). These references, particularly, have now to be considered in the light of archaeometallurgical research in the Taurus mountains (see below).

Jankowska (1969: 265), in her review of the evidence for tin in Neo-Assyrian booty and tribute lists, concluded that:

Although any definite conclusions may be hazardous owing to the scarcity of specific figures in the annals, we may still mark out *Bit-Zamani* as having the greatest mentioned reserves of tin (*annaku*), all other districts being incomparably poorer in this respect . . . Next to *Bit-Zamani*, the *Lage* of Hammath are mentioned as being the most considerable reserves of tin . . . the locality ranking third among those richest in tin, namely *Bit-Halupe*, lay midway between *Lage* and *Bit-Zamani*.

Bit-Zamani, significantly, occupied much of the western part of the earlier *Nairi*-lands.

There are so many uncertainties in establishing a reliable comparative series of prices for tin in Mesopotamia from the late third to the first millennium BC that existing data do not contribute anything of substance to attempts to understand the dynamics of the tin trade. Powell (1990: 87), in a recent analysis of long-term price fluctuations in general in Mesopotamia, has challenged the prevalent view that tin was excessively cheap in the Late Bronze Age (Middle Assyrian period) and therefore much more abundant than it had previously been (contra Muhly, in Wertime and Muhly 1980: 47 ff.). Moreover, Varygas (1986) has forcefully criticized Heltzer's interpretation of the evidence for metal values in Ugaritic texts, which involved postulating a tin source closer to Nuzi than to Ugarit, where in his view tin was more expensive (Heltzer 1978: 108–11). Varygas (1986: 111) points out that in fact the prices of tin at Nuzi and Ugarit were closely comparable.

(2) *The evidence of geology*

In the close study given to potential tin sources in recent years, the old literature has been thoroughly scrutinized and tested against the most reliable modern geological evidence. Although this examination has left much less room for manoeuvre than was once the case, as the

possible sources for ancient tin have been very considerably narrowed down (cf. Franklin *et al.* 1978; Muhly 1985), modern geological information is neither comprehensive enough nor infallible enough to remove all doubts and confusions without new and specific field research in potential source areas:

Eastern sources. Although geological circumstances in isolated parts of modern Iran are suitable for the occurrence of tin, possibly once yielding alluvial tin as they may have yielded alluvial gold (Muhly 1973: 260–1; Muhly and Wertime 1973: 119), hard evidence for tin there is still elusive. Tin is not mined in Iran today and there is no medieval evidence for its exploitation locally (Allan 1979: 27 ff.). Muhly (1976: 98) notes a tin source in the area to the south of Birjand, in the Dasht-e Lut, reported by the Geological Survey of Iran. It is hardly surprising, then, that attention has increasingly concentrated on possible ancient tin sources east of Iran. Worked tin deposits certainly exist in the region south-west of Samarkand and along the Kok-Su river in Turkmenia, with associated artefacts suggesting exploitation by the third and fourth centuries AD, if not earlier (Ryzanov 1979; Crawford, H. E. W. 1974). However, analytical evidence (Terekhova 1981: 319) indicates that tin-bronze was not used in this area until the late third or earlier second millennium BC.

Strabo (xv. ii. 10) referred specifically to Drangiana, the modern region of Seistan in south-west Iran (into Afghanistan) as a source of tin. Muhly (1973: 260) associated this directly with Gudea's report of receiving tin from *Meluhha*. It is now known that Afghanistan has two zones of tin mineralization. One embraces much of eastern Afghanistan from south of Kandahar to Badakhshan in the north-east corner of the country (Shareq *et al.* 1977); the other lies to the west and extends from Seistan north towards Herat (Cleuziou and Berthoud 1982), the valley of the Sarkar river, where the hills are granitic. Here tin appears commonly as cassiterite, frequently associated with copper, gold, and lead, and in quantities sufficient to attract attention in antiquity. Bronzes at Mundigak, and the controversial Snake Cave artefacts, indicate local use of bronze by at least the third millennium BC (Shaffer 1978: 89, 115, 144). A number of scholars have pointed out the possibility that tin arrived with gold and lapis lazuli in Sumer through the same trade network, linking Afghanistan with the head of the Gulf, both by land and sea (cf. Ratnagar 1981: 39 ff., 70 ff.; Stech and Pigott 1986: 41–4). It is too early to assess the view that lead-isotope determination for objects from Troy IIg may indicate a possible trade-route across the Black Sea for copper, tin, and gold coming from sources in Central Asia (Muhly *et al.* 1991: 218–19).

It seems unlikely that tin sources in India or Pakistan serviced the metal industries of Mesopotamia to any marked degree, if at all. Tin's use in the Harappan

period is well documented, but it is not yet established which, if any, of the tin sources in the region provided the metal (Hegde 1978; Chakrabarti 1979; Muhly 1985: 283; Stech and Pigott 1986: 43–4). Sources further to the east, in Thailand, now seem much less likely, particularly if the Bronze Age there was not as precocious as was claimed a few years ago (cf. Muhly 1988: 12–13).

Western and north-western sources. The eastern desert of Egypt has yielded evidence for significant deposits of alluvial cassiterite accessible in antiquity in an area exploited for other mineral resources. But there is, as yet, no evidence for its exploitation in antiquity. Bronze does not appear to have been produced regularly in Egypt until the earlier second millennium BC (Muhly *et al.* 1980; Muhly 1985: 283). Long-standing advocacy of tin sources in Lebanon and Syria has not survived modern scrutiny (Muhly 1973: 258) and the geological structure of Cyprus is said to be inappropriate for tin (cf. Muhly 1985: 277).

It has long been thought that the most likely source of tin within the Near East itself was Turkey, on grounds both of geological probability (cf. Jesus 1978: 101; 1980: 51 ff.) and of the early production there of tin-bronzes (Stech and Pigott 1986: 52–6). However, as virtually all the present evidence for bronze artefacts before Early Bronze II, in the middle of the third millennium, in Turkey involves debatable archaeological contexts for the objects in question, the archaeological argument is still of equivocal significance (cf. Hall and Steadman 1990: 224–7). Recent intensification of field research into possible Anatolian tin sources has revived claims for local tin deposits, whilst at the same time provoking sharp dissent about the validity of the geological and metallurgical evidence cited (cf. Muhly *et al.* 1991; Hall and Steadman 1991). Belli (1991) has surveyed the written sources for tin in Anatolia from about 2000 BC through Ottoman times, concluding that it was always imported.

A rich tin deposit has been identified geologically at Madenbelenitepe, near Soğukpınar south of Bursa, that some scholars believe was exploited in the Early Bronze Age. This has been forcefully denied by others (Muhly *et al.* 1991: 215; Belli 1991). After detailed investigations Yener and her colleagues (1986; 1987; 1989; 1989^a; 1992) have proposed that tin deposits existed and were exploited in the third millennium BC at Bolkardağ, Kestel-Sarıtuzla, and Kuruçay in south-east Turkey, where excavations at Tarsus and Mersin produced some bronzes of this date, though not to an extent that would necessarily indicate a local abundance of tin (Hall and Steadman 1991: 227). Willies (1990; 1992) has argued that tin (in the 0.1–1 per cent grade) was being mined at Kestel, perhaps also gold, in the Early Bronze Age, as indicated by Carbon-14 datings and pottery sherds relating to the mining activity.

Muhly *et al.* (1991; Pernicka *et al.* 1992) proposed that it was a source of gold (and lead). Hall and Steadman (1991) argue that, due to their high iron and lead content, the complex polymetallic ores at Bolkardağ were not processed for tin, more probably for lead and silver. Both groups of scholars contest the view of Yener and her colleagues that a significant source of tin, exploited by the Early Bronze Age, existed in the region of Tarsus. However, as Yener's evidence increases, her case gains strength. If the information from old mine workings is at times of equivocal significance, that from local processing centres is not.

At Göltepe, two kilometres from the Kestel mine on a prominent rocky outcrop, Yener has excavated a settlement site of the mid- to later third millennium BC that produced stone moulds, innumerable ground stone tools for ore dressing (like those recovered at the adjacent mine), ore, slag, and crucible fragments. It is evidence of this kind that in the long run is most likely to provide well-dated indications of what metal or metals were being processed there. Vandiver and Yener (1992) have now reported that tin was being processed in crucibles found at Göltepe.

The question of tin sources in Transcaucasia and Caucasia, where again there seems to be no firm geological evidence for its presence, is complicated by reports of uncertain value about ancient metallurgical operations at Metsamor. This is a site on a large, low outcrop of rock in the Araxes Plain upstream from Erevan in Soviet Armenia (Mkrtichian 1967). The original report (cf. Burney and Lang 1971: 68; Pigott 1981: 74 ff.) suggested that cassiterite supposedly found at Metsamor might have been recovered from alluvial deposits near Paleoarakas, at the foot of Mount Aragats (Alagöz) to the north, where a recent geological report was said to confirm the presence of tin, gold, and silver. Tin-bronzes do not appear until the local Late Bronze Age; previously arsenical-copper alloys were the norm. Selimkhanov, who has conducted extensive research on the composition of early copper alloys in Azerbaijan, has more recently argued that reports of local tin sources in the Caucasus are without geological confirmation (Selimkhanov 1985).

It is thought unlikely that well-known sources of tin in Europe were drawn upon by Near Eastern workshops until the Iron Age. Even then it is far from clear whether or not tin from the west Mediterranean or further afield in Brittany or Cornwall reached Mesopotamia through Phoenician trading networks (cf. Ezekiel 27: 12). The role played by tin from the Erzgebirge in central Europe in supplying local industries and those further afield to the east and south-east down the Danube and by sea through the Aegean in the late third and earlier second millennium BC remains controversial, when it is not entirely dismissed (cf. Muhly 1985: 288–9).

(c) Objects

Objects of tin are easily confused by eye with those of silver, and it may well have been used for personal ornaments more often than is currently apparent when so little metalwork has been properly analysed. The caps of an Early Dynastic III lapis lazuli pinhead from Kish are tin, not silver as inspection might suggest (M. Müller-Karpe: personal communication). Seven personal ornaments from three children's graves (nos. 148, 158, 227) of the nineteenth century BC at Tell ed-Der in Babylonia are made of tin (Lerberghe 1984: 107–8, pl. 27: A1–7). The analysis of one bracelet indicated a good quality product of 91.4 per cent tin, with a little copper (0.38 per cent max.) and antimony (0.27 per cent max.) and no lead.

(d) An interim assessment of the 'tin problem'

At present the available written sources from the third and earlier second millennium BC all indicate tin reaching Mesopotamia either by land through Iran in a trade often controlled by Elamites, or by sea up the Gulf where *Dilmun* controlled distribution northwards. This tin was then traded westwards into Syro-Palestine and Turkey. Afghanistan is currently identified as the most likely source of this tin. Whether tin sources were also being exploited in Iran at this time is unknown. It is not until the second half of the second millennium BC that texts, from Hittite and from Middle Assyrian

towns, name parts of Turkey, *Nairi* (eastern Turkey), and *Kizzuwatna* (Cilicia) as sources of tin, though with no certain indication that the metal itself was then mined there. Current research on possible tin sources in the Taurus mountains, exploited as early as the third millennium BC (see above), begins to suggest that these records may indeed refer to tin sources in Turkey.

This remains a case when absence of evidence from texts should particularly not be taken as evidence of absence, since the periods to which the very few surviving mentions of tin refer are relatively short and the places involved few and scattered. There is still plenty of room for relatively minor occurrences of tin to have been sporadically exploited and to leave no trace in the written record.

(viii) ZINC

There is no evidence, artefactual or textual, that zinc (Zn) as a metal was known in Mesopotamia. Its role, alloyed with copper, is treated here under Brass (see p. 254). This metal was not separated in Europe until the eighteenth century AD (Aitchison 1960: ii. 480–2). Its role, as a trace element, in the copper used in Mesopotamia, is discussed elsewhere (see p. 248; cf. Berthoud *et al.* 1982: 50–1). There is a possible reference in Strabo (XII. i. 56) to the production of zinc in antiquity in Anatolia by a kind of distillation process (cf. Waldbaum 1983: 26–7; cf. Craddock (ed.) 1990).

THE BUILDING CRAFTS

THIS CHAPTER IS CONCERNED WITH BUILDING materials, the basic techniques used to manipulate them, and the uses to which they were put. It is not a study either of architecture or of building design and execution. Although many of the standard histories of art and architecture in the ancient Near East deal in passing with architecture, it is only recently that systematic studies have been devoted to it as an applied as much as a fine art. Aurenche (1981) has provided a richly detailed review of the evidence for domestic architecture in the Near East as a whole during prehistory. Kubba (1987), who is a trained architect, has written a series of essays on aspects of prehistoric architecture in Mesopotamia that are particularly useful when his professional expertise is directly involved, not least in a cogent and penetrating critique of many aspects of current ethno-archaeology in relation to Near Eastern domestic architecture in antiquity (Kubba 1987: 84–90). The major monuments of the historic period in Mesopotamia, the palaces and temples, have been catalogued and formally analysed by Margueron (1982) and by Heinrich (1982; 1984), with Tunça (1984) providing a specialist study of temple architecture in prehistoric and early historic times. E. Salonen (1970: 35–58) has analysed the terminology for builders and their craft skills, whilst A. Salonen (1961; 1972) has reviewed that for doors and gates and for bricks and brick construction. Damerji (1987) has dealt with the architecture of doors and gates from the archaeological evidence.

1. Bricks and Brickmaking in Mud and Clay

And now I must describe how the soil dug out to make the moat was used, and the method of building the wall. While the digging was going on, the earth that was shovelled out was formed into bricks, which were baked in kilns as soon as sufficient number were made; then using hot bitumen for mortar the workmen began by revetting with brick each side of the moat, and then went on to erect the actual wall. In both cases they laid rush-mats between every thirty courses of bricks.

Herodotus, i. 179 (of Babylon)

Mesopotamia is a land of mud and mudbrick architecture. From the earliest phase of settlement in the region it was appreciated that the soils available there were generally excellent for building purposes. They provide a very acceptable substitute for stone as a building material when moulded and exposed to the intense summer heat of the plain (it can reach 50 °C in Babylonia in the shade) for an appropriate length of time, or better still when kiln-fired. Once bricks had been developed, it became general practice to build the mass of a building in sun-dried bricks, whilst facing the lower courses and paving the floors with kiln-fired bricks. In a country short of wood for fuel baked bricks were a luxury, commonly used only where necessary to protect the unfired from erosion by wind or water. There may, however, have been a ritual preference for sun-dried mudbrick in some temple construction from early times (cf. Koldewey 1914: 55).

This preference for brick is not surprising in Babylonia where good building stone is generally absent, but its equal popularity in Assyria is remarkable, since suitable building stones were available close to major settlements or within reach by water transport. 'With stone so plentiful at no great distance, its comparatively sparse use in buildings at Dur Sharrukin [Khorsabad] can be attributed only to the architects' failure to recognize its possibilities or their desire to stick fast to tradition' (Loud and Altman 1938: 15). It should also be said that timber was more readily available in the north to fire kilns whilst in the south, where fuel was scarce, *terre pisé* and sun-dried bricks had distinct economic advantages. Mudbrick is very adaptable and easy to use. It is also remarkably durable when properly protected against the weather.

Soils are commonly described by a classification based upon grain size: clay, gravel, sand, and silt. Most natural soils are a mixture of two or more of these with some organic material, partially or fully decomposed. Philip (1968) has given quantitative mineralogical characterization of the light and heavy fractions of clays from Ramadi and Falluja in Iraq. Apart from clay minerals, the light fraction consisted of quartz, chert, opal, chlorite, muscovite, and calcite. The Euphrates samples contained more chlorite and mica than those from the Tigris. Iron ores, epidotes, amphiboles, and pyroxenes constituted more than 80 per cent of the heavy fraction

Partial Chemical Compositions of Clays and Sherds from Babylon and Kish

	Clay ^a	Sherds ^b	Brick ^c	Bodies ^d
SiO ₂			47–52	50 ^e
Al ₂ O ₃			14.3–17.7	15–16
Fe ₂ O ₃	5.3–6.2	6.0–7.4	5.7–7.7	7–9
CaO	13.0–17.2	15.6 (Kish sherds)	16.3–17.5 (21.8)	16–18
MgO			5.9–7.1	5–6
Na ₂ O	1.2–2.1	1.8–2.3	1.7–2.4	1.5–2
K ₂ O	1.4–2.6	1.5–1.9 (1.1)	1.7–2.2	1

^a Neutron activation analysis. Brookhaven National Laboratory. Babylon Clays VZM 189–192. Kish Clay VZM 183.

^b Neutron activation analysis. Brookhaven National Laboratory. Babylon Sherds DBBB 1–6 (CaO not determined): see Ref. 9. p. 74. Kish sherds VZM 184, 185.

^c Electron beam microprobe analysis, Smithsonian Institution. Five glazed bricks from the Ishtar Gate at Babylon.

^d Isoprobe and optical emission spectrometry, Research Laboratory for Archaeometry and the History of Art, Oxford, England. (Ref. 8. p. 31. Table 1.)

^e Estimated by difference.

Source: Matson 1985: 65.

(cf. Nijs 1986). X-ray diffraction was used by Berry *et al.* (1970) to study suspended river sediments; those from the Euphrates revealed montmorillonites (smectites) to be dominant with chlorite. There was also some illite and kaolinite present.

There is no one chemical composition. Matson (1985: 65) has tabulated a few, incorporating some results obtained on pottery in Oxford (Hedges and Moorey 1975). (see above).



Fig. 19. Detail from the 'Ur-Nammu Stela', found at Ur, showing the King Ur-Nammu (c. 2112–2095 BC) officiating at a temple-building ceremony. He carries the tools of a builder: axe, basket, builder's dividers, ladle for bitumen mortar, and a flat wooden trowel (after Woolley 1974: pl. 41a).

As Matson (1985: 66) remarked, 'The high iron, alkaline, earth, and alkali contents are not unexpected in light of the clays' sedimentary history and observed physical properties. Similar results were obtained in a quantitative analysis of Tigris River clay from Seleucia-on-the-Tigris.' Such clays required tempering materials for brickmaking. Chaff, readily available, was used

most often, as sufficient sand would have been difficult to obtain. Analyses of bricks from various southern sites indicated that they contained primarily silt, less clay, and little sand, some of it added, and an organic binder like straw (Torraca *et al.* 1972: 262–4).

In the earliest phase of the use of mud to create walls the material was formed by hand without artificial aids (moulds or forms) in a manner still familiar to the inhabitants of the area:

In Iraq, *tauf* [*terre pisé*] walls are still used, generally as garden or courtyard walls, and forms are not employed . . . A *tauf* wall is built of a mud mix of sufficient fluidity so that the lowest 'course' may be molded with the builder's hands, with a vertical face on either side, to a height of about 3 or 4 inches without slumping. Having laid the first 'course', the builder simply waits a day or so for complete sun-drying before he adds the second 'course', after which he must wait again, and so on. The mud mix contains straw or grass to prevent cracking, just as does that used for preparing the later sun-dried mudbricks (*libn*).

(Braidwood and Howe 1960: 40; cf. Nissen 1968: 108)

In strictly chronological terms such *terre pisé* preceded brick in the Near East from the first permanent structures at sites like Jarmo; but in many cases the two were used together from an early date. In reality, as Aurenche (1981: 54 ff.) found in his comprehensive survey, distinctions are often difficult to draw in the earliest stages. Both the nature of the evidence, in itself confusing (see below), and the recurrent inadequacies of publication confound all attempts to plot the emergence of bricks, or indeed the use of wooden forms or casings in the construction of primitive mud walls. As the Russian excavators pointed out at Yarim Tepe I, 'it is of interest that its foundations are made up not only of clay layers (*tauf*) which preceded bricks, but also of blocks, brick prototypes, rectangular in shape and rather small and equal in size' (Munchaev and Merpert 1973: 6; cf. Merpert and Munchaev 1987: 20–1).

Some of the earliest walls to be described as 'brick-built' by their excavators may, in Aurenche's (1981: 58, fig. 9) view, simply be of *pisé* constructed with the help of a wooden form (indeed, the strict meaning of the term *pisé*) and strips or lumps of mud. In his assessment, 'moulded *pisé*' appears first at such sites as Choga Mami, Eridu, and Tell es-Sawwan in Mesopotamia in the second half of the sixth millennium BC (cf. Aurenche 1981: table 4, map 5). In such a procedure the 'bricks' could be formed in place as the 'courses' were laid; but as early houses are more widely and carefully excavated (and precisely described in reports) evidence is accumulating for the use of *pisé* composed of lumps or slabs of clay not unlike true bricks. The size and shape of such lumps are often hard even for the meticulous excavator to distinguish, since they were not dried before use so merge one into another in a wall (cf. Hassuna: Lloyd and Safar 1945: 273; Umm Dabaghiyah: Kirkbride 1973: 206).

(i) THE EMERGENCE OF MUDBRICKS

Nemrik, a pre-pottery Neolithic village 55 km. north-west of Mosul, now provides the earliest architectural sequence for northern Mesopotamia. In the oldest, ninth-millennium settlement, *tauf*-walls were built of variously sized 'blocks', 20 cm. thick on average. In the eighth-millennium phase 'the walls . . . consisted of a single thickness of cigar-shaped sun-dried mudbricks, measuring 51 × 12 × 6 cm. on average, and closely resembling bricks known from much later Mesopotamian sites such as Choga Mami and Oueili' (Kozłowski and Kempisty 1990: 353, pl. 1). In the seventh millennium BC walls were built either entirely of sun-dried mudbricks or of a combination of bricks and pack clay (*tauf*). These houses had substantial built-in fittings and certain parts of them appear to have been set aside for craft activities. Hand-shaped sun-dried mudbricks (and possibly some moulded examples: Aurenche 1981: table 5, map 6), appeared in settlements on the line of the Euphrates, at places like Bouqras and Ramad, by at least the second half of the seventh millennium BC.

Primitive bricks may be observed in the next thousand years at sites like Matarrah, Shemshara, Umm Dabaghiyah, and Yarim Tepe I in northern Mesopotamia. Moulded sun-dried mudbricks, whatever the precise stage their earliest development, begin to be widely evident in the Hassuna/Halaf/Samarra/Ubaid I cultural horizons in the second half of the millennium BC, in north and south. The mudbricks of Ubaid I and the early levels at Tell el-Oueili in the south are of the cigar- and loaf-shape well known in Khuzistan, where they were already employed at Choga Bonut. (cf. Dollfus 1987: 183 ff.) 'Archaic I', and at Tell es-Sawwan and Choga Mami (Oates, J. 1987). At Oueili there appears to be continuity in their use through to Ubaid 4. This use of

loaf-shaped bricks is best taken as an evolutionary stage in the development of building in mudbrick rather than as a necessary sign of cultural unity.

The basic limitations of an architecture of *terre pisé* had a profound long-term effect on the builders of ancient Mesopotamia. The laws of gravity and the quality of the workmanship in foundation setting and in ramming technique determine the relationship between height and width in packed earth walls. *Terre pisé* tends to be unstable. Certain fundamental inhibitions survived the introduction of pre-dried and standardized bricks, which made walls lighter and thus capable of being taken higher so long as points and lines of stress were appropriately treated. The real key lay in the proper use of mortar and of kiln-fired bricks:

The Mesopotamian architect, who used bricks profusely, was always hiding them behind the thick mud facing applied to all walls. He failed to realize that the use of a different type of mortar to set bricks would permit him to increase the height of his walls without making them so thick as to endanger their durability. Eventually . . . mortar was used in combination with fired bricks, and the technology of arches and domes was transposed from the level of stone block architecture to that of brick architecture. The width of the rooms, hitherto restricted by the span of the roof timbers, or expanded by means of a forest of columns, then increased. A new technique was created, based on the interplay of weight and support, stress and counterstress, structure and fill, and the heavy mud-faced and gaudily painted walls and the massive, piled-up temple towers were replaced, after little more than a millennium, by scintillating walls in enameled and intricately patterned bricks, and by slender towers and graceful domes.

(Oppenheim 1977: 325)

(ii) BRICK MANUFACTURE AND DEVELOPMENT

Salonen (A. 1972) provided a concise survey of the archaeological information in his philological study of bricks in ancient Mesopotamia; but it is regularly taken from secondary sources, already old at the date of publication, with superseded or controversial chronological and cultural attributions. In general the textual evidence he provided is relatively rich, not least the documents and pictures illustrating the role of the king in ceremonial brickmaking and foundation-laying in temples from at least the middle of the third millennium BC down to the Seleucid period (cf. Ellis 1968: 20 ff., pls. 22 ff.; also Lackenbacher 1982).

(a) Manufacture

The preferred brick manufacturing month was the 'third' (May–June), immediately after the spring rains, when water would be plentiful and the whole summer lay ahead, if necessary, for drying. Chaff or straw was easily available at this time. The July–August period was characterized as a time of building, when the dry-

ness of the ground would have facilitated foundation-laying. The association of the fire-god with building may arise from this conjunction of intense heat and construction (Ellis 1968: 20).

Broadly speaking, as with *terre pisé*, the methods of making sun-dried moulded mudbricks (*libn*) evolved in remote antiquity have endured in Iraq substantially unchanged, as examination of surviving bricks and the witness of texts relating directly to the manufacture of bricks makes clear. Aurenche (1981: 64 ff.) has given a detailed review of techniques, whilst Salonen (A. 1972: pls. XXXVIII–LII) provided a useful series of pictures of brickmaking in modern communities in comparable regions (cf. Wulff 1966: 115 ff.).

Mudbricks were commonly produced in rectangular wooden moulds, open at the top and bottom, usually singly, but sometimes in twos or threes. Almost any soil may be used as the medium, though one with a greater clay content is more satisfactory (for gypsum bricks, see p. 332). Generally, red-brown bricks have derived their colour from fresh soil taken from agricultural land, whilst grey bricks are those for which occupational debris was used. Red bricks, however, often appear with grey mortar, perhaps coloured by ash, since settlement debris may have given a stronger bond. Some form of tempering was always necessary to avoid warping and cracking. Chopped straw or dung was most commonly used. It has been calculated (Oates, D. 1990: 390) that 100 bricks require about 60 kg. of straw (i.e. 1/8 hectare of barley). The resistance of sun-dried mudbricks to fracture decreases with the decay of the straw bonding. Pulverized sherds and other mineral matter were sometimes employed. The lime content of many clays in Iraq make them particularly suitable for the manufacture of durable mudbricks (cf. Wright, H. E. 1955: 84). There is no evidence that bitumen was incorporated in the clay mix in antiquity, though it has been in recent experiments (Paulus 1985). When kings were involved in formal ceremonies at the start of a building project, tools of ivory and equipment of precious woods are mentioned:

I (Assurbanipal) made bricks for the (Gula Temple in Babylon) out of cuttings of aromatic plants, in a mould of ebony and *musukannu*-wood. I had (them) wield the hoes, and I saw to the correct laying of the foundations.

(CAD H: 180b)

As the basic material and temper are puddled with water to a suitable consistency for putting into moulds by hand, the presence of plenty of water is a decisive factor in the location of brickfields. They are commonly, and presumably always were, in or adjacent to a cultivated field beside a canal or river. The brickmakers move regularly so as not to dig too large a cavity in any one cultivated area. The surplus mud is cleaned off the top of the mould by hand (save for plano-convex bricks,

see below). The mould is removed and the brick dried in the sun for a period of time appropriate to the season, with regular turning. 'In the modern village of Khorsabad bricks are left to dry in the summer sun for but a day or two, after which they are sufficiently hard to handle as one would a kiln-baked brick. They are subsequently laid with mud plaster between courses and vertical joints' (Loud and Altman 1938: 13).

It is usually assumed (as Ellis 1968: 30) that the addition of substances like cedar oil, ghee, and honey to mud mortar (or plaster) and bricks (Gudea: Cylinder A: XVIII. 21 ff.), as reported in Mesopotamian texts, was non-functional. However, as Torraca *et al.* (1972: 263) point out, tannins, proteins, sugars, or their decomposition products can stabilize mudbricks. As organic materials decompose inside ageing bricks, they would not easily be identified by modern analyses.

A liquid form of the same mixture used for bricks generally serves both for *mortar* and for *wall plaster* (cf. pp. 329 ff.).

The making and laying of bricks for public buildings, especially temples, is known from textual sources to have been accompanied by ceremonies and ritual to propitiate the gods, including a specific brick god, and to create the most favourable circumstances, especially for the crucial process of making the first brick (cf. Ellis 1968: 17–29; Lackenbacher 1982: 129 ff.; Edzard 1987). For each new project unbaked mudbricks had to be freshly made, as they cannot be salvaged from old buildings. Written evidence indicates that such rituals attended work on simple houses as well (Ellis 1968: 19).

As Delougaz (1933: 6–7) pointed out, it is by no means easy to estimate the degree of standardization in sun-dried mudbrick manufacture from observation of the results: 'brickmaking does not require any special technical knowledge, so that practically every villager does it occasionally. Of course there are some men in every village specially skilled in the making and handling of mudbricks.' Delougaz recorded that his best brickmaker in the Diyala in the early 1930s held a record for making almost three thousand a day. 'If we attribute approximately the same number to brickmakers in antiquity, we can understand why rather large sections of buildings are made of bricks of identical size, not through any intentional standardization of size, but simply because one brickmaker turned out thousands of bricks from his own particular frame. Therefore only in large buildings, where of necessity many brickmakers had to be employed, do we find that bricks of different sizes and proportions were used during the same period.' Whatever the rate may have been this was, in general, a simple but slow method of production.

There is no comprehensive synthesis of the textual information on brick manufacture (Salonen, A. 1972 is a survey of vocabulary); but a group of texts from Kish gives some idea of bureaucratic procedures for brick

production in the Old Babylonian period (Donbaz and Yoffee 1986: 26 ff.). In this case there was an official hierarchy charged primarily with the two basic operations: digging out the raw material; moulding the bricks.

Bricks are unique among Mesopotamian artefacts 'because they are the only surviving artifact for which textual evidence attests that they incorporate norms of length, area, volume, capacity and weight—a rather remarkable combination in the history of pre-modern metrology' (Powell 1982: 117). But, as Powell has found, the surviving material evidence does not lend itself to systematic analysis, 'because every archaeologist (or brick-measurer) operates according to slightly different principles, which creates a significant margin of error'. However, there already exists an extensive literature on the mathematical aspects of quantity assessment and related brick problems based on the surviving documentary evidence (cf. Neugebauer and Sachs 1945: 91 ff.; Dunham 1982; Powell 1982). Bricks were used in enormous quantities, especially for the platforms or rafts of mudbrick which replaced trench foundations in the Neo-Assyrian period, and at all times for ziggurats.

(b) Kilns

Matson (1985: 66–7) has described the significance of colour as an indicator of firing temperature for baked bricks: 'Consistent with many Mesopotamian calcareous clays tested, the reddish-brown coloration at 600 °C (using Munsell terminology) changes to pink, then reddish-yellow, and finally to a very pale yellow or white as the calcium ferrosilicates develop. The pale surface scum due to the soluble salts in the clays becomes increasingly marked over 900 °C.' In Matson's opinion firing temperature seldom exceeded 800–900 °C; but he was largely observing Neo-Babylonian bricks from Babylon. Many ancient bricks are softer and more porous than their modern equivalents; Rathgen (1913) thought many appeared not to have been fired much over 550–600 °C. Such low temperatures are not surprising in view of the primitive nature of the kilns used, the poor quality of available fuel, and the continuing demand for large, regular brick production.

Virtually nothing is known archaeologically of brick kilns in ancient Mesopotamia; even in Egypt pictorial evidence is rare (Verhoeven 1987). Below the 'Stone Cone Temple' at Uruk a concentration of what may be late prehistoric brick kilns was excavated, many apparently used only once, to produce bricks measuring 32 × 18 × 9 cm. (Lenzen 1959: 11–12). Others have been claimed at Khafajah (Frankfort *et al.* 1932: 76) and Nuzi (Starr 1937: plan 25; 1939: 238). It is commonly assumed that they differed little from their more primitive modern counterparts everywhere evident in

the Iraqi countryside (cf. Salonen, A. 1972: 119 ff.). However, the well-built rectangular kilns, some with tall stacks to increase the draught (and fired by oil), are not a sound analogy. As Matson points out, the bricks of antiquity were probably fired in quickly built scove kilns: 'such kilns consist of a rectangular stack of bricks with adequate interstitial space to support the draft for the circulation of flames and hot gases. Fuel pits along the base of the unfired brick and possibly corridors beneath them are readily built and leave little archaeological evidence of their existence. Even the outer casing, sometimes of fired brick or a mud and dung protective facing on the outer green brick, would disappear' (Matson 1985: 71). In surveys at Umm el-Hafriyat Vandiver (personal communication) was able to distinguish rectangular brick kilns from variously shaped pottery kilns of the later third and earlier second millennium BC.

(c) Bricks: sun-dried and kiln-fired

In structures, especially large public buildings, the proportions of sun-dried and kiln-fired bricks varied. In general, often to a surprising degree, sun-dried were preferred to kiln-fired. It appears that for both court and temple, as well as for private persons, the high cost of fuel made kiln-fired bricks so expensive to manufacture that their use was minimized. Moisture is a great threat to mudbrick. In southern Iraq, where the ground water is extremely saline, rising damp is a persistent danger. Salts, drawn up into a wall by capillary action, recrystallize as they dry causing the brickwork to crumble. Thus whoever could afford it employed baked brick and bitumen for damp-courses. Elsewhere kiln-fired bricks were used only in areas requiring protection from water, such as water basins and drainage channels, or where resistance to wear, as in thresholds, entrance halls, or courtyards, was particularly needed. They were also used for door-sockets in houses; stone being preferred for this in major public buildings. In some contexts where bitumen might be anticipated, baked brick served, as in the early second-millennium BC houses at Ur. In ziggurats open channels were regularly provided in the core, where courses of sun-dried brick generally alternated at set intervals with layers of reeds to create a ventilation system that counteracted the effect of infiltrating humidity and thus conserved the integrity of the brickwork.

(d) Towards the standard rectangular brick

It was on sites of the Samarra culture, notably Baghouz (Mesnil du Buisson 1948: 15, pl. XV.3) and Tell es-Sawwan (Wahida 1967: 172; al Wailly and Abu es-Soof 1965: pl. XVII. 56), that sun-dried moulded bricks of relatively regular sizes were first observed. At Baghouz they measure approximately 59 × 24–9 × 8–9/81 × 45 × 10 cm.; at Sawwan 50–70 × 21–30 × 6 cm.

By the Ubaid period they may be observed in use from Gawra level XIII in the north southwards to Eridu (Aurenche 1981: 67, table 6 (with dimensions), map 6). The figures for brick sizes reveal both an increasing standardization and a reduction in size. For the first time bricks no more than 50 cm long are more common than larger ones. On ethnographical analogies Aurenche (1981: 67) interprets this as indicative of moulding. In discussing the bricks used in temples of the Ubaid period at Uruk Schmidt (J. 1974: 177) observed that, even if the technique of brick manufacture was still primitive, regular form and size (45–42 × 24–22 × 8–7 cm.) indicated organized mass-production. Tobler (1950: 34) implied a very similar conclusion in his discussion of brickwork in the shrines of Gawra XIII.

The emergence of the widely distributed 'tripartite' plan for houses and temples in the Ubaid period reinforces the argument that new levels of social organization now affected the builder's craft across the whole of Mesopotamia. Fairly elaborate systems of brick-laying had already been evolved by the time of the emergence in the archaeological record of the first major monumental buildings in the south (Eridu, Uqair, and Uruk), with an interplay of projecting piers and wall recesses that probably owes much to earlier building there in reeds and palmwood.

No baked bricks have yet been reported before the Uruk period, save for an anomalous instance in Gawra XIII. A find in the Eastern Shrine 'consisted of a total of ninety-nine model bricks made of well-baked terracotta . . . Examples of full bricks, square half bricks, long half bricks, and quarter bricks were represented . . . Apparently these model bricks were used to determine the most satisfactory method of bonding and building the complicated recessed piers and pilasters found in Stratum XIII structures' (Tobler 1950: 34).

Up to the middle of the fourth millennium BC moulded mudbricks had tended to be large and flat. In the Uruk period smaller proportions emerged so that two bricks could be handled together. Now, also for the first time, bricks were baked in kilns for special purposes and shapes were varied to suit particular functions in a building. Finkbeiner (1986: 47 ff., appendix II lists brick sizes) has provided a full review of the brick-shapes used at Uruk through the later prehistoric levels (VII/VI–I). *Riemchen*, bricks of square section, predominate in level IV, with rectangular bricks appearing more rarely for specific purposes, as in the use of large-sized mudbricks (*patzen*) in terraces or the city wall or small baked bricks in the water channels and basins. *Riemchen* have a height equal to their breadth; but a length always greater than double their breadth; they vary in size from 16 × 16 cm. *Patzen* are large rectangular bricks measuring 80 × 40 × 14–16 cm. (in level V: North-South Terrace) to 40 × 20 × 8 (in level III: Eanna). *Riemchen* persist

through level III, but *Riemchen-nahe* then also appeared (Heinrich 1935: 10), slightly rectangular rather than square-shaped in section; rectangular bricks were increasingly used. In level I/7 (the earliest phase of I) plano-convex bricks (see below) appear for the first time with *Riemchen*. In I/6 plano-convex *Riemchen* briefly appear, but have disappeared by I/5. In I/5 to I/1 plano-convex and rectangular bricks are in use side-by-side. This broadly sustains the view that brick shapes may serve to a limited extent as chronological indicators at the transition from the late prehistoric to the early historic period; but they may at times be more site-specific than is apparent from some publications.

Elsewhere in the Uruk IV–III horizon brick sizes and shapes vary within the ranges found at Uruk itself (cf. Uqair: Lloyd and Safar 1943: pl. XVIa; Eridu: Safar *et al.* 1981: figs. 118–9). There is a striking similarity between building practices at Uruk and the so-called Uruk 'colonies' on the middle Euphrates which provide excellent evidence for contemporary building practices (cf. Ludwig 1979). In the large administrative building at Jamdat Nasr (Uruk III) two sizes of flat bricks were used: 20 × 8.5 × 8 cm. and 23 × 9 × 6.5 cm. (Mackay 1931: 290). The former were always unbaked; the latter were both baked and unbaked. The baked bricks, normally found in paving, but occasionally used for walling, had three oblique holes through them, averaging 1 cm. in diameter, presumably to help in firing.

There is only one period in Mesopotamia when a brick type is so distinctive and so widely employed that it may be used, with due caution, both as a chronological indicator and as a cultural trait. The plano-convex brick (pcb) appeared at the outset of Early Dynastic I, c.3000 BC, and began to disappear in the later part of Early Dynastic III, some six hundred years later. Neither its appearance nor its disappearance was so sudden and clear-cut as has often been assumed. At the outset, in the Eanna complex at Uruk and in 'Archaic I' at Ur, *Riemchen* and plano-convex bricks were used together (cf. Eliot 1950: IV; Woolley 1939: 1–4), whilst at Tell Uqair (Lloyd and Safar 1943: 147) *Riemchen* bricks are laid in the herring-bone patterns particularly associated with plano-convex brickwork (see below).

The return of the rectangular, flat brick (33 × 24 × 6 cm.) is first documented at *Girsu* (Telloh) buildings attributed to the time of Entemena (Sarzec and Heuzey 1884–1912: ii, pl. 31: 2–3), but plano-convex brickwork is still evident at other sites into the Akkadian period (Tunça 1984: 125 ff.; Finkbeiner 1986: 56), whilst isolated examples were used in foundation deposits for much longer (cf. Woolley 1965: 670). Both at the beginning and the end there may have been regional variations in usage concealed by the restricted body of data currently available.

The distinctive *bombé* shape of the plano-convex

brick has commonly been explained as the omission of a stage in the process of manufacture. In making a *Riemchen* brick the surplus mud was cleaned off the top of the wooden mould; with a plano-convex brick it was left and marked with the fingers or palm of the hand. Such bricks vary in size, but are generally larger than the *Riemchen* they superseded (broadly 20/30 × 12/20 × 3/6 cm.), more irregular in shape, and generally less well-made. Tunca (1984: 123) is not convinced that plano-convex bricks were invariably moulded (cf. Delougaz 1933), arguing that a significant number of the sun-dried examples were freely modelled by hand.

The first appearance of the plano-convex brick is closely, if not exclusively, linked to a distinctive method of bonding that formed 'herring-bone' patterns. The appearance of this phenomenon originally encouraged the idea that both this brick's shape and the methods of using it presupposed a tradition of laying stone alien to the lower Mesopotamian plain. On this assumption, invasions from the eastern mountains were postulated to account for its appearance (cf. Jordan 1931: 18; Delougaz 1933: 25–6, 34, 37–8; Woolley 1934: 35). Even if a derivation from stone-laying is correct, it does not require foreign innovators. It might have derived from the indigenous use of stone for building.

However, in recent years there has been a marked tendency to accept the plano-convex brick as part of a complex process of evolution, with various strands of invention and borrowing contributing to a gradual development within local brickworking traditions (cf. Tunca 1984: 126 ff.). Gibson (1980^a: 96) has suggested an origin in one of the simplest techniques of building with mud still evident in southern Iraq.

I have seen them [farmers in muddy areas near Nippur] building walls, usually compound walls, by just taking the shovel they have . . . a small, shallow shovel which is the easiest to use in mud, and turn over the mud as they go along. Each shovelful is turned over onto the preceding one to build up the wall. When they get to the end, they throw each shovelful back the other way and get a herring-bone pattern.

Nissen (1988: 93) has argued that the combination of flat layers of plano-convex bricks in the structurally important parts of a building (corners, door-frames) and herring-bone pattern laying between allowed for faster, less skilled work: 'If, in addition, it is assumed that this technique made it possible for experienced and inexperienced people to work hand in hand, we would have yet another example of an expansion in the division of labour [at this period].'

The plano-convex brick was particularly characteristic of Sumer. Its identification elsewhere has at times been obscured by arguments over definitions of type. Mallowan (1946: 136; 1947: 54–5) claimed to have identified it at Tell Jidle in the Balikh valley and at Tell

Brak. It does not seem to be represented in buildings of the Early Dynastic Period excavated at Assur; but Tunca (1984: 123–4) has argued, contra Parrot, that it may be recognized in use at Mari in the Pre-Sargonic buildings. If such brickwork penetrated beyond the northern limits of primary Sumerian culture, diffusion up the line of the Euphrates and its tributaries is the most likely channel of craft communication.

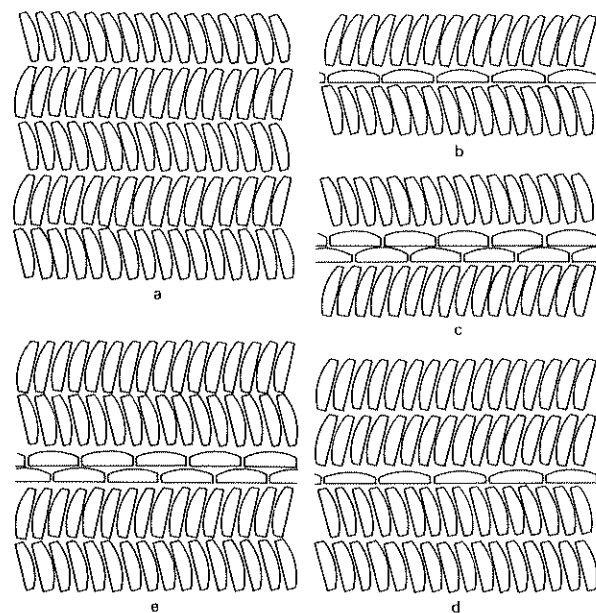


Fig. 20. Various patterns used in the laying of plano-convex bricks, c.3000–2350 BC (after Delougaz 1933: fig. 19).

Remarkably well preserved buildings of the Early Dynastic period in the Hamrin region indicate how much knowledge is lost when little but foundation courses are available for study. A number of round buildings ('fortresses') distinguish these sites. That at Uch Tepe, with surviving mudbrick vaulting arches, was constructed of mudbricks and mortar, comparable in composition, with a hardness equivalent to soapstone (Mohs 3) and 'an abundance of gypsum'. In this structure the bricks and mortar formed a tough homogeneous mass (cf. Gibson (ed.) 1981).

With the return of flat bricks of regular shape by the last quarter of the third millennium BC, brick shapes and sizes were to become more or less standardized for the better part of two millennia. By the outset of the second millennium BC kiln-baked bricks were generally square and thereafter most fall within the range 40/30 cm. square, 8–10 cm. deep. Both Loud and Altman (1938: 13–14) and Mallowan (1966: 464) have reviewed the sizes and the techniques of Neo-Assyrian brickwork; Koldewey (1931–2: 4) those of the Neo-Babylonian period. The special requirements in brickwork and in mortar across the millennia, for specific structural purposes, have been concisely

described by Benseval (1984). Specially shaped bricks (triangular, half-spherical, etc.) for particular purposes are known from the third millennium, as in the 'Piliers de Goudea' at Telloh (reconstructed for Louvre displays 1989), to the first millennium, as at Nineveh (Nebi Yunus) and Khorsabad.

A chronological sequence, though only for bricks from major public buildings, may be established through bricks with royal inscriptions (Walker 1981). From rare Early Dynastic examples until the end of the IInd Isin Dynasty (c.1157–1026 BC), all brick inscriptions from Sumer and Babylonia, with the exception of those from Tell Asmar (Eshnunna), and occasional individual rulers of provincial cities, were written in Sumerian. For the period from about 721 to 637 BC they are either in Sumerian or Babylonian; from Nabopolassar (625–605 BC) only in Babylonian. In Assyria the local language was used throughout, save for Sargon II's use of Sumerian in a specific case in the late eighth century (Walker 1981: no. 168). In the south inscriptions were either stamped or inscribed by hand with a stylus on either face of the brick, on both faces, or on the edge. Stamped inscriptions are generally rather more common than inscribed ones and stamps, in stone or metal, have survived (cf. Salonen, A. 1972: pl. XVIII). Assyrian bricks are inscribed rather than stamped, and appear never to have been stamped on the edge. Inscriptions on the faces would not normally have been visible when set in a wall; but those on the edge of a brick would.

In the absence of inscriptions it is much less easy to characterize brickwork as the work of specific rulers. At Ur Woolley (1965: 3) sometimes attempted this. In the case of the architectural enterprises of Kurigalzu (I), c.1400 BC, a sandy clay was used to make lightly baked bricks, in contrast to the widely employed sun-dried mudbricks of earlier and later times. They were used with mud mortar, less commonly with the bitumen mortar previously used, and casually employed. In constructing, or reconstructing, walls, Kurigalzu's builders only put a burnt brick facing over a core of old walls or rubble without any attempt to bond old and new. The detailed recording of brickwork has not progressed enough to take such lines of investigation very far, nor, in view of the nature of the archaeological evidence for Mesopotamian mudbrick buildings, is it likely that any modern study can do real justice to the skills of local bricklayers.

(iii) DECORATIVE TECHNIQUES IN MUDBRICK ARCHITECTURE

(a) Late prehistoric cone mosaics

Even though the archaeologist in Mesopotamia has normally to deal only with the foundations or lowest courses of buildings, significant information has sur-

vived about the techniques of wall decoration either in modelled clay or in paint, though this is more elusive. The widespread use of colour, whether in variously tinted plaster surfaces or in murals, has often been underestimated since it was so fugitive and is often only evident through the most meticulous excavation, particularly in villages. It is less often overlooked in excavations of major public buildings. In the prehistoric period there is so far no evidence that bricks themselves were moulded for decorative purposes; but in the later part of the period cone-shaped objects were used in various ways both to protect and to decorate, often at one and the same time, the walls of major buildings. This technique was to spread during the Late Uruk period across the Near East to an extent never again matched by so typical a Mesopotamian building device.

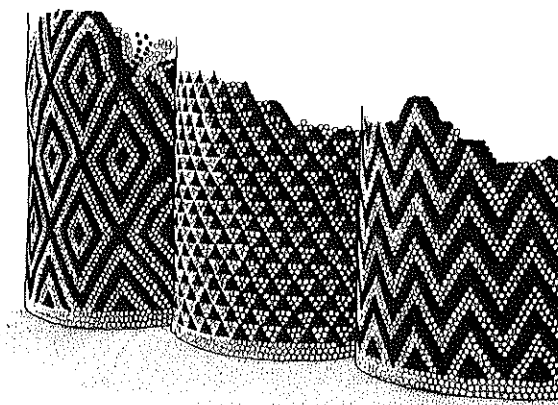


Fig. 21. Reconstruction of part of a terracotta cone mosaic façade at Uruk, c.3500 BC

The definitive evidence for this prehistoric form of cone mosaic was recovered over fifty years ago from Uruk. Three main types of terracotta cone were recognized (for stone see p. 339 here; cf. Lenzen 1974^a; Trokay 1981; Finkbeiner 1986): relatively small, solid clay cones or pegs whose coloured ends were used to form geometric patterns on walls by pressing them point first into the plaster spread on the face of mudbrick walls (*Tonstifte*); cones with hollowed-out blunt ends, often of considerable size (*Grubenkopfnägel*); and hollow, coarse-ware clay cones, often very much like pottery vessels in appearance, inserted in rows into walls (*Tonflaschen*). Uruk remains the site where the most coherent cone mosaics have been excavated, notably the façades of the 'Rundpfeilerhalle' (Uruk IVb) (Loftus 1857: 188; Nöldeke *et al.* 1932: 12, pl. 8; Moortgat 1969, pl. I) and the 'Pfeilerhalle' (Uruk IVa) (Brandes 1968). Such mosaics may have first appeared in the Late Ubaid period and survived in some form into Uruk III (Finkbeiner 1986, for stratigraphy). Terracotta cones are great survivors and many of their appearances may be chronologically deceptive. For instance, at Abu Sala-

bikh in the mortar of an Early Dynastic wall 'there was a surprising frequency of clay wall-cones of the familiar Uruk type . . . A salutary warning for the avid surface collector' (Postgate 1984: 108).

At Uruk the decorative cone mosaics were particularly applied to free-standing columns and to walls with buttresses and recesses. Moortgat (1969: 3) argued that the terracotta cones dipped in black, white, or red, less often yellow or dark blue, followed the use of stone-cone mosaics (see p. 339 here), themselves derived from patterned rugs or mats hung as decoration on the walls of the earliest shrines in southern Mesopotamia. But this might have been secondary to a primary interest in protecting parts of walls vulnerable to wind and water erosion by covering them with reed mats (cf. Nöldeke *et al.* 1932: 21, pls. 10b, 11; Perkins 1949: 123). Whatever the case, the intimate relationship of protection and decoration is evident in most uses of these cone mosaics. The general pattern of their use has been established through occurrences on major shrines in the south as at Eridu (Safar 1981: 240, fig. 118), Larsa (Parrot 1968^a: 219–20, fig. 12), Telloh (Parrot 1948, 35–7, pl. 7b, p), Ubaid (Hall and Woolley 1927: 48–9, 51 ff., 153, pls. XIII.6–7, XV.2), and Ur (Woolley 1939: 5–6, pls. 11, 14b; 1956: 28, 188, pl. 15 lower). At Tell Uqair both isolated cones and representations of coherent mosaic decoration on wall-paintings were found (Lloyd and Safar 1943: 143, pls. X, XVIIIA). At Uruk terracotta fragments, particularly for corners, imitate patterns made by hollow-ended cones (Nöldeke *et al.* 1932: 32, fig. 19; cf. Behm-Blancke 1989: fig. 3), whilst models illustrate façades with cone mosaic decoration (Nöldeke *et al.* 1937, pl. 48).

Terracotta cones have been reported regularly from surface surveys in southern Iraq and in Khuzistan, where they have been taken to indicate 'architectural complexes . . . usually identified as "temples"' (Adams 1981: 77). Johnson's (1973: 105) assumption that the presence of such cones on small village sites in Khuzistan indicates 'administrative outposts of large centers' stretches the available evidence. They need indicate no more than the presence of a shrine. In many ways more remarkable is the presence of evidence for various types of cone mosaic along the middle and upper Euphrates and its tributaries in Syria and Turkey in settlements related to the so-called 'colonial' expansion of Uruk (cf. Trokay 1981; Behm-Blancke 1989), among the best-preserved of which are those in and about the 'Eye-Temple' at Tell Brak (Mallowan 1947: 96, pl. VI.3). Cones of this distinctive type, made in local clay, found at Buto in the Egyptian Delta indicate the extraordinary penetration of some aspects of the Uruk culture (Way 1987: 247, figs. 2:6, 3:1–4).

(b) Unglazed fancy brickwork

It was not only the late prehistoric taste for cone mosaic decoration that may have owed its inspiration to the forms and decoration of the organic materials, palm-wood and reeds primarily, used in the age-old architecture of southern Iraq (cf. Aurenche 1981: 88 ff.; *columbage*). Some of the decorative effects found in developed mudbrick architecture recall the surface decoration of the palm tree. As the free-standing column or pillar appears to have played little part in early Mesopotamian buildings (Collon 1969), their possible wooden precursors (and successors) have not always attracted due attention. Parrot (1939: 23) argued that palm trunks had decorated a passage in the Dagan Temple at Mari, whilst spiral patterns on the walls of the Ninni-zaza Temple may derive from the patterning of palm tree trunks (Parrot 1967: 23, fig. 14). Certainly in the Early Dynastic temple at Tell al-Ubaid at least three palm trunks had served as columns in a covered portico or perhaps more likely within the shrine itself. They were coated with bitumen and overlaid with a mosaic of mother-of-pearl and pieces of pink and bituminous limestone, again imitating the scaly surface of the trimmed palm tree. At least four wooden columns in the same temple had metal overlays, as was the custom much later in the Neo-Assyrian period (cf. Hall and Woolley 1927: pls. IV, XXXIV.3, XXXV.6, 7; compare Khorsabad: Loud 1936: 97–8, figs. 99, 102; Pottier 1924: nos. 136, 152).

At some point in the last third of the third millennium BC the degree of planning in Mesopotamian architecture conspicuously increased as details of decoration and structure become more elaborate ('drawing-board architecture'). The first real indication of decorative brickwork is a feature of this development. Such an increase of precision bricklaying as this presupposes a greater degree of previous planning than had been customary for the palaces and temples built in plano-convex mudbricks. The earliest clear imitation of the palm tree entirely in brick has been found at Ur. The so-called Treasury of Siniddinam (c. 1849–1843 BC) had 'elaborately constructed engaged mudbrick palm-columns which were covered with a thin coating of plaster identical in colouring to that used in the fort built by Warad-Sin' (c. 1834–1823 BC) (Woolley 1976: 92). In the 'Bastion of Warad-Sin' columns of 'carved' or specially moulded baked bricks are bonded into walls where they touch them and serve no structural purpose (Woolley 1939: 42–3, pls. 29–30, 71): 'bricks, segmental in shape and with the outer edge not only rounded to the curve of the column shaft, but with a further boss, in relief so that each set of three bricks . . . produced a truncated triangle standing out from the column in low relief; these triangles . . . set in rows one above another, made of the brick shaft a very close imitation

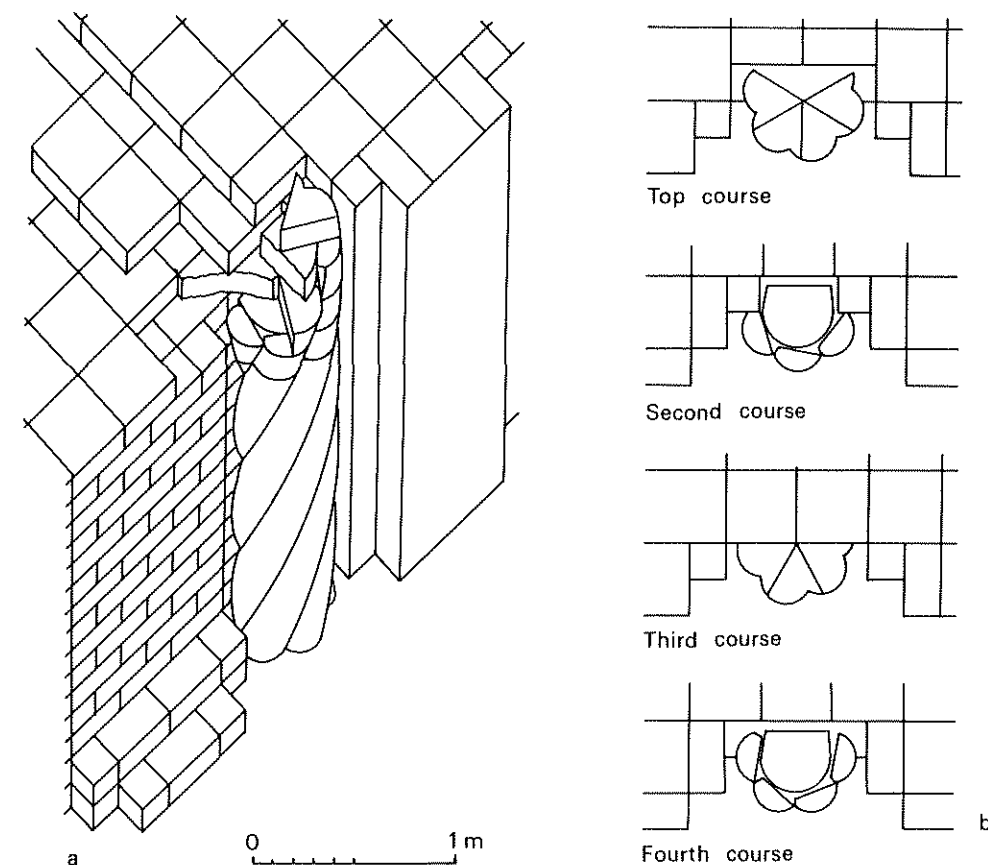


Fig. 22. Decorative mudbrick laying in the ziggurat at Tell Rimah, early second millennium BC (after D. Oates 1990: fig. 4): (a) Diagrammatic reconstruction of a spiral column on the west façade. (b) Successive course plans.

of a date-palm trunk' (Woolley 1939: 42). Somewhat similar decorative brickwork, perhaps of the same date, also occurred in the Nannar Court at Ur (Woolley 1939: 82–3, pl. 32b).

In the Old Babylonian period at Larsa the interior walls of Courtyard I in the main temple complex (*E. Babbar*) were decorated with spirally ribbed columns made with specially moulded baked bricks (Calvet *et al.* 1976: 4, pls. I.1, II.1, III.4). They are closely matched at this time on sites in Northern Mesopotamia, at Tells Leilan, Rimah, and Brak (Oates, D. 1987: 167, pl. XXII). At Tell Leilan the northern façade of the level II temple on the Acropolis (north-east), is similarly ornamented. On the southern façade of the level II temple one mudbrick column was 'sculpted' to resemble the trunk of a trimmed palm tree. The same phenomenon was observed in the earlier level III (Weiss 1985).

At Tell Rimah in the time of Shamshi-Adad I (c. 1813–1781 BC) the east façade of the temple adjoining the ziggurat was decorated with spiral baked-brick columns and with columns in the form of palm trunks

(Oates, D. 1967: 79, pls. XXXII–XXXIII, XXXVI). Two types of pattern were used, diamond-shaped and scale-like, to represent frond scars. Comparable brickwork was also used on the west façade of the ziggurat. Oates (D. 1967: 88–9; cf. Oates, 1990) examined in detail the method of designing and laying these bricks. 'Each column, whether palm trunk or spiral, was built with mudbricks bearing on their outer face pattern in relief which, by repetition in a standard sequence, produced the required motif. The basic shape of brick employed was a 60° sector of a circle of radius c. 29 cm. The brick could have been made in a mould of this shape or it could have been cut from a brick made in the standard square mould . . . the ornament was then carved on the curved surface. In the "scale" palm trunk the motif was only one course high and each brick bore three scales; the "diamond", being four courses high, required four different patterns of brick' (Oates, D. 1967: 88). The spiral components were slightly more complex, but created to the same principles. As Oates (D. 1967: 90) pointed out, the links with the 'Warad-Sin Bastion' at Ur are so close as to indicate a common

architectural tradition with its home in the south. The later examples may only be used in temples. A terracotta model of palm columns now in the Louvre (AO 17277; Contenau 1941) may be an architectural model which facilitated diffusion of such designs.

The simpler forms of decorated brickwork were probably more widespread than is apparent. Loftus (1857: 236) recorded scattered examples at a number of sites in the region of Uruk, though he dated them to the Parthian period. In some cases at least they may be Old Babylonian or Kassite, particularly the parts of spiral columns. At Assur in the Old Babylonian period specially shaped bricks were used in the construction of engaged columns (Haller 1955: 34, fig. 8). At Tell Haddad in the Hamrin, in an Old Babylonian temple, a panel with a palm tree carved in mud plaster was found to one side of an altar (M. Roaf: personal communication).

So far as present evidence goes, moulded or cut brickwork was not employed for anthropomorphic decoration until the fifteenth century BC when for the first time brick friezes in relief become a feature of temples erected by Kassite rulers. At Uruk a small temple for Ishtar, built by Kara-indash (c. 1450–1400 BC), had walls decorated with human figures executed in moulded bricks made to standard patterns assembled into repetitive friezes. Male and female figures, holding vases from which water flows, form a frieze with the zigzag streams of liquid uniting to form a link; beneath their feet is a band of half-circle ornament (Jordan 1930: 30–8, pls. 15–17; Moortgat 1969: pls. 226–8). Two fragments from the pioneer excavations at Nippur indicate that a very similar brickwork frieze decorated a temple there during the Kassite period (Kraus 1952).

Evidence from Aqar Quf and Ur suggests that such decoration was a standard feature of Kassite religious architecture. At Aqar Quf (Dur-Kurigalzu), in the north corner of Court 18 of the temple complex, adjacent to the ziggurat, were 'several fragments of a moulded brick façade including parts of the dresses and horned heads of gods and animals' (Baqir 1944: 12). At Ur Woolley reported that 'we have occasionally found loose in the ruins of temples, particularly in those of the *Enunmah* and *Edublalmah*, moulded bricks with fragments of design in high relief; these unquestionably belong to human figures of more or less life-size, and with them come simpler mouldings, plain half-circles or zigzags representing flowing water' (Woolley 1965: 3, 64). The Ur examples probably date to the fourteenth century BC. An isolated and unprovenanced fragment of such a frieze, part of a bearded figure, is cited by Moortgat (1969: 94 n. 9); but there is no good reason to accept it as 'Kassite'. It may well be Iron Age and from the Mediterranean region rather than the Near East (cf. Przeworski 1936: 115 ff.). Kassite moulded-brick friezes do not appear to have been glazed,

although by the later Kassite Period, if not earlier, glazed and moulded-brick friezes were used in Susiana (cf. Amiet 1976^a: 15–18, figs. 1–11, 19–22, 27–8). By the earlier first millennium BC in Assyria and Babylonia fancy brickwork was polychrome glazed above ground. Only deep in foundation levels are unglazed bricks to be found, as in the Ishtar Gate at Babylon (see below).

(c) Glazed brickwork

Few aspects of the technology of the ancient Near East have generated more false assumptions and confusions than the production of glazed materials. These are dealt with above in more detail in the sections on glazed baked-clay vessels and on faience. Here only the problems particularly relevant to glazed architectural features will be highlighted. Natural conditions in Iraq are not conducive to the survival of glazed objects in a pristine state. When it is possible to examine surviving glazed bricks first-hand by eye, it is obvious in all but the rarest cases that their colours are badly weathered or chemically modified. Even allowing that it describes an extreme case, the following comments by the American excavators of Khorsabad need always to be borne in mind: 'When found, the colour had largely faded or disintegrated, during which process the blue apparently first turns to green before becoming a pale, dead yellow, while the green reverts to a primary blue' (Loud and Altman 1938: 41).

Publication has, unfortunately, added a further problem. Authors, since the middle of the nineteenth century, with commendable intent, have used contemporary processes of colour reproduction to illustrate glazed-brick friezes or individual bricks or tiles. They easily give a misleading impression, since colour-tinted drawings may restore colours too decisively, whilst colour photography may equally distort tonal variations, above all when reproduced in books. This hazard is increased by the fact that some of the most commonly illustrated glazed-brick friezes, those from Babylon now in East Berlin and those from Susa now in the Louvre, have been restored in modern times in museum laboratories so that the extent of recent 'touching up' is by no means clear to the eye even on direct inspection, less still when studied in a book illustration. Albenda (1986: pls. 150–1) recently published Flandin's original watercolours of glazed brick fragments from Khorsabad in colour.

With bricks, as with vessels, it is not always easy to judge by eye whether the body material is clay or sintered quartz, or another type of composite material. In Mesopotamia until the Achaemenid period the body of glazed bricks varied little, if at all, from that of unglazed bricks. In the Achaemenid period, in the Neo-Elamite tradition, a body of sintered quartz or faience comes into use for glazed-brick friezes.

(1) Baked-clay wall 'nails' (*sikkati*) and plaques

The idea of decorating walls with terracotta cones arranged in patterns, their ends dipped in paint, goes back to the prehistoric period in Mesopotamia (see above). The custom of securing a decorated square plaque to a mudbrick wall by a peg driven through a hole in the centre of it is almost as old and was particularly exploited in stone by relief sculptors in the Early Dynastic period (Boese 1971: 155 ff.). During an extended history many variants of the 'peg' or 'nail' were used, plain and inscribed, in South Mesopotamian buildings and in foundation deposits (cf. Ellis 1968); but it does not seem that the idea of using them to secure decorative baked-clay plaques to a wall appeared until the middle of the second millennium BC, when they were manufactured in plain and in glazed terracotta (cf. Nunn 1988: 160 ff. for a comprehensive review). In general, wall-pegs (*sikkati*) were associated with such royal buildings in capitals and provincial centres as fortifications, palaces, and temples, with and without inscriptions (Assur: Donbaz and Grayson 1985; elsewhere: Grayson 1976: 49–52, 80); but the glazed examples of the middle and later second millennium BC are primarily found in religious buildings. They include 'wall-pegs', sometimes glazed, of unusual form, like those with open mouths ('trumpets') from the Middle Assyrian Ishtar Temple at Nineveh (Reade 1979^a: 21; see Nunn 1987: 160–3 for an illustrated survey).

The earliest extant examples, usually ornamented with floral or geometric decorations in low relief, when glazed, are blue or green in colour. A Middle Assyrian terracotta wall-knob from Tell Rimah (cf. Carter, T. H. 1964: 40, top) was glazed green with an alkaline glaze coloured by copper (Pollard and Moorey 1982: 45 ff.). Some of the most explicit information on the setting of wall-pegs, by no means always found with plaques at this early stage, was recovered at Nuzi in contexts which are either late fifteenth or early fourteenth century BC (stratum II) (Starr 1939: 59, 151; 1937: pls. 97–9). 'In many cases the shanks were not of sufficient length to have borne any great weight; consequently, their main purpose must have been decoration. Since they were found only in the Ishtar section of Temple A, and in L5 and L8, the palace chapel, it is evident that this form of decoration was restricted to the cult. In L5 they were found in position, inserted in the wall 178 cm above the pavement, 95 cm apart, the first being 130 cm from the corner (Fig. 21). Elaborations of this same type were found in Temple A (pl. 98E–H), used apparently in the same manner' (Starr 1939: 59, cf. 151–2). A wall-knob was found at the small site of Tell al-Fakhar, south-west of Nuzi (Al-Khalesi 1977: fig. 43c). A fragmentary plaque, with central perforation, with a floral decoration glazed in green and yellow, was recovered from a fourteenth-century context in the Gula Temple at Isin (Hrouda 1981: 9, 82, pl. 28: 1B 1264). Tile frag-

ments were found in levels II and IC of Dur Kurigalzu (Aqar Quf), glazed in blue and yellow, of the thirteenth to twelfth centuries BC (Baqir 1945: 14).

The most spectacular find of glazed wall-pegs was made by Ghirshman at Tchoga Zanbil in Khuzistan, where some rooms in the first stage of the Ziggurat, built in the later fourteenth or thirteenth century BC, had been used to store them in quantity (Ghirshman 1966: 12, pls. XVII–XIX, XXV; in colour: Amiet 1966: pl. 261); some were inscribed for Untash-Napirisha. Pieces of comparable wall-pegs, inscribed for Shilhak-Inshushinak, were found at Susa (Amiet 1967: 28–9). Glazed knobs and tiles were found at Tepe Malyan in Fars (Carter and Stolper 1976: 37, figs. 1–4) stored together as at Tchoga Zanbil, both ornamented with floral designs. According to Fukai (1981: 5), glazes in blue, green, and white (others report yellow) were used at Tchoga Zanbil; two occasionally in combination but never all three. He also published the analysis of a blue-green glaze from one of the knobs, showing it to be a non-lead copper glaze (Fukai 1981: 6).

The history of this type of decoration in Assyria is not documented before the Middle Assyrian period, but then it runs parallel to that documented elsewhere in Mesopotamia, as in the thirteenth-century Ishtar Temple of Tukulti-Ninurta I at Assur (Andrae 1935: 95–6, pl. 38) and at Kar-Tukulti-Ninurta (Eickhoff 1985: 54–5, pls. 4–5) as well as at provincial sites like Tell Fakhariyah in Syria (McEwan *et al.* 1958: 42–3, pl. 43: 1–2). 'Frit' (? glazed terracotta) plaques, in the form of rosettes, are reported from the Middle Assyrian palace and temples at Kar-Tukulti-Ninurta (Nashef 1992: 311–12, figs. 12; 14).

Andrae's (1925) study remains the basic treatment of the Neo-Assyrian *sikkati*, though it is based only on the evidence from Assur, where, as elsewhere, excavated examples seem to be primarily of ninth-century date.

The head of the knob was given a tapering neck and one or more rings at the foot, at the place where it enters the wall. The long stem which must remain firmly in the wall is left unglazed, while the foot, neck and head were often glazed. If the stem was left out the hollow knobs had to be fixed to the wall with wooden pegs, and to attach it immovably to the pegs it was made fast with a pin for which a hole is found in the neck. The ring at the base is sometimes widened to a disk . . . But usually and especially from the ninth century onwards, the stem is left out, and the neck and head of the knob are made hollow. In this way arises the *knob plate*, in which the disk at the base preponderated and became the chief part of the decoration.

(Andrae 1925: 65)

Clear evidence for the arrangement of these lozenges or cushion-shaped, sometimes round, wall-plaques in Neo-Assyrian buildings is scarce, perhaps because of the height at which they were normally set on a wall.

On one wall of the Palace of Assurnasirpal II at Assur (Preusser 1955: 21, pl. 14) were the 'ghosts' of seventeen square plaques set at about the height of a man in a row. Andrae (1925: 66), for reasons not stated, thought that this was a later arrangement, 'as if in late Assyrian times someone had had the pleasure of collecting and bringing together again, to some extent suitably, well-preserved knob-plates from the palace ruins, perhaps at the order of the Babylonian satrap resident in Assur'.

Most of the plaque decorations restored at Assur were the familiar floral friezes of the period, used also on relief sculptures and murals. A few bore geometrical patterns and there were fragmentary examples with scenes of lion-hunting (Andrae 1925: pl. 9: 31-6; figs. 39, 41, 45, 47-8). Similar plaques have been found on the other major Neo-Assyrian palace sites, as also in temples. Albenda (1991) has reviewed them on the basis of examples now in the British Museum from Tell Ajaja (Arban), Tell Billah, and Nimrud, all of the reign of Assurnasirpal II (cf. also Balawat, Sherif Khan; comments of Loud and Altman 1938: 43 (Khorsabad)). She concluded that each group was made locally to distinct patterns. Although best known from the ninth century, the series endured through into the seventh century, at least at Assur. Andrae detected some modifications through time in their decoration. With reference to the colour of glazes he remarked that 'we have to deal with yellow and light blue, only in a few cases with any other colour—for instance, dark blue. White and black give the essentials of the pattern' (Andrae 1925: 73). Pegs and plaques do not appear to have survived into the Neo-Babylonian period; but were found at Nippur in the Late Assyrian period (Gibson *et al.* 1983: 187, fig. 30).

The fashion for glazed polychrome wall-plaques secured by pegs with decorated heads is also found in western Iran in the first millennium BC. In the ninth century they seem to have been more immediately under the influence of Neo-Assyrian designs, though some local traits are already evident. At Hasanlu, for example, in the late ninth-century debris of level IV, plaques comparable to those from Assur appear to have been secured to walls in certain cases with pegs having anthropomorphic or zoomorphic terminals in distinctively local styles (Dyson 1959: 14; fig. 13, lower r.; Fukai 1981: fig. 9). Wall-tiles of this type have also been reported from trenches cut into the citadel at Ziwiyeh, perhaps a century or more later than those from Hasanlu IV (Dyson 1963: 35). At Susa the Middle Elamite tradition of glazed terracotta endured, though undocumented until the eighth century BC, when Shushruk-Nahhunte II built a small temple at Susa. Amiet (1967) has restored the archaeological context of its scattered terracotta decoration. The actual scheme of decoration is impossible to reconstruct with certainty.

At some height on the walls zoomorphic pegs were used (Amiet 1966: figs. 368, 380 ff.; 1967), but whether to secure plaques is not evident from the publications.

(2) Glazed fists ('Hands of Ishtar')

Among the baked clay architectural fittings used in the Neo-Assyrian period there is a group of life-sized, and slightly larger than life-sized, shanked human fists, whose exact function has yet to be established (Buren 1930: 270-2; 1945: 59-9; Peltenburg 1968; Frame 1991). Peltenburg proposed that they were used primarily 'as window-ledge fixtures of a decorative and apotropaic nature', largely on the evidence of a basalt frame from Hama, level E, carved with a series of alternating, projecting talons and recessed rosettes (Peltenburg 1968: pl. XIV). As these fists were either glazed or covered with bitumen, sometimes overlaid with sheet metal, an external or an internal use is possible, though the glazes would not have withstood water effectively. In the North-West Palace at Nimrud Smith found one 'planted upright in the wall, embedded in mortar between the bricks' (Smith, G. 1875: 75 ff., 429). At Assur they were also reported in a vertical position, though Andrae, probably correctly, took this to be a reuse (Andrae 1925: 63, fig. 36). He preferred to see their role as decorative: inserted inside rooms under the roof-beams or as supports for glazed friezes (Andrae 1913: 7; 1925: 67). A role in ceiling or roof construction was almost certainly their most common use (cf. Preusser 1955: pl. 14b). Frame (1991) has provided a detailed catalogue of these objects with a thorough study of their inscriptions.

Fists have been reported loose in debris from all major Neo-Assyrian sites (Nimrud: Layard: 1853^a: pl. 84, 14, 16; Smith 1875: 75 ff., 429; Mallowan 1953: 11; 1954: 121, 124, 143; Nineveh: Campbell Thompson and Hutchinson 1931: 99, pl. XX. 55, 57-8; Khorsabad: Place 1867-70: i. 86; Assur: Andrae 1913: 8, pl. 8, fig. 5, 36, pl. CII.9464, 43, pl. LXXIX; Preusser 1955: 21, pl. 17). In Syria a variant form is known from Zinjirli, where they resembled cupped hands; they are glazed but uninscribed (Andrae 1943: 60 ff., fig. 73, pl. 31 d-e). They may also have been used in Urartu (Peltenburg 1968: 58 n. 6). They are first recorded in Assyria with inscriptions of Assurnasirpal II and appear to be most popular in the ninth century BC; none have seventh-century inscriptions. The inscriptions refer to palaces, to temples, and possibly to gates. They have also been found loose in private houses at Nimrud, and by the city wall at Assur, where thirteen were also found in a tomb (Haller 1954: 155: tomb 53).

No certainly Middle Assyrian examples have been reported, nor are any precursors evident outside Assyria before their earliest appearance there. They seem to be a local phenomenon. As has been noted, their structural role is obscure and may have been vari-

ous. None is made to carry any great weight. The only constant in their role may have been apotropaic (Buren 1945: 57 ff.). As intimate association with a particular deity is not evident in the available archaeological and textual evidence, the popular description 'Hand of Ishtar' is best avoided as a generic term (cf. Frame 1991: 357-9).

(3) Glazed-brick friezes

The use of glazed bricks to produce friezes comparable to those achieved in sculptured reliefs and murals is not evident in the material record before the Neo-Assyrian period, though textual evidence indicates extensive use of glazed bricks (apart from the *sikkati*; see above) in the Middle Assyrian period; evidence from sites like Dur Kurigalzu and Nuzi is too scattered to reconstruct assemblages. The earliest textual reference to systematic glazed brickwork may be in a text of Adad-nirari I (c. 1305-1274 BC) (Reade 1979^a: 19; Nunn 1988: 165). Tiglath-Pileser I (c. 1114-1076 BC), in describing the palace he built at Nineveh, speaks of 'bricks glazed (the colour of) obsidian, lapis lazuli, *pappardilû*-stone (i.e. yellow), (and) *parûtu*-stone (white). I installed on its towers replicas, in obsidian-coloured glazed brick, of date palms . . .' (Grayson 1976: 33; modified after Oppenheim 1970: 17; cf. Lackenbacher 1982: 110, 114-15).

These texts indicate that architectural details, if not true panoramas, were finished in glazed brick by the end of the Middle Assyrian period. Although moulded-brick friezes were a feature of Kassite architecture (see above) the published examples do not appear to have been glazed, though similar friezes of the twelfth century at Susa were (Amiet 1976^a). Throughout the Neo-Assyrian period it seems likely that true panoramas in glazed brick were to be seen most commonly in palaces (for surveys cf. Salonen, A. 1972: 157 ff.; Nunn 1988: 165 ff.).

Tiglath-Pileser I has been credited with the glazed-brick frieze on the lower façade of the Assur Temple at Assur, depicting battles and processions (Haller and Andrae 1955: 56). But Weidner (1926) argued, on epigraphical grounds, that this decoration should be attributed to Sargon II (c. 721-705 BC); Fridman (1969) has presented reasons for identifying the king here as Tiglath-Pileser III (744-727 BC) (see below). Consequently, there appear at present to be no surviving glazed-brick friezes earlier than the ninth century in Mesopotamia.

Reade (1979^a: 19 ff.; cf. Nunn 1988: 160 ff.) has concisely summarized the main characteristics of Neo-Assyrian glazed brickwork. He isolated three main categories of brick or tile: those glazed on the square side or face like a modern tile; those glazed on the edge and sometimes also on part of an adjoining edge or side; those with one edge moulded and then glazed.

The history of this craft is unevenly represented in the surviving material evidence, with a heavy concentration on the ninth and eighth centuries BC. The relatively uncommon panoramic designs were usually made up of glazed 'tiles', whilst edge-glazed bricks were used to frame architectural units. At Assur some of the glazed bricks were so large that Andrae described them as brick orthostats (Andrae 1925: pls. 7-10). Some old references to 'painted' bricks are to glazed ones, whose outer surface has decayed to the point where it has the appearance of matt paint.

The oldest dated Neo-Assyrian glazed brick scene is from the reign of Tukulti-Ninurta II (c. 890-884 BC). This fragmentary orthostat (66.5 × 46.5 cm.) was found in the Temple of Anu and Adad, near the east corner of the Adad Ziggurat at Assur (Andrae 1925: pl. 7; Reade 1983: pl. 18; Nunn 1988: 166, pl. 121). Fragments of a chariot scene, with inscription, are framed between chevron bands. The scene is rendered in dark line on a light blue ground in a combination of yellow, blue, white, and black. On a contemporary inscribed fragment (Andrae 1925: pl. 8; Nunn 1988: 167, pl. 122) a god drawing a bow, set within a disk, hovers over another charioteer. Although one or two other fragments from Nimrud may perhaps belong to the same reign (cf. Nunn 1988: 167-9, pl. IV, 123-4), it is to the time of Assurnasirpal II (c. 883-859 BC) that the first major evidence belongs, as indeed may these isolated pieces. This king is unique in referring technically to having had 'blue glaze baked on bricks' (Oppenheim 1970: 17; cf. Lackenbacher 1982: 86).

On the so-called 'Banquet Stela' found at Nimrud, Assurnasirpal described for the first time what sounds like extensive panoramas of glazed brick on the exterior courtyard of the North-West Palace: 'I depicted in greenish glaze(?) on their walls my heroic praises, in that I had gone right across highlands, lands, (and) seas, (and) the conquest of all lands. I glazed bricks with lapis lazuli (and) laid (them) above their doorways' (Grayson 1976: 173). As the vestiges of this decoration found by Layard in the last century are now largely lost, it is not possible to decide whether the phrase rendered here as 'greenish glaze' describes mural paintings rather than glazed-brick friezes (cf. Lackenbacher 1982: 115).

The south side of the great outer courtyard of this palace was occupied by the triple entrances to the state apartments; in Layard's words: 'Between the bulls and lions (i.e. of carved stone), forming the entrances in different parts of the palace, were invariably found a large collection of baked bricks, elaborately painted (i.e. glazed) with figures of animals, and flowers, and with cuneiform characters. It is remarkable, that on the back of these bricks, or on one of the sides not coloured, are rude designs, in black paint or ink, of men and animals, and marks having the appearance of

numbers. They appear to have been built into a wall above the sculptures' (Layard 1849: ii. 13–14; 1853^a: pl. 84; cf. Dayton 1978: 374, fig. 337; to be dated later than Assurnasirpal II, as Nunn 1988: 172–3).

In excavating the Temple of (Ishtar) Sharrat-niphi at Nimrud, built by Assurnasirpal II, Layard found that the exterior walls had been adorned with glazed bricks as also were the battlemented 'altars' on either side of the entrance (Layard 1853: 359; cf. Reade 1983: water-colour on contents page); such also was the case with the Ninurta Temple (Reade 1983: fig. 3) and the Kid-murru Temple, excavated by Rassam in 1878 (Rassam 1897: 225).

Fragments of glazed-brick friezes found at Nineveh include military and cult scenes set within framing bands of chevrons and guilloches, comparable to those on the better-known carved stone orthostats of Assurnasirpal's reign, though they may not be earlier than the reign of Shalmaneser III (c.858–824 BC) (Campbell Thompson and Hutchinson 1931: 80–1, pls. XXVIII–XXXII; Dayton 1978: pl. 23: 1; Nunn 1988: 169–70, pls. 125–30). 'The colours most commonly used were white, yellow, green, black, more rarely brown, and very rarely red' (Campbell Thompson and Hutchinson 1931: 83). Scattered glazed bricks were also published from above or near the Nabu Temple site at Nineveh, again using blue, green, yellow, white, and brown, the latter usually for outlines (Campbell Thompson and Hutchinson 1929: pl. LVII.350–8; Nunn 1988: 171).

The most grandiose architectural monument of the reign of Shalmaneser III (c.858–824 BC) was the *ekal mašarti* (Fort Shalmaneser), which occupied the south-east corner of the city enclosure at Nimrud. Oates (D. 1962: 9; pls. II–III), in justifying his restoration of the West Gate, noted that:

The proportions . . . and some idea of the overall size of the battlements is given by the rows of impressed rosettes in glazed brick which were commonly used to decorate the upper parts of walls. No glazed bricks have been found among the ruins of the outer wall of Fort Shalmaneser, but they were employed on the north face of the south-east corner tower, and from components recovered there we know that the height of each rosette was three courses.

A semi-elliptical panel, over four metres high, surmounted the courtyard doorway of Room T3 in Fort Shalmaneser, and on the outer wall of the throne room (T1) there had been a glazed-brick frieze of rosettes, found scattered in the courtyard. Reade (1963; cf. Dayton 1978: pl. 24 (colour); Nunn 1988: 173; pl. 140) restored and published the panel, which bears an inscription of Shalmaneser III. In the lower centre panel two kings stand facing one another below a winged disk containing 'Assur', then comes the inscription, and above it rampant bulls, heads turned back, flanking a tree. The whole design is framed first by

rosettes and guilloches, then by a triple border: from inside to out, of alternating pomegranates and buds; of kneeling goats and palmettes. The glaze colours were green, yellow, white, and black on an entirely (originally ultramarine) blue background.

In Room T20 of Fort Shalmaneser glazed bricks were marked on top with pictographs in white paint showing a plough, a human face, a mace, and other motifs, as well as Aramaic letters in black paint. This is their earliest recorded use in Assyria, possibly indicative of artisans from an Aramaic-speaking region (Curtis 1990: 11, fig.; 1992: 161).

Individual glazed panels are less commonly reported. One, measuring 12 × 9 inches, from Layard's excavations at Nimrud, of the ninth century BC, shows a king holding a libation bowl, followed by attendants (Layard 1853: 167–8; Perrot and Chipiez 1884: 307–8, pl. 14; Andrae 1925: 29; Reade 1983: fig. 41 (colour)). In a dwelling house (no. 69) at Assur, on the outer line of the Neo-Assyrian city wall, an 'orthostat' (56 × 27.5 cm.) was set into the lower part of an inside wall. This may be a secondary use (Preusser 1954: 54–5, pl. 25b; Andrae 1925: pl. 10 (colour) for an object made in the ninth century; but its dating is not certain. A deity, or his statue, set on a podium, is worshipped by a man standing before it. In the field above his head is a locust; in a line at the top: a sun disk; a winged disk; a crescent; and a rosette (cf. Nunn 1988: 182, pl. 145; late eighth century). The only provincial centre so far to have yielded evidence for Neo-Assyrian glazed brickwork is Carchemish, where it is probably to be dated to the ninth century (Woolley 1952: 159–60, frontispiece, pl. 33; Nunn 1988: 184).

The best-known Neo-Assyrian glazed-brick friezes, since they were excavated in the nineteenth century and coherently published at an early date, are those at Khorsabad set up by Sargon II (c.721–705 BC) (Nunn 1988: 175 ff.). As Layard (1849: ii. 13) recognized, Assyrian builders seem to have reserved glazed-brick decoration particularly for panels or friezes set above the true voussoirs of the arches of gates and doorways (cf. Pillet 1962: pl. VIII; Reade 1983: fig. 7). Place (1867–70: i. 234; iii, pls. 9–17; cf. Albenda 1986: 97–8, pls. 150–1; Loud and Altman 1938: 15) discovered almost intact the glazed brick decoration of town gate 3 at Khorsabad. Within a border of small rosettes, typical Neo-Assyrian winged genii with pails and cones, alternating with large rosettes, provided an apotropaic frieze. The figures are in yellow; the rosettes in white on a blue ground. More spectacular were the tableaux flanking entrances in that part of the palace designated 'Harem' by Place, but shown by the subsequent American excavators to be a temple complex (Loud 1936: 80 ff.). In these palace shrines the glazed-brick friezes flanked the doorways leading from the courtyard into the temple itself, where they took the place of the

sculptured winged bulls and genii flanking palace portals. They rose about 1.50 m. in height, from ground level, and extended the width of the buttress with a projection of 1.0 m. from the buttress face.

On the Sin and Shamash Temples at Khorsabad (Loud 1936: figs. 99, 104–6, 110, 115) single figures of a lion, an eagle, a bull, a fig tree, and a seeder-plough are set in sequence on the front face, with the king and his chief minister(?) at either end. In the Ningal Temple space forced the omission of the eagle and the bull. The figures were outlined in black on a vivid ultramarine blue ground; they were of yellow with black hair and beards. The leaves of the fig tree were green; the border rosettes were white-petalled with yellow centres and stripes. In the Nabu Temple (Loud and Altman 1938: 56 ff.) a pair of friezes flank the doorway through which access was gained to the central court, whilst in the central court they adorn the façade of the inner temple exactly as round Court XXVII in the palace. The friezes here were less well preserved; but did not, in what is recognizable, substantially differ from the others (ibid.: pl. 17D, 44).

This by no means exhausts the role of glazed bricks at Khorsabad, or presumably elsewhere in the later eighth century BC, since they are regularly found, if not always in quantity, in the debris of rooms, where they had served in some minor way to decorate the interior, perhaps as narrow rows, commonly of rosettes, between wall-top and ceiling. A more individual use is their presence, as a single band of rosettes, in alternate horizontal joints of the stone facing of the arched bridge connecting the palace and the Nabu Temple (Loud and Altman 1938: 56, pl. 12). Their only occurrence as part of a free-standing structure was in the central court of the Nabu Temple, where they formed part of an altar (ibid.: 42, pl. 42, pl. 22C–F). This stood 1.50 m. square, but both its original height and its surface designs were lost.

Archaeological and philological arguments suggest that the glazed frieze showing a king on campaign and a fragmentary scene of a king enthroned from the podium in front of the temple of Assur in that city should be dated to the later eighth century rather than to the reign of Tiglath-Pileser III (c.744–727 BC) (Nunn 1988: 180–2, pl. 144; contra Fridman 1969).

Outside Assyria, at Tell Halaf in Syria, what may have been an altar of comparable type, with glazed designs on its sides, stood before the ninth-century palace portal. It was in much better condition and its geometric designs were still evident (Naumann 1950: 71 ff., colour plates I–III). In this case the design consisted of registers of rosettes in green and yellow, a scale pattern, in yellow and white, and a guilloche in green, yellow, and white. In some cases here the bricks had been cut to shape to make up the pattern rather than it being painted on the surface of rectangular bricks.

Amiet (1966: pl. L) has reconstructed a similarly decorated podium of the eighth century BC in a temple at Susa. It is possible that it is from this same building, or a related structure, that two pieces of decorated glazed terracotta, now in the British Museum, originally came. They were published by Smith (S. 1928: pls. XVI, XXII; BM 9196, 117981) as from the excavations by Loftus at Warka; but the protome, at least, is much more likely to be from his excavations at Susa.

In his inscriptions Sennacherib (c.704–681 BC) refers to his palace as embellished with glazed bricks the colour of obsidian and blue (Luckenbill 1924: 107.vi.42); he also provides what may be the first textual reference to 'glazed' bricks for a temple (ibid.: 148). There is no archaeological material certainly relevant to these texts (cf. Nunn 1988: 182).

In the part of Nimrud now known as 'Fort Shalmaneser' Layard found a series of decorated glazed bricks ('tiles') reused in a pavement whose exact location is unknown (Layard 1853: 165–6; 1853^b: pls. 53–4; Nunn 1988: 183, pls. 146–51). They show Assyrian soldiers in seventh-century uniforms campaigning in Egypt (Postgate and Reade 1976–80: 317). The technique is distinctive; 'the colours have faded . . . The outlines are white, and the ground a pale blue and olive green. The only other colour used is a dull yellow' (Layard 1853: 166). Esarhaddon refers in his inscriptions to the construction of glazed-brick friezes (Borger 1956: 62). Although Ashurbanipal (c. 668–627 BC) boasts of building an entire New Year's Chapel of blue and red glazed bricks, relevant archaeological material has yet to be identified (Oppenheim 1970: 17).

In contrast to the relatively continuous evidence for use of glazed 'tiles', plain or figured, in Neo-Assyrian architecture, the use of moulded or shaped glazed bricks is much rarer. They have been reported, and then, unusually, at Nineveh (Rassam 1897: 222; Campbell Thompson and Hutchinson 1931: pl. 26: 2, 4; Nunn 1988: pls. 131–6, 137) and at Nimrud from a panel above a door of Assurnasirpal (Postgate 1973: 193). None seems to be securely dated outside the ninth century BC.

Both the Old Testament and classical authors preserved memories of the glazed-brick decoration of Babylon. Ezekiel (23: 14) recounts how Oholibah 'saw male figures carved on the wall, sculptured forms of Chaldaeans, picked out in vermilion', whilst Diodorus Siculus, writing in the first century BC, included a description of two major palaces, one on either side of the Euphrates, given by Ctesias (early fourth century BC):

And within this (the outer palace wall) she (Semiramis) built a second, circular in form (Koldewey preferred 'annular'), in the bricks of which, before they were baked, wild animals of every kind had been engraved, and by the

ingenious use of colours these figures reproduced the actual appearance of the animals themselves.

(II. viii. 3-6)

Then:

On both the towers and the walls there were again animals of every kind, ingeniously executed by the use of colours as well as by the realistic imitation of several types; and the whole had been made to represent a hunt, complete in every detail, of all sorts of wild animals, and their size was more than four cubits. Among the animals, moreover, Semiramis had also been portrayed, on horseback and in the act of hurling a javelin at a leopard, and nearby her husband Ninus, in the act of thrusting his spear into a lion at close quarters.

(II. viii. 6-9)

From the eighteenth century travellers commented on the prevalence of glazed bricks at Babylon and other sites in the south. But it was not until the German excavations at Babylon that the account given by Diodorus was actually illustrated: 'The discovery of these (glazed) bricks formed one of the motives for choosing Babylon as a site for excavation. As early as June 1887 I came across brightly coloured fragments . . .' (Koldewey 1914: 26). Koldewey (1914: 129-31) later commented on the description left by Ctesias in the light of his own discoveries. The first passage appeared to describe the Neo-Babylonian decorations of the 'Processional Way' and the 'Ishtar Gate' (see below), whilst the latter recalled the fragmentary glazed bricks of the 'Persian Building', for only there were human figures discovered (cf. Haerinck 1973). Nebuchadnezzar II (c.604-562 BC) refers in his inscriptions to the blue bricks of the temple tower *Esagila* at Babylon, especially those of the sanctuary which crowned it (Langdon 1912: 114. i. 43). The 'silver' coloured bricks decorating the approach to another chapel were probably also glazed (Langdon 1912: 128. iii. 56; cf. 158. vi. 36; cf. Oppenheim 1970: 17).

At Babylon two complete Neo-Babylonian schemes of decoration in glazed brick may be reconstructed, attributed to Nebuchadnezzar II (cf. Nunn 1988: 185 ff.; pls. 152-8). In the great royal palace (the 'southern Citadel') the throne-room lay on the south side of the main courtyard approached through three doorways, one in the centre flanked by one towards each end of the façade. Although details in the restoration have become the subject of continuing debate (cf. Nunn 1988: 185 ff. for summary), its general layout is agreed. The entire wall was decorated with panels of slender columns with volute capitals, connected by a series of palmettes, rendered in yellow, white, light blue, and green, on a dark blue background. Above was a frieze of white double palmettes, bordered below by a band of squares, alternately yellow, black, and white. White borders, against the dark blue background, heightened the effect. Below was a procession

of lions *passant* on the central archway (Koldewey 1914: 104 ff.; 1931-2: 84 ff., pls. 37-8, colour; Meyer, G. R. 1965: pl. 174 in colour = Moortgat 1969: pl. 292, not in colour). Better known, primarily from the modern reconstruction in the Vorderasiatisches Museum in Berlin, is the so-called 'Processional Way' and the 'Ishtar Gate' through which it passed. Along the lower walls of the 'Way' were lions *passant* framed above and below by rosettes; blue glazed-brick battlements ran along the top. On the walls of the 'Gate', from the top to deep in the foundations (where they were not glazed) were separate rows of bulls and 'snake-dragons'. They were widely spaced, within patterned borders, on battlemented façades entirely surfaced with deep blue glazed brick (Koldewey 1914: 38 ff.; 1918; Meyer, G. R. 1965: pls. 168-71 in colour; Moortgat 1969: pls. 289-91, not in colour; Nunn 1988: 189).

It is noticeable how the glazed-brick friezes of Neo-Assyrian palaces are little more than murals following the conventions used also in the contemporary narrative relief sculptures. By contrast the glazed-brick friezes of Babylonia in the sixth century BC, with their emphasis on high relief and individual motifs, follow the independent traditions of Babylonian relief sculpture as represented on the finest *kudurrus* of Middle and Neo-Babylonian times. So long as there is a complete absence of evidence between the Kassite period and the sixth century BC it may only be conjectured that Babylon had its own enduring tradition of moulded terracotta architectural sculpture, glazed and unglazed, parallel to that in Susiana (Elam), independent of developments in Assyria.

The scattered evidence for glazed bricks, usually monochrome, from other sites in Babylonia offers no coherent designs like those recovered at Babylon. They are simply indications of the use of glazed bricks quite commonly in religious, if not also in secular, structures. At Ur Woolley reported that 'in the rubbish lying against the sides of the Ziggurat there were found quantities of bricks of Nabonidus of which one side, or one side and one end, were covered with a bright blue vitreous glaze' (Woolley 1939: 133; cf. Hall 1930: 81). Examples now in the British Museum (BM 116981) are blue, blue-green, and deep red in colour.

None were found *in situ* and Woolley therefore assumed that they had fallen from high on the structure, perhaps from the sanctuary on top, by analogy with Nebuchadnezzar's *Esagila* description.

The famous inscription in which Darius I described the building of his palace at Susa clearly informs us that 'the men who wrought the baked bricks these were Babylonians' (DSf: Kent 1950: 142 ff.; Vallat 1971). In Mesopotamia itself only at Babylon are there vestiges of glazed brick decoration certainly of the Achaemenid period. The so-called 'Persian Building', adjoining the Southern Citadel, contained fragments of polychrome

glazed bricks, probably from friezes of guards (Koldewey 1931-2: 121 ff., pl. 28 in colour; Haerinck 1973). The date of this building is uncertain. The excavators attribute it to Artaxerxes II, as does Vallat (1989). Schmidt (E. F. 1953: 28) and Haerinck (1973: 129) have preferred Darius I. As Vallat points out, an inscription, and very similar glazed brickwork at Susa attributed to Artaxerxes II, are in his favour if inscription and bricks are contemporary. As might be anticipated, such decoration was relatively rare at Persepolis, where stone was readily available, and restricted in its use of motifs (Schmidt, E. F. 1953: 70-2). But it was well represented at lowland Susa, associated with various rulers through the Achaemenid Dynasty. The repertory, whether of individuals or groups of people, of animals and monsters, or of floral designs (Haerinck 1973: 118 ff.; Nunn 1988: 194-8), has much in common with that carved in stone at Persepolis, where much of it was originally picked out in paint of comparable colours (Roaf 1983: 8-9). Glazed bricks recovered from Borsippa by Rassam (1897: 270-1; Reade 1986: 48, pl. XIVb, c, XVa, b) are probably Achaemenid in date (Nunn 1988: 190, pls. 155-6).

The persistence of the glazed-brick tradition in Mesopotamia is clear from the decoration of the Seleucid Anu-Antum Temple at Uruk (Jordan 1928: 18 ff., pls. 48 ff.).

(4) Techniques in glazed brickwork

Brick bodies and glaze colourants. The body of glazed bricks does not appear to have differed significantly from that used for unglazed bricks in Mesopotamia until the Achaemenid period. Dayton (1978: 375), for instance, describes a glazed brick from Fort Shalmaneser at Nimrud as a vegetable-tempered clay brick which did not appear to have been fired much above 900 °C. It was wedge-shaped, not rectangular in section, with a glazed face 110 mm. long; the back face tapered to 102 mm. It had been fired face-up in the kiln, since the glaze had run in streaks down the unglazed side in firing. The glaze showed the poor adhesion commonly seen on Neo-Assyrian glazed bricks. It has not yet been established whether such bricks received a special surface treatment when used to decorate outside walls. Freestone (1991) has analysed the bodies of ninth-century plaques made of calcareous clays with chaff temper, fired above 850 °C.

In the Achaemenid period a body of sintered quartz (or faience) appears, indicating a conscious effort to provide a body fabric to which glazes would adhere better. Certainly the surface of surviving Achaemenid glazed bricks is commonly less 'crazed' than that of Neo-Babylonian or Neo-Assyrian ones. This change may be explained by either the fact that the Neo-Elamite faience industry had a greater impact on those producing bricks for glazing than did its Mesopotamian

counterpart (whose existence at this time is anyway doubtful) or that Egyptian technology had already influenced Achaemenid craftsmen by the reign of Darius I.

In 1913 Bigot reported on his attempt to replicate glazed bricks like those used at Susa for the frieze of archers:

En résumé, les Perses fabriquaient un mortier avec du sable assez grossier et une chaux spéciale, ils le plaçaient dans des moules, puis le laissaient sécher et durcir à l'air, et le cuisaient à une température élevée. Les pièces, à leur sortie du four, étaient ajustées, retouchées, puis recouvertes d'une matière solide, en poudre impalpable, pour boucher les pores de la surface à émailler. Les cernures étaient disposées à la main et les émaux placés dans les cernures et autour. Les pièces étaient mises au four, disposées de façon que les surfaces émaillées restassent aussi horizontales que possible, et le four était porté à une haute température. Ces deux opérations de cuisson pouvaient se faire avec la plus grande rapidité sans aucun risque de brisure au feu, puisque les matériaux ne sont pas argileux. (Bigot 1913: 278)

Mecquenem (1947: 48) reported thus on the Susa bricks: 'les carreaux émaillés sont faits d'une fritte formée de silex broyés assez grossièrement mélangés à un mortier de chaux (20 per cent)'. Schmidt (E. F. 1953: 71) described the glazed bricks he recovered from the Apadana at Persepolis as 'a tan, rather porous, frit-like mass, apparently made of lime and sand'. Dayton (1978: 383) analysed a Persepolis brick, commenting that 'the body was very similar to a modern sand-lime brick; no clay was present as the absence of alumina showed. The calcium oxide proportion was about 9 per cent, and the amount of SiO₂ about 90 per cent.' Koldewey (1931-2: 122), on the basis of analyses by Rathgen, described the glazed bricks from the 'Persian Building' at Babylon in the same terms.

The glazes on some bricks, probably of the Neo-Babylonian or Achaemenid period, found at Borsippa by Layard (1853: 166), were analysed in the middle of the last century: 'The yellow is an antimonate of lead, from which tin has also been extracted, called Naples Yellow . . . The white is an enamel or glaze of oxide of tin . . . The blue glaze is copper, contains no cobalt, but some lead . . . the red is a sub-oxide of copper.' These old analyses are the ultimate origin of such recurrent statements as: 'tin glazes (or enamels) were first used in decorating brick panels by the Assyrians after 900 BC, then the knowledge of their manufacture was lost until it was rediscovered by Islamic potters in the ninth century AD' (Rice 1987: 12). In fact there is no evidence at present for tin-glazes at this early date. The old results have been corrected by the recent analyses of Hedges and Werner (cited by Dayton 1978: 49; cf. also 378 ff.). The base glazes are high-potash, high-magnesia, soda-lime-silica type with antimony-based opacifiers.

Hedges analysed three different areas of colour (white, yellow, and green) on some weathered Neo-Assyrian glazed bricks from Nineveh (Campbell Thompson and Hutchinson 1929: pl. LVII):

These were estimated for their content of Cu, Zn, Pb, Sn, Sb. Pb was present above the trace level only in the yellow areas, together with Sb, and X-ray diffraction work on a sample of the material showed that it contained lead antimonate (with very probably an excess of lead in the glaze). Antimony was present both in the white and yellow areas. Presumably the white of the glaze is due to the presence of calcium antimonate. Tin was only present in traces on the green areas, which were the only areas containing a substantial amount of copper (probably originally up to 5 per cent of the oxide). Zinc was present in all areas at the 0.1–0.2 per cent level; it was not associated with the presence of copper in the 9 samples examined.

(Hedges and Moorey 1975: 31)

Freestone's (1991) analyses of ninth-century glazed plaques indicated lead antimonate (yellow), copper (green), calcium carbonate (white) and manganese (black) as colourants.

Glazes on the Neo-Babylonian bricks from Babylon, now in Berlin, have been studied by Fitz (1982). Cobalt and copper ions in trace amounts produced the blue glazes; cupric ions contributed to the turquoise-coloured glazes. Lead antimonate was the yellow colourant, whilst calcium antimonate was the opacifier for the white and some of the turquoise glazes. The black is probably due to iron; manganese levels are low.

Fukai (1981: 25 ff.) has published analyses of four glaze colours on a brick of the Achaemenid period from Susa. The yellow contained 44 per cent lead, with lead antimonate as colourant. Comparable high-lead yellow glazes were reported on Iron Age objects from Azerbaijan (Fukai 1981: 21). No lead was reported in the white. The green, coloured by copper, had lead in it. The black/purplish colour was low in lead with copper oxide, iron oxide, and cobalt oxide as colourants. Dayton (1978: 378–9), in publishing analyses of glazes on other Susa bricks, attributed the blue colour to cobalt modified by antimony, the orange/yellow to iron oxide rather than to reduced copper. The dark dividing lines on a brick from Persepolis were said to be of iron oxide rather than manganese; but the character of these separators in polychrome designs requires more research (see below).

Design and Layout techniques. In the late eighth century at Khorsabad the glazed bricks were the standard fire-baked bricks. They were 'never employed singly, they were first set up as units, perhaps in the "paintshop", where the design was painted upon the face of the temporarily erected panel or structure. The painting finished, the bricks were carefully removed for the firing required to effect the glaze. At the time of removal for glazing they were marked in such a way as

to expedite their final re-assembly' (Loud 1936: 93). 'Such a process is evidenced by the fact that, while an entire decorative design may be repeated over and over again without apparent variation, one example is never exactly the same, brick by brick, as another' (Loud and Altman 1938: 14; cf. Albenda 1991: 46–7 on techniques).

Reade (1963), in publishing his reconstruction of a large ninth-century panel from Nimrud (see above) has provided a more elaborate description of the procedures used in manufacture and assembly. Fitters' marks were painted in thin glaze on the upper side of almost all bricks, one to denote the course to which the brick belonged, the other its position in that course. Significantly, there were omissions when the shape or decoration of a brick was itself distinctive; distinctions were also made by using different glaze colours. The bricks were slightly baked and, when necessary, shaved down prior to painting. 'The design in all its details was then drawn on them in black; these lines have sometimes survived where the glaze has perished. The fitters' marks were added while the bricks were being put into or taken out of position; for the marking was certainly done before the glazing, and it is quite clear that, for glazing, the bricks were picked up individually. This is indicated by several slight inconsistencies of line, where the painter did not conscientiously follow his preliminary outlines, and some of the colour, as where a single chevron, black on one brick, becomes white on the next; moreover the dribbles of glaze, which continually obscure the fitters' marks, never coincide on adjoining bricks' (Reade 1963: 40). They were baked again after decoration, with the painted side upwards; on many bricks the melted glaze has run over and trickled down the sides.

In the case of Assyria it is possible to make direct comparisons with mural paintings. As might be expected, the techniques of draughtsmanship were close. The Assyrian by contrast to the Neo-Babylonian and Achaemenid glazed-brick friezes were murals in every sense save that glaze replaced pigment as the medium and surface treatments were different. Evidence, when available, from Neo-Assyrian sites other than Khorsabad and Nimrud, indicates that procedures were uniform in court workshops.

The range of colours used in Neo-Assyrian glazed friezes is well documented. Nunn (1988: 157–9) has tabulated the evidence reign by reign. The colours used for geometric designs were green, yellow, dark brown, and white, with less commonly an intense blue and more rarely a strong red. On the figured designs the colours are again yellow, blue, green, white, and brownish-black. Caution is needed in commenting on the colours used, since modern reproductions often give a richer impression than may be justified. In a single composition the range of colours is only from three to

five: brown, green, blue, dark and pale yellow (Layard 1853^a: pl. 84.12); orange, lilac, white, yellow, and olive-green (Botta 1849–50: pl. 155, fig. 3). Combinations of four colours are more common: red, white, yellow, and black (Botta 1849–50 pl. 155, fig. 2); deep and pale yellow, white and brownish-black (Layard 1853b: pl. 55, fig. 6); yellow, blue, white, and olive-green (Layard 1853^b: pl. 53, figs. 3, 4; pl. 54:12–14). When as few as three colours are used, the background is generally also the colour of the figures. Yellow, blue, and white on a blue ground (Layard 1853^b: pl. 53, figs. 2, 5; pl. 54, fig. 9); the same colours on a yellow ground (ibid.: pl. 53, fig. 1); white and yellow on a blue ground (ibid.: pl. 54, fig. 7); white and yellow on olive-green (ibid.: pl. 53, fig. 1). The strength of outline is marked. It is almost always coloured differently from the object depicted, either in black, white, yellow, or brown. The figures, by contrast with the sculptured reliefs, are generally slimmer and less muscular; size varies considerably, from brick-size figures to others standing at least three feet in height.

Various methods have been proposed for the construction of the Neo-Babylonian glazed reliefs, the earliest being that of Thomas in 1863 (cf. Oppert 1863: i. 145) and the most comprehensive Koldewey's (1914: 28 ff.). A method of mass-production is evident from the constant reproduction of the same few motifs. Presumably a master relief was made for each motif and then moulds taken from it for forming the individual bricks into which the master pattern had been divided up. 'The edges of the figures do not project more or less squarely as they do in Assyrian alabaster reliefs, but in an obtuse angle. Also there are no even upper surfaces as there are on Assyrian stone carvings. Both peculiarities would considerably facilitate the withdrawal of the tile from the mould' (Koldewey 1914: 29). The brick was fired before glazing; 'the contours were then drawn on it with black lines of a readily fusible vitreous composition, leaving clearly marked fields. These were filled with liquid coloured (glazes), the whole dried and then fused, this time apparently in a gentler fire. As the black lines had the same fusing-point as the coloured portions they often mixed with the colours themselves . . . With the Persian glazes . . . these black lines have a higher melting point and therefore remain distinct and project above the coloured glazes after firing' (Koldewey 1914: 29–30). Fukai (1981: 25) has explained these prominent outlines as indicative of a squeeze technique, like the use of a bag for icing a cake. Built-up lines were made by squeezing out the glaze through a nozzle from the bag. As this technique is particularly evident on an unusually elaborate glazed jar from the excavations at Babylon (Koldewey 1914: fig. 152 (frontispiece); Meyer, G. R. 1965: pl. 157: both colour), dating to the seventh or sixth century BC, Fukai argued that the technique passed

directly from Neo-Babylonian to Achaemenid craftsmen. As the brickmakers at Susa (see above) are known to have been Babylonians this makes good sense; but the matter still needs detailed investigation.

Some of the surviving glazed bricks from Persepolis and Susa (cf. colour plates in Dayton 1978: pls. 27–8) appear to the eye to have *cloisons* carefully made from short, thin strips of some metal, possibly sheet copper or bronze. This method of laying out the design is in marked contrast to the black lines, whether flat or projecting, just commented on and traditional before the Achaemenid period. Such 'metal' outlines seem also to be used on at least some parts of the glazed brick decoration of the Achaemenid palace at Babylon (cf. Koldewey 1931–2: pl. 39f, t). This technique has a close affinity with that used for the polychrome inlays so popular in the 'Court Style' of jewellery produced under the Achaemenids.

In the Neo-Babylonian period green and brown do not seem to have been fashionable colours on glazed friezes (cf. Koldewey 1918: 27; 1931–2: 85), though they reappear in Achaemenid times at such major sites as Babylon, Persepolis, and Susa (Haerlinck 1973: 120). Blue and yellow, black and white, retained their popularity throughout; red (chemically changed to green) appeared at Babylon in Neo-Babylonian times (Koldewey 1918: 27, 85), but not apparently in the Achaemenid period.

In order to facilitate the assembly of a design, as in Assyria, the bricks were marked on the upper edge in rough glaze with a series of simple signs and numerals. Sign was intended to match with sign in the laying. This system was best seen at Babylon in the 'Southern Citadel', where more coherent sections of glazed brickwork were recovered. Here each colour was outlined in black and the position marks used again, as on the 'Ishtar Gate'. Koldewey described it as follows:

Here (i.e. on the capitals) the markings consist of numerals combined with dots. They are marked on the upper edge of the bricks with a poor, somewhat blackened, glaze. The signs that distinguish the courses are in the centre, those for the lateral arrangement are close to the vertical joints. Each of the latter signs is a counterpart of the sign near the vertical joint of the brick adjoining it. On the central signs that mark the courses the top course of the upper row of volutes has one stroke, the second has two, and so on up to seven. The seven courses of the lower row of volutes are numbered in the same way, but the groups of strokes are preceded by a dot to distinguish them from those of the upper series. For the sequence of the bricks one of the intermediate ornaments forms a single unit with the capital adjoining it on the right. All the bricks that belong to the same unit bear the same number of strokes. The counting runs from left to right. The numerals are crossed by a transverse stroke, which, in order to mark the direction of the signs, has a dot attached to it. This direction line is parallel to the vertical joint on the central ornament, and parallel with the front of the brick on the

volutes. It is quite probable that the separate groups were first provisionally built together, at any rate for the purpose of drawing the design, which is still visible in red colour under the (glaze), so as to secure that boldness and freedom of outline which delights us with its beauty at the present time. But when once the process of (glazing) began—the transportation of the bricks, the drying, the burning, and all the unavoidable processes that had to be carried through before the bricks could be placed in the wall—it would be impossible to keep them apart. The marks would then afford the only means of placing them correctly on the walls, and rendering it easy to deliver them in groups to the respective masons.

In order to close the joints completely the bricks are slightly wedge-shaped. The joints between the courses are laid in mud over bitumen, which, as we observe in other careful building, does not extend to the front of the building but stops at a distance of half a brick, thus avoiding any blotching of the face of the wall.

In addition to the black outline and the dark blue ground, the colours employed are white, light blue, yellow, and red. The red now has everywhere the appearance of green, but where this colour is thickened, as for instance where drops have trickled down, a core of brilliant red is found coated with green, which must be the result of a superficial change of colour that has occurred during the course of ages. We have also some large pieces of (glaze) from ancient breakages in which we can observe this same fact. The green coating extends to a depth of 2 to 3 millimetres, which in the ordinary (glaze) on the brick would entirely supersede the original red colouring. This is an important point, because the manufacture of opaque red glaze has been attended with considerable difficulty even in recent times, while transparent red glaze is made with ease at the present time. Thus in forming a judgement on the sense of colour of the ancient Babylonian it must not be forgotten that this fine red was included in his scheme. We can all imagine a red-haired, but not a green-haired lion.

(Koldewey 1914: 105–7; cf. Nunn 1988: 153 ff., figs. 10–12)

This chemical change is typical of a red glaze (or glass) coloured by reduced copper. This effect would not have been observed had the colourant been iron.

(d) Wall-painting

Wall-painting was the most vulnerable of all the builder's crafts in Mesopotamia. As painting on plaster allows for a greater freedom of expression than carving in stone, the disappearance of so much of this aspect of craftsmanship in the region may well have deprived us of some of its most varied and lively productions. What has been discovered in excavations is often fragmentary, extremely difficult to retrieve, to restore accurately, and to publish in detail. As with reports of glazed artefacts, publications of murals need to be treated with caution, particularly when they are reproduced in colour, usually not from the originals but from modern copies of variable quality. At one point or another every predictable fault is encountered and exposed when specialists restudy at leisure what has

survived in museums: large and small inaccuracies in restoration and copying; over-confident restoration of designs; inaccurate descriptions of design and technique; very partial study of the surviving pieces; unstable colours. Where field records are poor, reconstructions are enduringly controversial.

Murals have primarily been the concern of art historians interested more in matters of iconography and of style than in questions of technique and pigment analysis. In histories of Mesopotamian art, for obvious reasons, as commonly in field reports, it is the monumental designs which receive most attention and they belong to major public buildings (cf. Moortgat 1959). However, more meagre and much more scattered evidence in reports suggests that the purely ornamental painting of ceilings, walls, and woodwork (or imitations of it and of decorative stones) was much more common and widespread, both in public buildings and in private houses in all ranks of society, than the published evidence might indicate. The basic pigments were readily available and, as far as may be assessed, relatively cheap.

The following survey does not seek to repeat information about design, about iconography, or about layout accessible in the standard histories of art in Mesopotamia and in original excavation reports. Tomabechi (1983–4: 74) has announced a major study of Mesopotamian wall-paintings, for which she has already produced a series of articles. Nunn (1988) and Spycket (1988; 1989) have published basic surveys of the evidence in published sources. A survey of paints by Forbes (1955^b) contains little that is specifically relevant to Mesopotamia and, when it does, the information is largely drawn from textual sources, which need revision in the light of subsequent philological research.

Both Sumerian and Akkadian (like ancient Egyptian) possessed four basic colour terms: black, white, red, grue (green/blue), with a term for 'variegated' (Unger 1957–71; Nunn 1988: 17–18, 238 ff.). They are given in the canonical bilingual lexical lists in this order with 'variegated' between red and grue, possibly pointing to a later inclusion of the latter (Landsberger 1967^a; Baines 1985).

(1) *Concise historical survey* (cf. Nunn 1988: 34–141) Although the transition may not yet be traced in any detail, it is already apparent, notably at Chatal Hüyük in Turkey (Mellaart 1967), that the earliest settled communities in the Near East had in no way abandoned the traditions of their Palaeolithic predecessors in the highland zone in decorating their dwellings with murals, both geometric and figurative (Aurenche 1981: 226–32). In the second half of the eighth millennium BC geometric designs were used on plastered interior house walls at Mureybet in Syria (Cauvin, J. 1978: 30), whilst there were similar traces of wall and other floor designs

elsewhere in early villages. Red and black were the most popular colours, as on the more commonly monochrome painted floors. At Bouqras some of the earliest figure designs have been uncovered; in one case birds in frieze on plastered house walls, in another a human face rendered in relief and painted red with eyes inlaid with obsidian pieces (Clason 1989–90).

At Umm Dabaghiyah in Iraq (Kirkbride 1975: 7, with figures), in the earlier sixth millennium, red, black, and yellow pigments were used on gypsum walls to depict what have been interpreted as scenes of onager hunting as well as other themes derived from nature; scenes are reminiscent of those painted on contemporary pottery. In so far as it is possible to judge, such scenes were in domestic rather than cult contexts; even at Chatal Hüyük, where 'shrines' have been specifically identified, the distinction is not always self-evident.

Although there were traces of murals in the Early Uruk period temple of level VII(?) at Eridu (Safar *et al.* 1981: 35), the earliest known Mesopotamian shrine with extensive traces of interior murals is that of the Late Uruk period at Tell Uqair (Lloyd and Safar 1943: 139 ff., pls. X–XII; cf. Nunn 1988: 60–3), where 'wall faces inside the building were also carefully mud plastered. Every surviving square foot bore traces of color washes or painted ornament.' Preservation was poor and recovery proved difficult. In some cases 'a slightly different design had been repainted over the first'. The background everywhere was white gypsum plaster; among the colours the excavators noticed the absence of blue and green. The popular plum red was very similar to that used on 'Jamdat Nasr' pottery. 'The figures were freely and competently sketched out with a red or orange line, and the corrected outline added in black on top of, or beside the red. The most usual arrangement was a band of plain color, usually some shade of red, forming a dado about 1 meter high all round the room. Above this there would be a band of geometrical ornament about 30 cm. high. The upper parts of the walls were decorated with scenes of human or animal figures on a plain white ground. Unfortunately, none of the human figures was recoverable above the waistline, owing to the proximity of the surface' (Lloyd and Safar 1943: 140). What was recovered of the figured designs on walls resemble those on contemporary cylinder seals and carved stone vases. The altar was guarded by a pair of cheetahs (cf. Buren 1939: 13), one reclining, one sitting (Moortgat 1959: pl. 7).

The paintings at Uqair indicate that the baked-clay cone mosaics in red, white, and black at Uruk (Brandes 1968) were a variant of geometric designs elsewhere painted on plaster; indeed, a façade of cone mosaics is represented among the Uqair murals. Whether murals were as widespread in major shrines at this time as cone mosaics has yet to be established; but traces of figured designs in the *Riemchengebäude* at Uruk (Nunn 1985)

and vestiges at Tell Qalinj Agha (Al-Soof 1969: 6–7) in the north suggest that they may have been.

Traces of geometric designs, alternating red and black lozenges, on the white plastered walls of a house in level XVI at Tepe Gawra (Tobler 1950: 2, 40, pl. XLIa), belong to the fourth millennium (Ubaid 3), probably earlier than the Uqair murals. In level XIII red and reddish-purple paint appears on some of the walls of the 'Eastern and Central Temple', but too low for anything significant to have survived (Tobler 1950: 33).

Evidence for mural painting in the third millennium BC is still notably rare. Little has yet been published of a reported find of wall-paintings in the temple of Inanna at Nippur (Hansen and Dales 1962: 79). Parrot published what seem to be little more than graffiti on the walls of a chapel of the Ninhursag Temple, described as 'a procession of figures, some standing on bulls, all of them treated in a schematic, filiform style: each consisting of only a few streaks of black hastily splashed onto the plaster of the wall' (Parrot 1940: 18–19, fig. 14). At Tell Halawa on the Euphrates a house of the first half of the third millennium BC was decorated with a scene of palms and possibly human figures in a simple style somewhat akin to that used at Mari (Orthmann (ed.) 1988: 101 ff.).

In describing the so-called mausoleum of Shulgi (c.2094–2047 BC) at Ur, Woolley reported that 'there seemed to be traces of bright blue paint on pieces of fallen plaster' (Woolley 1974: 3). In the same period geometric paintings adorned houses at Eridu (Hall 1930: 210, fig. 181: horizontal stripes of red and white). The most significant survivors of this period, however, may be the original versions of certain murals among the remarkable number revealed through excavations in the palace at Mari, where some trace of paintings was evident in at least 26 of about 300 courts and rooms (Pierre 1984: 223). Colour washes, primarily of black and red in various shades, were also used throughout for floors, dados, and other fittings (cf. Tomabechi 1980: 139; Spycket 1989). It is not clear how durable such murals were; whether iconography is a certain guide to age or whether they were recopied time and time again.

Study of these renowned wall-paintings is now complicated by ambiguities, contradictions, and omissions in the excavator's various reports of them, and in published copies (some in colour), culminating in a major study that is a descriptive survey, concentrating on iconography, rather than on a detailed catalogue (Parrot 1958^b; 1961, coloured plates on pp. 275–83). The extent of recovery was exceptional and was pioneering work; but the published record does not do justice either to the skill involved or to the data recovered. The secondary bibliography continues to grow; but in the absence of technical detail in the primary reports, has inevitably

concentrated on art-historical analysis (cf. bibliography in Pierre 1984; 1987; Pierre-Muller 1990; Nunn 1988: 66–92; Spycket 1989). Correlation of Moortgat's (1964; 1969: 69–74) perceptive chronological analysis of the murals with Margueron's (1982: 209 ff.) meticulous structural dissection of architectural sequences in the palace, and her own observations of the various surfaces upon which murals were painted, allowed Pierre (1987) to offer a chronological sequence for the major concentrations of fragments critical of that offered by Tomabechi (1980), who seems to have depended entirely on the published reports:

- 1(a) *Possibly Ur III* Secteur B: Room 132 (Parrot period (c.2100–1958: 70 ff., pls. XVII–XXI; 2000 BC), more Moortgat 1964); variously probably interpreted as an audience hall c.1800 BC? or chapel.

As it is hard to accept, even in a covered area, that the paintings found in a palace destroyed three or four centuries later were those originally painted at this date (cf. Tomabechi 1980: 141), some scholars, like Parrot (cf. Nunn 1988: 88–9), have preferred to date them closer to 1800 BC than to the Ur III Period argued by Moortgat. Heinrich (1984: 71) has suggested that the paintings in 132 were, in their final state, plastered over and the room was undecorated (cf. Assaf 1990).

- 1 (b) *Ur III* Secteur H: Room 52 (graffiti period(?)) Parrot 1958^a: 13 ff., figs. 13–15).
2. *'Assyrian Interregnum'* Secteurs H(?E); I (31, 34); J (42, 43, 46); M (106, 64); F (220) (Yasmah-Addu; Parrot 1958^b: *passim*; on 219–Ishar-Lim) c.1800–20 see Pierre-Muller 1990).
1750 BC.

There is a continuing debate over the exact date of the most famous mural, in Court 106, that reflects the imperfect state of the basic evidence. As the 'Investiture Panel' is painted directly on to mud plaster rather than a lime or gypsum plaster, it may be earlier than the 'Assyrian Interregnum' at Mari, rather than later, as has commonly been supposed (Margueron 1990).

3. *Zimri-Lim's* 'Investiture Panel' in Court 106 reign(?) c.1750 BC or earlier. (Parrot 1958^b: 16 ff., pls. VI–XIV; cf. Margueron 1990).

Broadly speaking, the earliest murals at Mari (Room 132) are on mud plaster (*torchis*), the later on white-washed or plastered surfaces; in Room 42 the excavator noted that it was plastered over a whitewashed surface (Pierre 1987: 554, 560). However, no scientific study has been made of what Pierre makes clear were various processes for preparing the ground for painting. As at Alalakh (Woolley 1955: 228), where it was claimed true fresco technique had been used on lime plaster, 'the pigments are bound only by calcium carbonate; there

is no evidence for the use of gum or any other vehicle or binding agent' (Barker, in Woolley 1955: 233–4; but see below). At Mari the colour range of the earlier paintings was primarily, if not exclusively, red and yellow, with black and white.

In describing the plastered surfaces of the large Court 106, Parrot (1958^b: 86–7) writes: 'En examinant l'un après l'autre, chacun des côtés de la cour, nous avons observé toute une succession d'opérations, faciles à préciser. L'épaisseur du revêtement mural variait sur les parois ouest et est entre 7 cm. et 9 cm. On rencontrait en effet, de l'extérieur vers l'intérieur: une couche de plâtre (1 cm. à 1.5 cm.) recouvrant un enduit de boue (3 cm. à 4 cm.) piqué pour faciliter l'adhérence et placé lui-même sur un deuxième enduit de boue (2.5 cm. à 4 cm.), rainé pour la même raison. On arrivait enfin sur l'appareillage en briques. Ainsi trois couches protectrices (la dernière ornementale) se trouvaient superposées . . .' The colour range here is particularly rich, embracing brown and orange, yellow and pale red, grey-green, and pale blue as well as the more regular colours. The figures were also laid out in incised line rather than in black as elsewhere.

Little or no scientific information is available on technique. In comparing the Mari murals with those at Alalakh, on which there was a short scientific report (Barker, in Woolley 1955: 233–4), Parrot (1958^a: 109) wrote: 'Il est en tout cas une différence essentielle entre peintures d'Alalakh et peintures de Mari, c'est que les premières sont des fresques (Woolley 1955: 229; one exception, 230), donc exécutées alors que le support était humide, mais que les secondes sont à la détrempe, réalisées sur un enduit sec. Par contre et cela ne saurait étonner, les couleurs de base sont les mêmes: blanc, noir, rouge, jaune, bleu et brun.' At Alalakh these were shown to be: calcium carbonate, carbonaceous silicate, 'iron earths' (red, yellow, and brown), and a 'copper glass' (i.e. blue frit) (Barker, in Woolley 1955: 233–4). At Mari they have yet to be analysed (cf. Pierre 1984: 241). More specifically, Parrot (1958^a: 58) remarked of the painting of the 'Investiture Panel' that 'on peut penser qu'elle a été exécutée à l'œuf, ou à l'aide d'une gomme adhésive mélangée aux couleurs', noting in a footnote that: 'Monsieur G. Goulinat, chef de l'atelier de restauration des peintures du Louvre, hésite à se prononcer: ou fresque retouchée à la caséine, ou peinture exécutée à la caséine.' Tomabechi (1980) has rested her chronological reassessment on specific colour combinations, including 'rose' and 'cobalt-blue'; but Parrot took the former to be a variant of red ochre, whilst blue does not appear to be listed for the earliest paintings (cf. Pierre 1987: 552 n. 6) and is almost certainly blue frit, not cobalt blue, when it does appear in the eighteenth century BC.

Although art-historical questions (cf. Pierre 1984; 1987 with bibliography) fall outside the range of this

enquiry, any study of the materials and techniques used in building is broadened by noting the uses to which paint was put in imitating other materials used in the decoration of the palace at Mari and now lost. Red ochre was employed to imitate wood, veined to suggest its graining in Court 106; to imitate marble or some other ornamental stone in various places; and to reproduce tapestries or ornamental textiles, notably the famous 'Investiture Panel' in Court 106 (cf. Pierre 1987: 569–70).

At Nuzi in the first half of the fourteenth century BC there was evidence for formal decorative panels, but not of more elaborate friezes. The most coherent designs, retrieved from debris in a corridor leading to a 'bathroom' in the palace, had been placed as ornamental bands at door-top level (Starr 1939: 143–4, 491–2; 1937, pls. 128–9). They were in tones of red, with black and white, on a grey ground. In a series of panels a frontal bull's head and a female head with cow's ears alternate with a voluted plant. The borders are in the Mesopotamian tradition as exemplified at Mari; but western or Syrian connections, best exemplified by painted pottery, are evident at Nuzi (cf. Qatna murals: Mesnil du Buisson 1928: 13, pl. IV.4; 1935: 143). Getten's (in Starr 1939: 491–2) brief scientific report on the pigments and background for painting does not indicate any innovations in palette or technique. The colour range remains very limited with much use of red ochre, carbon black, and a grey-blue pigment not tested by Gettens. Gypsum was used for plaster and whitewash; a grey priming also seems largely to be made of gypsum.

In the near-contemporary private houses excavated at Nuzi, 'the colors used were red, pink, white, black and gray, the first four of which were often laid over a background of solid gray. The colors were in films of microscopic thinness, except in occasional instances where the white formed a thick layer that stands out beyond the surface, almost in relief. The colors, on the whole, were applied in thin, even solution, giving a surface of constant texture' (Starr 1939: 57). It was conventional for the main room in a house to be decorated with a vertical panel on only one wall, usually that opposite the main point of entry. The other walls were plain grey. The paint was usually applied on to a plastered surface, rarely direct onto the mudbrick surface.

Among the most impressive wall-paintings so far recorded in Mesopotamia are those recovered from the south and north sides of the great palace terraces at Kar-Tukulti-Ninurta, opposite Assur, dating to the second half of the thirteenth century BC (Andrae 1925: 11, pls. 1–14; Eickhoff 1985: 38–9) at a time when elaborate painted decoration was again popular on certain types of pottery, predominantly produced within the area of the Mitannian Empire. The main colours in these murals were red and blue, black and white. 'The red stands midway between vermilion and Indian

red, and when fresh is of great luminosity . . . the blue, too, is very pure, and corresponds to the light blue *uknu* (i.e. 'blue frit') . . . the white is chalky and very full of body, so that corrections of mistakes, or alterations, could be contrived with it. Isolated parts of the design are covered with this body white. Black is chiefly used for the outlines, but is also used as a colour in the border patterns. On fresh pieces it is pure and rich. The outlines were painted on the design last' (Andrae 1925: 12). The designs are highly stylized formal patterns of sacred trees with animals and genii, in panels, also familiar on Middle Assyrian cylinder seals and, more distantly, on glazed-brick friezes at Susa (cf. Amiet 1966: pls. 300–1). Here, as at Mari, the designs have been taken to imitate textiles stretched over wooden frames and used for wall decoration (cf. Stevenson Smith 1965: 114 ff.). No scientific study appears to have been made.

The mainstream tradition of decorating palace walls with painted geometric patterns and figured friezes is widely evident in the Kassite royal palace at Dur Kurigalzu (Aqar Quf), notably in unit H, 'everywhere . . . tantalizing indications of walls and ceilings ornamented' (Baqir 1946: 81; cf. Tomabechi 1983). Baqir (1946: 80) divided them into two groups: the geometric and floral designs predominantly on the walls of rooms, and the standing human figures in procession in the reveals of doorways. The best preserved and published are those on the inner reveals of doorways I–IV of unit H in level Ia. Red and yellow, shades of blue, black and white are the recurrent recorded colours. Backgrounds varied from white or yellow to shades of blue.

Baqir (1946: 81) described the process of figure-painting thus 'The ground on which they are painted is the original basic coat of yellowish distemper. On this they are evidently first outlined in red and the spaces between them thereupon filled with weak cobalt similar to that lying beneath the horizontal bands above. Details of the costume and the exposed flesh of face and arm are then painted red, while hair, beard and shoes are picked out in black. The whole figure is in some cases finally strengthened with a black outline, but since here, as elsewhere, the paintings have been more than once repainted or retouched on later occasions, it is difficult to tell which of these outlines are original.' No scientific reports are available. 'Cobalt' may only be taken as a colour description, since the blues are likely in the main to be of blue frit.

Tomabechi (1983) has demonstrated, after comparison of the published drawings (Baqir 1946: pl. XII = Moortgat 1969: fig. 72) with surviving fragments in the Baghdad Museum, that details of iconography and costume, as well as the proportions in some cases, were incorrectly published. For the moment the best parallels for the stance of the human figures and their costume are to be found on two glass vessels excavated

from the debris of level IV (c.1000–800/700 BC) at Hasanlu in north-west Iran (Saldern: 1970: 216–17: nos. 13–15, figs. 8–12), probably made in Kassite palace workshops (cf. Marcus 1991).

As with so many applied arts, it is difficult to trace any continuity directly from the Middle Assyrian royal workshops to those of the Neo-Assyrian period some three centuries later, since there is little or no archaeological evidence. Arguments of probability, if no more, indicate no serious break in the craft tradition for mural painting through this period.

It is difficult to establish how far paint was used on the carved orthostats which form so large a part of surviving Neo-Assyrian monumental art (cf. Nunn 1988: 229–34). Loud and Altman (1938: 41) argued that 'no attempt apparently was made to produce a brilliant dado by painting the entire slab'. Reade (1979^a: 18) supports this view; 'no traces of paint have yet been found as background colouring, and most carved surfaces are plain even on those orthostats where some paint is preserved. We may perhaps conclude that paint was only used for special effect.' Paley (1976: 10–11), in contrast, has argued that every figure was completely painted, and Tomabechi (1986: 44–5) also believes in the extensive painting of Neo-Assyrian relief sculpture, as in ancient Egypt and also, it seems, at Persepolis (cf. Tilia 1978: 32–68; Roaf 1983: 8; Stodulski *et al.* 1984). Paley (1983: 54) cites possible indications that in some areas of the reliefs, at least, a white undercoat or plastered surface underlay the colour. It is quite possible that these Mosul Marble slabs, to which the adhesion of plaster and paint was unstable, were largely stripped of them by natural processes once the palaces were abandoned. For want of conclusive evidence, the question must, however, remain open. The recorded evidence almost invariably indicates only details picked out on sculptures with pigment, generally red, blue, black, or white, the four colours that predominate in surviving Neo-Assyrian murals. Records of green, yellow and violet are rarer and less certain (Reade 1979^a: 18).

Scattered, and often meagre, as the published evidence is, it is likely that most major Neo-Assyrian buildings had paintwork, at least in the reception rooms. Assurnasirpal II (c. 883–859 BC) recorded that he had represented his triumphs 'in paintings' (but these might be glazed bricks; Mallowan 1966: 67). There were often, if not invariably, murals on the walls above the carved stone friezes (Rassam 1897: 28; Loud 1936: 67). Ceilings were also painted (Loud 1936: 68). Outside it is likely that monochrome washes sufficed, for at Khorsabad the ziggurat stages were painted, from the lowest upwards: white, black, red, (?)blue (Place 1867–70: i.141; Nunn 1988: 235–7), whilst at Nineveh battlements were striped in red, blue, and white (plain) (Reade 1979^a: 19 n. 14).

On the major murals white was the usual background, with the traditional blue also sometimes appearing, as at Nimrud (Layard 1849: ii.10) and Khorsabad (Loud and Altman 1938: 83). Black was used for outlines, with red, pink, brown, orange, green, and yellow among the other colours listed by various excavators in the main body of the designs (Layard 1849: ii.16; Place 1867–70: ii. 252; Smith, G. 1875: 78; Loud and Altman 1938: pl. 91, no. 30).

It was not until the excavations in Neo-Assyrian provincial centres in Syria that the evidence for murals in contemporary palaces began to have real substance in the archaeological record, as at Arslan-Tash in 1928 (Thureau-Dangin *et al.* 1931), then above all at Til Barsip in 1929–31 (Thureau-Dangin and Dunand 1936: 42–74, pls. XLIII–LIII; Tomabechi 1983–4; Nunn 1988: 102–22). Previously Layard (1853^a: pls. 86–7) and Place (1867–70: iii, pl. 32) had recorded no more than a few fragments in Assyria itself. At Til Barsip, from the time of Tiglath-Pileser III (744–727 BC), perhaps with some later additions (cf. recently Nunn 1988: 118–22), scenes extolling the Assyrian king, like those more familiar from the sculptured reliefs in royal palaces in Assyria itself (Parrot 1961: 100 ff.), were combined with geometric designs in horizontal bands (cf. Tomabechi 1983–4). In these provincial centres of the third quarter of the eighth century BC, a yellowish tone had replaced white as the standard background. Red, of various tones, and a rich blue remain the dominant foreground colours, sometimes blended to create a shade of aubergine; no green or yellow is reported. Designs were laid out in black or red lines (cf. now murals at Tell Sheikh Hamad, Kühne 1989–90: 320, fig. 138).

In their excavations at Khorsabad, Loud and Altman (1938: 83) reported that 'with the exception of our heroic figures, found to belong more than 6.5 m. above the floor, the painted rooms in Residence K at Dur Sharrukhin (Khorsabad) and those in the Til Barsip palace must have presented an almost identical effect. The colors are the same, and the details, though individually different, are so closely related in style that they might have been the work of the same artist.'

Nunn (1988: 123–30) lists fragments from Nimrud; but the Khorsabad murals remain the best published from a major Neo-Assyrian palace (Loud and Altman 1938: 83–6, pls. 88–91) with respect both to the reconstruction of designs and observation of techniques, though there was minimal scientific study. The primary description provides an epitome of the present evidence for Neo-Assyrian murals (Loud and Altman 1938: 83):

Gray mud plaster covered the mud-brick construction. This was surfaced with white lime, on which flat colors were applied. Finally black lines were added to cover the edges of abutting colors and to impart the hard, distinct outline which is so pronounced a characteristic of the work

... The colors were predominantly blue, red, and black, upon a white ground. The blue was granular and quite thick, a brilliant color. The red was more of a wash and had neither the sparkle nor the permanence of the blue. Green and brown also were noted. Unfortunately the green pigment was not analyzed, as were the blue and red (see below); hence the question whether that color might be merely the blue somehow changed in tone, as both Layard (1849: ii. 16) and Thureau-Dangin (1930: 28) consider, cannot be definitely settled. We believe it to be a separate and distinct color. It is found side by side with the blue and is outlined in black as adjoining colors invariably were. Brown was discovered in only one example ... Yellow did not appear at all.

It does not appear that lime (rather than gypsum) plaster was scientifically identified.

Loud and Altman (1938: 17) cited two colour analyses, made by the Sherwin-Williams Co.; both of which are anomalous, since neither lapis lazuli nor cinnabar (mercuric sulphide) are otherwise reported as early as this as pigments.

Blue: lapis lazuli which has been used with a clay high in silica.

Red: mercuric sulphide with a clay apparently used as binder, though it is possible that the clay was present with the mercuric sulphide at the time when it was obtained.

Many of the buildings which Mallowan excavated at Nimrud yielded traces of murals, both figured scenes and geometric designs applied in the same manner and with the same repertory of colours as at Khorsabad (see Mallowan 1966: *passim*; Postgate and Reade 1976–80 for full references and bibliography; Tomabechi 1986; Nunn 1988: 123 ff.). Plesters (1959) reported on the pigments, after examining samples by chemical microscopy. The *blue* is Egyptian blue or blue frit. The *green* is likely also to be a frit. The *red* 'is a deeply coloured iron ochre, much like burnt sienna in appearance'. The *black* 'consists of a coarsely ground carbon black which looks like charcoal'. The *white* 'consists of a mixture of calcium carbonate and sulphate. It is not possible to say whether the mixture was made deliberately.' Plesters was unable to detect any medium; 'there might have been a proteinaceous medium such as a glue, which has been washed out in the course of time, the pigment remaining adhered by absorption'. At Til Barsip Granger (1933) identified the *red* as iron oxide (red ochre), whilst he thought the *blue* was most probably Egyptian Blue.

Although glazed-brick friezes constitute a significant part of our evidence for Neo-Babylonian palace decoration (Nunn 1988: 160 ff.), there is no substantial evidence yet of painted murals for this period or for the Achaemenid supremacy in Mesopotamia (for Iran: see Nunn 1988: 139–41). The murals of Urartu in the eighth and seventh centuries BC show close parallels to those of Assyria in themes and techniques and may well be derivative (Nunn 1988: 134 ff.).

Although there is no evidence for the pigments used on stone reliefs of the Achaemenid period in Mesopotamia, those at Pasargadae and Persepolis have been analysed (Stodulski *et al.* 1984; cf. Tilia 1978: 31–69). One sample taken from the surface of a relief at Pasargadae was haematite with a trace of cinnabar. At Persepolis the limestone reliefs were painted with pigments of Egyptian Blue, malachite, haematite, and cinnabar. Larger specimens of pigment found in complete and fragmentary bowls containing paint found at the base of the Terrace Wall at Persepolis are of the same materials, save for a yellow pigment, which is yellow ochre (goethite and/or limonite). However, with the exception of one sample of Egyptian Blue, the coloured materials from the collapsed east portico of the Central Building were found nowhere else at Persepolis. The blue, green, yellow, tan (or white), and orange materials were identified as azurite, the rare mineral tyrolite (not otherwise recorded as a green pigment), orthorhombic sulphur, a mixture of calcite with a trace of yellow ochre, and realgar respectively.

(2) Technical summary

As there is little or no archaeological evidence on animal and vegetable pigments in Mesopotamia (for dyes, see Barber 1990: 223–43), this survey of colours and colouring in murals is concerned with minerals. The most readily available were the coloured earths including brown, red, and yellow ochres and clays, which are widely available sedimentary deposits, though no specific sources have yet been certainly identified. Less commonly available were the coloured minerals of the heavy metals: azurite and malachite (copper), cinnabar (mercury), and orpiment or realgar (arsenic), which have a tendency to be used as pigments only in or adjacent to source areas. The first appearance of artificial pigments depends upon the earliest history of coloured frits in Mesopotamia which has not yet been fully elucidated (see pp. 167 ff. here).

Nunn (1988: 18–25) has tabulated the colours reported by excavators; but descriptions vary considerably in their accuracy (as with green/blue) and what now appears to be the case may not be an accurate description of the colour originally intended, on account of subsequent chemical changes. At present there is no scientifically certain evidence for the use of dyes of vegetable or animal origin blended with a material like chalk and then pulverized for use as a pigment. Few murals have been scientifically analysed (cf. Al-Kaissi 1984).

Black. With the exception of the reported uses of bitumen as a pigment, this was usually carbon in some form, often perhaps just soot, otherwise specially prepared by burning organic materials.

Blue. Where reliably tested, it is the artificial frit that

consisted of a crystalline compound of silica, copper, and calcium popularly known as Egyptian Blue (see p. 186 here). There is no analytical evidence for azurite, a blue carbonate of copper, as a pigment in Mesopotamian murals for the moment; nor is there evidence for the use of powdered lapis lazuli before the Sasanian period as a pigment. Although reference is made from time to time to cobalt, there seems to be no firm evidence for its use as a pigment in painting in pre-Seleucid Mesopotamia.

Brown. This is likely to have been iron oxide (?limonite).

Green. This is again a frit, though it may at times have been made by combining a blue frit and yellow ochre. It is unlikely that powdered malachite was used for murals.

White. This was either calcium carbonate (whiting chalk) or gypsum (calcium sulphate).

Yellow. This was yellow ochre (?goethite), which tends to turn red on burning. The use of orpiment (yellow sulphide of arsenic) as a pigment in inorganic materials in ancient Mesopotamia has not yet been thoroughly investigated. Analytical identifications of arsenic in early Mesopotamian glass remain elusive (Beck, cited by Bass 1986: 279 n. 40); but it is chemically attested as a filler (25 per cent) in the beeswax used on Neo-Assyrian writing-boards recovered in Mal'lowan's excavations at Nimrud (Wiseman 1955: 5-6). It makes the wax more plastic and easier to write on, whilst giving the surface a bright yellowish colour. This analysis allowed the Akkadian word *katu*, mentioned in texts about writing-boards with reference to wax, to be read as orpiment rather than yellow ochre as previously. In the 1927-8 excavations at Mishrife-Qatna the excavator reported that: 'Une des plus curieuses découvertes de cette zone fut celle d'un petit bloc d'orpiment mélangé à un peu de soufre. Les gisements d'orpiment les plus voisins se trouvent en effet dans le Kurdistan à Julamerk et en Perse à Goramis. Il est probable que ce minéral était ici importé pour divers usages' (Mesnil du Buisson 1935: 128). At least one of the amphorae from the Late Bronze Age wreck at Ulu Burun (Kaş), off the south coast of Turkey, was carrying orpiment (Bass 1986: 278). It is said to occur in Syria and Turkey (Forbes 1972: 178-9) as well as further east. Traces of realgar, the red arsenic ore occurring naturally in veins of orpiment, were observed in the Ulu Burun samples.

The precise source of the ochres, for the other pigments were readily available locally, is unknown; but they were available in the highland zone and had been exploited from a very remote period (cf. Schmandt-Besserat 1980). A renowned natural red oxide from Hormuz was for long called 'Persian Gulf Oxide'. It has a particularly brilliant colour and may be mentioned in the texts from Ur c.2000 BC which

document trade up the Gulf (Leemans 1960: 207-8). Natural oxides require only grinding and sieving to convert them into pigments; washing and levigation are used to obtain finer products. The preparatory techniques had been known from the earliest period of settlement in the Mesopotamian plain. At Ali Kosh in Khuzistan, for example, grinding slabs, pestles, and other heavy stone tools concentrated in one room were coated with the red ochre or bitumen prepared or worked there (Hole *et al.* 1969: 44).

It is usually assumed, as elsewhere in the ancient Near East and Egypt, that mural paints in Mesopotamia were tempera paints (distempers), with a mixture of water and some adhesive as the vehicle, not oil paints. As Lucas (1962: 351) noted, 'although pigments, such as soot and red and yellow ochres, will adhere to plaster and stone to some extent if applied dry, and although the ochres will adhere still better if wetted, others of the ancient pigments, such as azurite, malachite and blue and green frits, will not normally adhere without some binding material. The possible and likely materials to have been used seem to be limited to size (gelatine, glue), gum and albumin (white-of-egg).' Even in Egypt the particular type of gum adopted has not been chemically established. There is no firm evidence yet in Mesopotamia of wax used either as a medium for painting or as a protective cover, though it is likely that murals were polished or burnished, as coloured floors and walls had been from remote pre-history.

The principal grounds used for wall-painting in ancient Mesopotamia were mud, gypsum or lime plaster, and stone. From earliest times to the first millennium BC paintings were applied to walls plastered with mud (*enduit de boue*; *Lehm*) (cf. Nunn 1988: 7-10). The authoritative separation of gypsum from lime plaster is a matter for expert examination by scientists; it cannot be done by eye. Consequently, systematic surveys and tables, like those usefully offered by Nunn (1988: 10-15), which are drawn directly from excavators' field reports have to be treated with due caution. On the basis of this evidence the ground for paintings at Umm Dabaghiyah (III), Yarim Tepe II, Mari, Nuzi, and Kar-Tukulti-Ninurta is listed as gypsum plaster, whilst lime plaster is given for the 'Burnt Palace' (Sargon II) at Nimrud (Mallowan 1966: 207) and Khorsabad (Loud and Altman 1938: 83 ff.).

One or other of three main methods of application are most probable. In *tempera* (or *gouache*) painting the pigments, bound with an emulsion (usually egg, glue, or casein), are applied to a hard, dry surface. In *fresco secco* pigments, with an organic or inorganic binder, are applied to a hard, but remoistened or soaked lime plaster. This produces a painting lacking the special durability and clarity of true *fresco* (*buon*

fresco). In *buon fresco* the pigments are mixed only with water or lime water (calcium hydroxide). They are applied to a lime plaster when it is drying out for the first time and is thus still malleable and soft. When properly executed, this method ensures the inseparable bonding of pigments and plaster, both by chemical and by mechanical means.

Studies of Near Eastern wall-paintings since the early part of this century have been strongly influenced by research on the superb murals recovered from Bronze Age palaces in Crete. When the first scientific studies of the Cretan wall-paintings appeared nearly eighty years ago, it was inferred, rather than conclusively demonstrated, that they had been executed in true fresco (*buon fresco*) (Heaton 1910). After a detailed consideration of the problem Cameron *et al.* (1977: 160 ff.) more recently listed over twenty criteria for establishing the use of true fresco. They provide the necessary critical basis for any future enquiry into related problems in Western Asia. In the case of Crete they concluded that 'there is now rather more readily visible evidence than was hitherto known for unmistakable signs of *buon fresco*' (ibid.: 166); but much remains open to doubt. Whatever the case in Crete, there is no reason to assume any close affinity with the procedures prevalent in Mesopotamia, where mud and gypsum plaster may always have been a more common working surface for painters than lime plaster, prevalent in Syria and Palestine (see next section), at least until the Neo-Assyrian period.

In the circumstances it is safest for the present to assume procedures most akin technically to those used in ancient Egypt. There powdered colours mixed with gum or size were applied to a dry plaster (or stone) surface, with water used to thin the mixture sufficiently for free application with a brush. 'In *gouache* painting, once the colours have been prepared and mixed with a gum, they will last for any length of time, and when hardened need only softening with water to become ready for use; one opaque colour can be painted over another when the latter has dried, and then completely hides it' (Davies and Gardiner 1936: xxxi).

In room NE 50 of Fort Shalmaneser at Nimrud, in a seventh-century context, the excavators found some dolomite with haematite staining which had been the host rock for a vein of the darker rock, of which a single specimen was lying nearby. This was quartzite, containing haematite and pyrolusite, a manganese ore. Barnes (in Oates, D. 1962: 17) commented that 'manganese is nowadays used quite extensively as a colouring agent in bricks, pottery and glass, and would give a pinkish tinge. Pyrolusite . . . used to free glass, through oxidization, from colours due to iron staining. I would therefore suggest two possible uses:

- (i) The use of the pyrolusite for colouring, the rest of the rock being incidental, or
- (ii) The use of both the haematite and the pyrolusite for the making of iron (the manganese would have a hardening effect), when again the dolomite would be discarded.'

Oates suggested that this rock had come from Jebel as-Safra, about 30 km. north-north-east of Nimrud, on the road from Nineveh to Erbil.

2. Plasters and mortars in building

In mudbrick architecture the plastering of surfaces to protect them from the elements outside, from water seepage within, was essential. At the same time it was a necessary preliminary to any kind of decoration on internal and external surfaces. Three materials were employed: bitumen (see next section), mud, and plaster, of gypsum or lime. Intimately linked to surface use was the role played by each of these substances as a mortar.

(i) MUD PLASTER

Mud was widely used at all periods, as it still is, to plaster surfaces, especially in domestic architecture. It was used equally often for mortar (Salonen, A. 1972: 47 ff.). Whereas the mud used for mortar had a similar consistency to that used for brickmaking, though at times without straw, that applied as plaster usually had this additive (cf. Carter T. H., and Pagliero 1966: 65). Today two coats are commonly applied. The first is mixed with straw or some vegetable additive and has a greater clay content; the second coat is finer and applied as thinly as possible.

In plastering, mud was often combined with gypsum (or gypsum plaster) (cf. CAD, s.v. *qadūtu*). There were also many other variations in mixture, some, but not all, accessible to examination by eye. At Aqar Quf in the Kassite ziggurat 'all four façades showed two special layers consisting solely of a kind of concrete made up of brick chips and beaten clay mortar, without matting' (Gullini 1985: 135).

Mud plaster is evident in the earliest settlements in Mesopotamia, and all the primary technical problems in its uses had been solved early. Typical examples of use for walls and floors are reported from such settlements as Jarmo (Braidwood R. J. and Howe 1960: 42), Telul al-Thalathat (Fukai *et al.* 1977: 51), and Yarim Tepe I (Merpert *et al.* 1977: 71). Wattle-and-daub techniques are particularly evident in Sumer, where instances of mud plaster applied to reed frameworks are regularly reported (cf. Hall and Woolley 1927: 57; Woolley 1956: 10).

(ii) GYPSUM AND LIMESTONE PLASTER

Any systematic study of gypsum and lime plaster is impossible in the present state of knowledge since they may only be distinguished by proper scientific examination, not by eye. As the Arabic word *juss*, often used by archaeologists in this region, derives directly from the Greek *gypsos* it properly describes a plaster with a gypsum base. However, in some archaeological reports it appears to be used specifically in the sense of lime plaster. Colloquially today it may simply mean 'plaster'. The safest rule-of-thumb when dealing with the archaeological literature is to assume that references to 'plaster' in ancient Mesopotamia, particularly in the south, refer to a gypsum-based plaster unless analytical evidence definitely indicates lime plaster (cf. Aurenche 1981: 26 ff.). As Partington (1935: 263) pointed out, Woolley's (1934: 231) description, 'fine white lime cement made from gypsum' (which would give neither 'lime' nor 'cement'), illustrates the potential for confusion. The distinction is an important one (cf. Gourdin and Kingery 1975) as both types of plaster were manufactured from the time of the earliest settled communities in the Near East, but with significant regional patterns of use (cf. Aurenche 1981; Rehloff *et al.* 1990).

Pure gypsum consists of calcium sulphate dihydrate. When this is heated to a temperature in the range 100–200 °C, three-fourths of the chemically combined water is driven off, leaving the hemihydrate: 'plaster-of-Paris'. When water is added to this it reverts to its original chemical composition, so gypsum rock and gypsum plaster cannot be separated by chemical tests. The plaster has to be distinguished through its distinctive microstructure. 'Plaster-of-Paris' is easy to form and to use, but is limited in its use for structural purposes. The mixture tends to set quickly without additives that retard crystal development. The plaster is consequently soft, absorbs water, and is relatively soluble, so is only suitable for external use in the driest of climates. 'When our Expedition House was built at Assur, the necessary reservoirs for water were made with gypsum mortar, and the gypsum wash on the walls, the roof, and balustrades of our house at Babylon has already lasted perfectly for twelve years' (Koldewey 1914: 103).

Some nineteenth-century references assist with the study of gypsum plaster in Mesopotamia. Campbell Thompson (1936: 149) cites Olivier, travelling at the very end of the eighteenth century, as a witness to the use of 'Mosul Marble' at Mosul for the manufacture of plaster. Rich (1816: 161) reported that in the western desert between Babylon, Hit, and Anah a type of calcareous earth called *borak*, resembling gypsum, was burnt to make whitewash and plaster. In his travels in Kurdistan he described a gypsum mill in a village not far from Nineveh:

The lime-hills behind Baasheka are composed of sandstone, limestone and gypsum. We saw a great quantity of the latter, seemingly of a very good quality, preparing for use at the village. It is first broken into pieces, then burnt, and afterwards reduced to a fine powder by being placed in a circle paved with stones, and rather lower at the perimeter than the centre. Mules tread round this as if they were treading out the corn, dragging after them a heavy stone-roller, not cylindrical, but square, which at every turn beats the time with its whole weight. It is a simple and convenient contrivance.

(Rich 1836: ii. 71)

The technology of production for lime plaster is more complicated than for gypsum. The plaster is prepared by heating limestone to a sufficiently high temperature to decompose it to calcium carbonate and calcium oxide. For this to happen, temperatures in the range 800–900 °C. (bright heat) have to be maintained for a long time, say three to four days, to calcine limestone satisfactorily in the kind of quantities usually required in building projects. This plaster, as with its gypsum counterpart, is identical in chemical and crystalline composition to the parent rock so cannot be distinguished by chemical or X-ray diffraction tests; but its microstructure is again distinctive. In contrast to gypsum, which forms a plaster paste immediately water is added, a lime plaster has to be prepared in advance of use. The highly reactive furnace product is first mixed with a quantity of water and allowed to hydrate, thus releasing substantial amounts of heat. The paste, usually mixed with sand, ground limestone, or other temper, is then applied. It loses its plasticity due to the evaporation of water and further hardens over a period of time. Without the fillers it has much residual porosity and no great strength. With them it is hard and durable, retaining its integrity in damp surroundings.

The advantages of lime over gypsum plaster are to some extent counteracted by the greater difficulty of making it and the considerable amount of fuel consumed in the process. In nineteenth-century kilns about 1.8 tons of limestone rock and two tons of wood (fir) were required to produce a ton of quicklime. For open-pit firing about twice that amount of fuel would have been necessary (Kingery *et al.* 1988). In Babylonia, perhaps also in Assyria where gypsum was locally available and fuel scarce, gypsum plaster is always likely to have been preferred to lime. The only lime kiln on an archaeological site so far identified by scientific analysis of the associated debris is in an Early Dynastic III context at Khafajah in the Diyala valley, where limestone and fuel would have been more readily available. Here chemical analysis of a whitish-grey granular substance recovered from near the kiln showed it to contain a large percentage of calcium carbonate (Delougaz 1940: 92, 131–3, 151, pl. III).

The textual evidence has not yet been processed in a way that helps significantly with distinguishing the

roles of gypsum and lime plaster in historic times. It is clear that *gašsu* (Campbell Thompson 1936: 48–150; CAD 'G': 54–5; AHw I: 282), the term for gypsum and gypsum plaster, was generally available. It was used structurally (for thresholds); manufactured for use as wall plaster or whitewash, often in combination with bitumen; powdered for employment as an abrasive; and mixed with bitumen to make figures. Specific reference to sources are rare. One phrase, 'you crush gypsum (of/ or brought on the) Euphrates', might refer specifically to gypsum from near the Euphrates noted by Chesney in the nineteenth century (Campbell Thompson 1936: 150). As *namrûtu*, taken to mean lime/lime-mortar, is not found in the building inscriptions of Neo-Assyrian or Neo-Babylonian kings, Campbell Thompson (1936: 150–2) speculated that this might indicate use of lime mortar was a late phenomenon: 'At Nineveh it is in my recollection that it was only buildings a long time post-Assyrian which were so strongly mortared together as to need the application of a crowbar and hammers for their removal. The Assyrian buildings had no harder plaster than could easily be removed with the ordinary pick.'

The use of plaster is so common in Mesopotamian buildings that any itemized survey would be endless and not very instructive after a certain point, particularly in the absence of proper distinctions between gypsum and lime plaster. In domestic architecture, save for use as whitewash, gypsum plaster seems to have been little used, possibly superseded by bitumen, in historic times. In the prehistoric period in Mesopotamia it had been widely employed on walls and floors, even at times surfacing open passages between houses as at Yarim Tepe I (Merpert and Munchaev 1973: 96) and Choga Mami (Oates, J. 1969: 116). At Umm Dabaghiyah, where the raw material was readily available, gypsum kilns were identified in level II on the east of the settlement where the prevailing wind would have blown away the fumes (Kirkbride 1973: 208). Here gypsum plaster was even used for various house fittings, including wall niches and chimney hoods. In the third millennium it appears for basins and channels, as well as floors, at Tell Chuera (Moortgat 1960: 3) and in houses of stratum VA at Tell Asmar for courtyard and entrance vestibule plastering (Delougaz *et al.* 1967: 169).

In public architecture in historic times it was ubiquitous for surfaces and to a lesser degree in fittings. In a few cases lime plaster may have been correctly identified, as at Nuzi: 'In a few cases lime cement was used identical with that known today in Iraq as *juss*. The most notable example of this was Street 5, in which layers of cement intermixed with small pebbles were spread from time to time over the accretion of rubbish to make new surfaces' (Starr 1939: 44). At Khorsabad in the late eighth century Loud and Altman (1938: 17) noted that 'in general lime plaster is found on exterior

surfaces, while mud plaster covers interior and court surfaces'. Analysis of the concrete bed of Sennacherib's aqueduct at Jerwan indicated that it 'consisted of a mix made up of a magnesian limestone' aggregate and muddy river sand, cemented by a magnesian lime made by burning a magnesian limestone (Jacobsen and Lloyd 1935: 15). Koldewey (1914: 128) described the pavement of the Achaemenid palace at Babylon as 'a flooring of lime mortar and pebbles in three layers. . . . There are remains of a pavement made in exactly the same fashion in the ruins of Babil.' Babylon in the early sixth century particularly well illustrates the extensive use of white plaster (?gypsum): 'The temple (Nin-makh), like all others hitherto found by us, is composed of mudbrick . . . its walls were covered with a white plaster that gave it the appearance of marble' (Koldewey 1914: 55).

(iii) MORTAR

Mudbrick was traditionally mortared with mud ('clay') in Babylonia. The difficulty of separating gypsum from lime mortar by eye has always to be borne in mind when assessing accounts of these mortars based on observation alone. The buildings of Babylon in the early sixth century BC have for long been thought to mark significant change in mortaring materials. Rich (1816: 25) long ago noticed in the Kasr there 'fine burnt brick . . . laid in lime-cement of such tenacity, that those whose business it is have given up working, on account of the extreme difficulty of extracting them whole'. In general at Babylon bitumen and mud, or bitumen and reed straw, were the materials regularly used as mortar. According to Koldewey (1914: 31) it was only in the Kasr, the principal citadel, and at Babil, that Nebuchadnezzar's masons used lime mortar. Lime mortars were combined with bitumen in some buildings and also produced in a variety of colours: grey, black, red, and white. For his Euphrates wall the masons of Nabonidus used bitumen, whilst, according to Koldewey, Achaemenid, Seleucid, and Parthian builders generally used mud mortar. Herodotus (i. 179) refers to bitumen mortar and the use of inserted mats in the great defensive walls of Babylon.

It is only for the late periods that analyses have been published. Reuther (1938: i. 427–8) reported that 'gypsum mortar, which already appears in the brickwork of the Greek theatre at Babylon dating from the Seleucid Period, hardens rapidly and holds the brick or stone mechanically, while lime mortar hardens slowly and binds the bricks by forming a chemical compound. The mortar of Sasanian buildings also is, in so far as chemical tests have been made, gypsum.' This quick-setting mortar increased the ease and speed with which the vaults of the Parthian and Sasanian periods could be constructed (cf. analyses in Wetzel *et al.* 1957:

46 ff.). Eight samples of plaster from Seleucia were found on analysis all to be made of gypsum (Debevoise 1941: 48 ff.).

In Neo-Assyrian buildings mortar was generally used with restraint. Stones were carefully dressed to fit from the eighth century BC, and mudbrick was mortared with clay as traditionally in Babylonia. Haller (1954: 77) believed that the use of gypsum mortar with well-laid stones was first evident at Assur in royal tomb III (?Assurbelkala, c.1073–1056 BC). Chemical analyses of Neo-Assyrian mudbrick and mortar at Arslan Tash in Syria revealed virtually the same composition; the plaster used there was gypsum (cf. Thureau-Dangin 1935).

(iv) GYPSUM BRICKS

In the prehistoric period there may have been much more experimentation with the composition of bricks than was subsequently the case (cf. Merpert and Munchaev 1987: 21). Already in the Halaf period at Yarim Tepe II the excavators found 'walls . . . made of blocks of clay with an admixture of gypsum coated with mud plaster'. By the earliest and most experimental phase of monumental building in southern Mesopotamia, during the fourth millennium BC, there was considerable variety in the composition of bricks. These are not easy to classify with accuracy since published descriptions have so far been almost invariably by eye, not by microstructure, and terminology varies. In structures below the ziggurat at Eridu, attributed to the period Uruk IV–III, were 'riemchen gypsum bricks 45–42 × 10 × 10 cm. (a few half this size 22 × 10 × 10 cm.)' (Safar *et al.* 1981: 64, fig. 14; cf. also 78). These seem likely to have been moulded blocks of gypsum plaster. The *Steingebäude* at Uruk also contained brickwork in which *Gipsmörtelplatten* were used (Schmidt, J. 1972: 20), and they were evident elsewhere in the *Eanna* complex during Uruk VI–II apparently manufactured from gypsum plaster with some temper (*Gipsziegel*). In Uruk V they measured 53 × 10 × 10 cm. and again appear to have been manufactured in wooden moulds exactly like mudbricks, though some were considerably larger than the conventional mud *Riemchen* bricks. At Uqair, in the first filling of the 'Painted Temple', were 'gypsum or cement bricks' which the excavators used as a chronological indicator of the Uruk period (Lloyd and Safar 1943: 149, pl. XVIa). Some of these bricks were marked with a trident sign. At Uruk (Schmidt, J. 1979: 16, fig. 2, pl. 5a) a triangle on a shaft and a shaft turned over at the top in a loop were used to mark gypsum bricks (cf. Buren 1945: A2 and C1).

At Ur in pit F, at about 8.40–8.80 metres above sea-level, Woolley reported the use of 'cement bricks' with ordinary mudbricks in a circular basin which had

been part of a potter's workshop, in a brick box or enclosure, in a kiln, and loose in the soil (Woolley 1956: 66). Some were in the size range 44/40 × 18/16 × 9–1; some 20 × 8/9 × 6/5 cm. From the site of Merejib, ten miles south of Ur, evidence for their use was more precise:

The site is a small mound composed of a very hard material resembling decomposed gypsum which is overlaid and the pockets in it filled with drift sand . . . The buildings were constructed of cement bricks, flat and rectangular, 0.24–5 m. × 0.11 × 0.125 m. × 0.075–0.12 m. . . . The walls rested either directly on the hard gypsum foundation or, where this was replaced by sand, on a platform of mudbricks . . .

(Woolley 1956: 83)

One of these bricks was analysed by Plenderleith (in Woolley 1956: 158).

	per cent
Siliceous materials	30.55
CnO	20.24
MgO	1.53
Al ₂ O ₃ + Fe ₂ O ₃	1.05
CO ₂	3.37
SO ₃	24.51
Loss on ignition (CO ₂)	16.63
Alkalis and chlorides not estimated	—
	97.88

The use of gypsum plaster for the production of moulded bricks does not appear in the published record after the late prehistoric period, when it was also used for tablets (cf. Nissen 1986).

3. Bitumen in Building and Other Roles

Bitumen was the most readily available, after clay, mud, and silt, of the raw materials used in ancient Mesopotamia, though by comparison relatively expensive. In building it was used primarily as a protection against damp and water and as a mortar; generally it served numerous purposes as an adhesive and a sealant, as well as being used medicinally. It was employed in liquid state and solid, in relatively pure forms and in mixtures (mastics). The ancient textual evidence, particularly in the later third and early second millennium BC, is extensive (cf. Salonen, A. 1972: 53 ff.). It reveals the various forms in which bitumen was made widely available, the details of its transport in skins and pottery containers or solid cakes, and its uses. But it is little, if at all, concerned with specific sources, with details of composition or the means of manufacturing and processing, all of which have to be reconstructed through scientific study of bitumen recovered through excavations.

Fortunately, the three source zones within Mesopotamia—in the Kirkuk region, on the middle Euphrates, and in Khuzistan—were ideal for distribution by water transport. As scarce fuel was needed to melt bitumen to mix it with mineral and vegetable temper, it was not cheap in quantity, so normally used extensively only in royal building projects. As so often with basic materials in Iraq, preparation methods do not seem to have changed much since antiquity. 'These old samples are built up of practically the same materials as the bituminous mastics of today, that is, besides bitumen, of a sand and a fine filler' (Forbes 1955: 58).

In samples of mortar and a threshold sealing from Tell Asmar (c.2500–1800 BC), for example, local clay or soil ('loam') with its characteristically high lime content had been added to the bitumen. This is hardly surprising, as mud mortar (see above) had been widely used in the region from the time of the earliest village settlements. Thus, as Forbes argued, since sand, straw, or chopped straw had long been found to be beneficial additions to mud mortar, they would naturally have been added to bitumen for similar purposes by builders. Limestone, marl, or chalk were added pulverized as quarry dust. Whether lime itself was added as an independent filler is not apparent until the Neo-Babylonian period, when it may first have been used in mortars (see above). Brick chips were also used as filler. Fibrous materials were added to bituminous mastics, as in the production of clay bricks and mud mortar. This practice may have been abandoned by the Neo-Babylonian period, at least in major building projects, to judge by the materials used at Babylon. Information on earlier changes is equivocal.

If a mixture of bitumen and mineral additives is to be poured at high temperatures, a specific amount of bitumen is necessary. Today this is from 12 per cent to 16 per cent for manipulation at 180–200 °C. In ancient samples the amount of bitumen is appreciably greater, allowing the mastics to be poured at much lower temperatures. This is a distinct advantage in a region where fuel is expensive and the practice probably derives from early recognition of the advantages of excess bitumen (33–50 per cent at times). The fibrous matter was then added to produce a fluid of sufficiently compact mass to be used with a trowel or to be rolled or tamped (cf. Forbes 1955: 64). Such mixtures were produced in ceramic and metal vessels, over heat, though very few certain examples have been identified (cf. Salonen, A. 1972: 124 ff.). An Early Dynastic II installation in the North Temple at Nippur, with a rectangular container of baked brick set above a fire-box, was identified by the excavators as a furnace for melting bitumen (McCown *et al.* 1978: 16, pls. 9A, 42A).

(i) AVAILABILITY

Within the area of modern Iraq and south-west Iran (Khuzistan) there are several hundred seepages of bitumen, gas, and oil as well as deposits of natural asphalt. Three primary regions may be defined:

- (a) Between the Lesser Zab and the Diyala rivers in the vicinity of Kirkuk (cf. Forbes 1955: map facing p. 2).
- (b) West of Baghdad around Abu Jir, Hit, and Ramadi on the west bank of the Euphrates (cf. Forbes 1955: map facing p. 2).
- (c) In Khuzistan with major sources at Ain Gir and Masjid i-Suleiman (cf. maps in Marschner and Wright 1978 and Marschner *et al.* 1978).

Texts also indicate that bitumen came from *Dilmun* (cf. Zarins 1992: 65). There are other sources: in Turkey (Samsat on the Euphrates), in Syria, and in Palestine (notably on the shores of the Dead Sea) (cf. Connan and Deschesne 1991); but it is unlikely that they played a role in supplying Mesopotamia.

It has been assumed that the distribution of bitumen was regional, not long distance, in Mesopotamia, but where water transport facilitated contact a complex pattern may be expected, varying from place to place, period to period. The textual indicators are sparse. Gudea (Statue B: VI.51–4; Falkenstein 1966: 51) recorded procuring bitumen from *Madga*, probably the Kirkuk area (cf. Edzard *et al.* 1977: 113). Classical references to the sources at Hit are recurrent (Herodotus, i. 179; Strabo, xvi. 743; Diodorus, ii. 12; Vitruvius vii. iii 8; Dioscorides, i. 83). In the words of Diodorus (ii. 12), 'although the sights to be seen in Babylonia are many and singular, not the least wonderful is the enormous amount of bitumen (asphalt) which the country produces; so great is the supply of this that it not only suffices for their buildings, which are numerous and large, but the common people also, gathering at the place (i.e. Hit), draw from it without any restriction, and drying it burn it in place of wood'.

Some bitumen at least reached Sumer from Khuzistan. The inscription on a decorated plaque made for Dudu, chief priest of Ningirsu at Girsu c.2450 BC, records that '(this stone) was brought from *Urua*' (Steible 1982: i. 266; Entemena 76.1–5). Steinkeller (1982: 244 n. 26) locates this town in the Deh Luran plain; Carter (E. 1984: 212 n. 275) proposes an identification with Tepe Mussian. No detailed study of the composition and technique of this low-relief bituminous wall-plaque has yet been published and the existing literature is confused on these key questions (cf. Boese 1971: 201, T. 12).

Linking the bitumen found on archaeological sites with specific sources is, like all attempts to fingerprint materials, a complex and hazardous undertaking, par-

ticularly when much of it is a mixture. As Connan and Deschesne (1991) have shown, chemical analysis can establish whether the oils and asphalts used are or are not biodegradable. If so, they probably came from seepages in the Hit region or in Khuzistan; if not, they are basic bituminous rock. Forbes (1955) on the evidence of his analyses argued that most of the bitumen in ancient Mesopotamia was from the Hit region. But the work of Connan and Deschesne (1991; 1991^a; 1991^b), on over a hundred samples of archaeological bitumen from Iraq and Syria of various periods indicated that only those from Babylon may be attributed to that area. Bitumen samples found at Tell el-Oueili Larsa, Telloh, and Uruk are from elsewhere. Since samples from Khorsabad in Assyria and Failaka in Kuwait are compatible with them, this was either the Kirkuk area (ancient *Madga*) or *Dilmun*. At present the diversity of natural asphalts in a single place and the multiplicity of potential sources in the Near East complicates any research programme for fingerprinting them (cf. Marschner and Wright 1978; Marschner *et al.* 1978).

In the artificial mixtures, vegetable debris and crushed minerals were blended with a bituminous binder. The bituminous material is usually a biodegradable oil or asphalt like those in the Hit region. Sometimes, however, as at Susa in the bituminous sculptures and other objects distinctive of the Old Elamite period (cf. Amiet 1966: figs. 117–22, 185, 210–11), it is different. Connan and Deschesne (1991) described it as a mixture of powdered bituminous limestone mixed with crushed minerals: 'c'est la présence de cette poudre de calcaire ayant les propriétés d'une véritable roche-mère de pétrole, qui a donné aux objets leur résistance mécanique et qui a permis de les sculpter et de les polir comme une véritable roche brute'. Their analyses have revealed in the same sample a mixture of non-biodegradable oil or extract of base rock and extremely biodegradable asphalt, impossible in nature, but clearly demonstrating the blending of different types of bitumen, like those enumerated by category in the ancient textual evidence.

As early as the Ubaid period at Ur there was evidence for prepared bitumen packed into baskets for transport (Woolley 1956: 8); perhaps even earlier at Tell el-Oueili (Huot *et al.* 1987: 299). Cakes of bitumen were found in the early third-millennium BC village at Sakheri Sugher in the Ur region (Wright, H. T. 1969: 58, fig. 14). At Tepe Farukhabad in Khuzistan, about 12 km. from a still active bitumen seepage at Ain Gir, four categories of bitumen pieces were recognized: 'rock asphalts', perhaps representing hardened seepage extracted as a raw material; thick round disks, possibly moulded to shape or simply the result of the hardening of little pools of split bitumen; angular melted pieces; particularly regular pieces which appeared to have been

shaped by fingers and could represent bitumen processed for transport (cf. Marschner *et al.* 1978: 100). At Tell Selenkahiyah on the Middle Euphrates, east of Aleppo, in the late third millennium BC bitumen was found in large slabs carrying the impressions of the reed mats on which they had lain or in which they had been transported from Hit, presumably by river (Loon 1968: 32).

No Sumerian or Akkadian text describes the process of recovery of bitumen (cf. Herodotus, vi. 119); but Woolley cites a medieval Islamic authority, al-Qazwini, who reported that:

There are two kinds of *al-kir* (native asphalt). First comes the kind that oozes from certain mountains; then we have the kind that appears with water in certain pools. It boils with the water and as long as they remain mixed the bitumen is soft; but if we separate them the bitumen hardens and becomes dry. It is collected by means of mats and thrown on the shore (of the seepage). Then it is brought in a kettle under which a fire has been lit, the sand is dissolved (?mixed) and a certain amount added, and a mix prepared by constant stirring. When the mix is ready, it is poured on the floor, where it cools and hardens.

(Cf. Woolley 1956: 162)

When experts reported on samples of natural asphalt found at Ur, they related them to the circumstances of recovery at Hit in recent times:

In the water (at Hit) are 'snakes' of asphalt, which collect together and are consolidated by the natives by hand pressure into lumps, which are then thrown aside. After a very short time they become flattened owing to subsidence under their own weight. It is possible that the material was collected in the same manner in ancient times . . . if this be so, it is not difficult to form a reasonable suggestion as to what occurred. The 'snakes' of asphalt, in which was partially emulsified the saline water . . . dried in the air and under pressure, and thus received the 9.4 per cent calcium sulphate found today. The mass was thrown on the ground whereby it picked up the vegetable matter and some sand; it probably received a further and intentional admixture of sand up to the 27.4 per cent found.

(Cf. Woolley 1956: 161)

(ii) RANGE OF USE

For convenience this section considers the uses of bitumen through the whole range of crafts, but with special reference to building. It has five primary characteristics recurrently exploited in ancient Mesopotamia:

(a) as a malleable material for moulding and modelling objects and, in the form of cold mastics, for carving them. This was particularly exploited in Susiana (cf. Amiet 1966, figs. 86, 113, 117–24, 133, 185, 200–2, 204–11; Kantor 1977), but rarely if ever in Sumer and Babylonia, which imported bituminous objects from Susiana (cf. Carter, E. 1990). In metalworking an object already cast or hammered in metal was filled

with a core of bitumen mastic; zoomorphic objects already carved or moulded in bituminous substances were covered with sheet metal; carved or moulded cores of bitumen were used as the form over which sheet metal was pressed or hammered to take a design. A fragmentary life-size foot of bitumen from Tell Brak (British Museum WA 126352) indicates its use for statuary, perhaps only for certain parts.

(b) as a coating to provide an impervious and tenacious surface protection against liquids, especially water.

(c) as an all-purpose adhesive.

(d) as a protection for other organic materials from the bacteria prevalent in warm and humid climates. This is best illustrated by its use in coffins and burials wrapped in mats, and in boat-building.

(e) as a fuel; it is to be found, for example, in some of the hearths excavated at Nuzi (Starr 1939: 44).

These applications were recognized early in the history of settled communities in Mesopotamia and then recurrently exploited. By at least the fifth millennium BC bituminous materials were already being used with skill not only for constructional purposes, but also for a variety of tools and other objects. It is likely that natural and processed bitumen, travelling as small solid cakes, heated as required for use, were being transported within the primary areas of their natural occurrence, through probably not yet over long distances (cf. Marschner and Wright 1978). The development of large-scale mudbrick architecture from the middle of the fourth millennium BC greatly increased the use of bitumen, but there do not appear to have been radical changes in the methods of preparation.

After bricks and mud or gypsum mortar (see above), bitumen in its various forms is the most common material recorded in excavation reports. This information is so repetitive that a comprehensive review would have little point. Two particular uses in building may be selected for brief comment: for mortar and for damp-proofing.

Since both baked and unbaked bricks were porous enough to absorb a significant quantity of the bitumen used as mortar, the compressive strength of the walls so constructed was substantial. This was particularly true when both the standardization of the flat rectangular bricks increased and the skills in jointing them. The degree to which bitumen was used in preference to other mortars, either in or above foundation levels, is not easy to establish from the published reports, when, of course, little more than foundations are often all that can be recovered. It is likely that mud was the most popular adhesive, save in damp-courses, until the major building projects of the Neo-Babylonian kings. Loud and Altman (1938: 17) noted that, although bitumen was readily available, Assyrian builders at Khorsabad

in the later eighth century BC used it more for its water-resistant properties than for its adhesive strength. Forbes's analyses (1955: 71, table IV) indicate the possibility that at some time between the third and first millennium BC the use of fibrous materials in mastic was widely abandoned. He argued that a bitumen-lime mixture had become more current by the Neo-Babylonian period. It was at this time that builders in Babylon experimented with methods of jointing in which thin layers of mastic and loam were combined. At the same time mastic was used extensively in the main streets of Babylon (cf. Koldewey 1914: 31).

Examples abound in all periods of the use of bitumen to provide damp-courses in walls and below pavements. Everywhere that structures might be damaged by the penetration of rain or running water bitumen was applied: in drains and drain-pipes; in gutters; in wells and water basins; in toilets and bathrooms; and in the piers of the bridge at Babylon. Grain bins in the early levels at Hassuna were lined with bitumen or with gypsum plaster (Lloyd and Safar 1945: 262); bitumen was used to line pits at Matarrah (Braidwood, R. J., *et al.* 1952: 7) and so it has been from remote prehistory to modern times. Bituminous mastic was used in the lavatories at Tell Asmar in the third millennium BC (Delougaz *et al.* 1967: 176), in the bathrooms at Nuzi in the fifteenth and fourteenth centuries BC (Starr 1939: 441). Woolley, however, commented interestingly upon the pattern of use in the first quarter of the second millennium BC at Ur:

Bitumen, which was freely used in temples both as mortar in the walls and as proofing for pavements, was never so employed in the private houses—in them indeed it scarcely ever occurs in any form. A bitumen-lined store-pit in no. 15 Church Lane, a bitumen-proofed tub in the neighbouring house, no. 13, a stand for a water-jar in no. 2 Quiet Street and the curtain-rings at the base of the chapel 'table' in no. 4 Paternoster Row are the only instances of the use of a material so pre-eminently characteristic of Mesopotamia . . .

(Woolley 1976: 21)

This may well be an illustration of the expense of using bitumen in quantity that generally put it beyond the means of most private building enterprises.

4. Building in Stone

(i) THE AVAILABILITY OF BUILDING STONE

It is not possible to speak of stone architecture in Mesopotamia, north or south, in the period treated here. Even where stone was used it always played a subsidiary role to mud or mudbrick, at times wholly concealed in foundation courses or behind a plaster covering. Even in Assyria, where suitable stone was more readily avail-

able than in Babylonia, the primary building material throughout was mud or mudbrick. An increasing use of fine stone masonry in public buildings in Assyria, from some time in the eighth century BC, may have more to do with the arrival of Syro-Phoenician masons as captives than with local taste. When Partington (1935: 262) offered one of the few existing surveys of stone and its use in Mesopotamia (cf. Boson and Weidner 1932), he repeated the commonly expressed view that 'in Babylonia proper there was no stone, and every pebble was valuable, whilst Assyria was much better equipped with stone.' The general truth of this conclusion has been sufficient to sustain it for generations, but it conceals some important exceptions, particularly relevant to the use of stone from time to time by builders in Sumer.

Limestone, often to a depth of many thousands of feet, is widely distributed throughout Mesopotamia, where it was used from a very early date for artefacts (Wright H. E., 1955: 84). It also had significant secondary uses for mortar and plaster (see above) as well as contributing to the lime content in clays employed in the manufacture of mudbricks. In many parts of Babylonia the bedrock geology is hidden by the present alluvium; for instance, 'the edge of the alluvium southwest of Eridu is an outcrop of cherty limestone. Northeast of Eridu and southwest of Ur is another outcrop, this one of gypsiferous Dibdibba sandstone . . . Thus the plain of Eridu is a *cul-de-sac* surrounded on three sides by bedrock outcrops' (Wright, H. T. 1981: 300; cf. Woolley 1934: 228). Expert analyses of stone and rock samples from Eridu (Rees Williams, in Safar 1981: 311) reveal the need for caution over the sources of common stones even with sites at the heart of Sumer. As Boehmer (1984: fig. 1) has argued, limestone (and gypsum) outcrops on the Euphrates west of Uruk, at As-Samawwa and Al-Khidr, and into the desert at Al-Ummayyad, are the most likely sources for the stone used in the later prehistoric buildings at Uruk. Black and white limestone are the only stones represented as 'model bricks' in the foundation deposits at Nippur and the Diyala sites (Meyer 1981).

Gypsum (hydrated calcium sulphate) is also very abundant in Iraq, both as a soft rock and as a salt in the soil. In its compact, non-crystalline form, it is generally known as 'Mosul Marble' (or 'alabaster'). Gypsum can occur as secondary deposits in the form of crusts at, or beneath, the surface, probably due to evaporation of saline groundwater and precipitation within groundwater (Dorrell 1972: 69 ff.) Beds of gypsum are almost as widely distributed as limestone in the bluffs of the Euphrates, the Tigris, and their tributaries and over the Jezireh and into the foothills of the Zagros (cf. Ainsworth 1838; Wright, H. E. 1955: 85). This stone was used from a very early date for artefacts, for building, and, above all, for the manufac-

ture of plaster (see above). 'Mosul Marble' served an outstanding role as the primary medium for Neo-Assyrian monumental sculpture (see below). Unsuitable for exterior use, where the local limestones generally served, 'Mosul Marble' proved an ideal resource in the first millennium BC for the programmes of royal sculpture carved on orthostats inspired initially by comparable reliefs, commonly on local basalt, long incorporated into royal palaces in Syria and adjacent parts of Turkey. By at least the third millennium BC it was used for building purposes, as at Tell Brak (cf. Oates and Oates 1991: 138).

Moving up the river Euphrates from the Gulf to a point level with the city of Aleppo in Syria, those in quest of building stones, by the easiest means for moving them in any quantity, would have found only gypsum and limestones. However, after the junction with the Khabur river, in the bend of the Euphrates, there is a volcanic massif. This includes diorites and dolerites, basalts and trachytes. These stones are found from time to time on Babylonian sites, particularly on the Euphrates, though rarely if ever in a strict sense as building stones, as well as in Assyria, where basalt is the one most often used for building accessories. It could also be obtained around Cizre in the upper Tigris valley.

It is hardly surprising, in view of the rarity of ancient quarries within Mesopotamia, that little or nothing is known of stone procurement at source. Only under the Neo-Assyrian kings do reliefs offer some evidence for the manufacture of monumental statuary for palaces and their transport from quarries to their appointed destination (Reade 1990; see below). Where ancient quarries have been studied in Egypt, Iran, and Turkey (cf. Waelkens (ed.) 1990), there is evidence that not only extraction but also a considerable amount of roughing out was done at source, both in the preparation of masonry slabs and of sculpture.

Foster (B. R. 1982: 27, 46 ff.) has argued that a group of texts from the official residence of the *ensi* Ennalum at Umma, dated to the reign of Rimush (c.2178–2170 BC), record the forced labour of defeated citizens of Umma in stone quarries at *Sabum*, identified as a district in the Zagros between Der and Susa. Records of the high death-rate, copper 'breaking' tools which regularly need reworking, work measured in cubic volume, and references to 'stone men' are all said to support such a reconstruction. However, the entire hypothesis, and its supporting arguments, have been forcefully challenged and rejected by Steinkeller (1987; 1987*).

Outside the range of intermittent royal procurement by force of arms, it is not known whether access to rock outcrops was or was not restricted and controlled. Indeed, it is not known whether exploitation was organized at all or simply inefficiently and unsystematically

undertaken by small groups for brief periods (cf. Torrence 1986). Quarries on the mountain fringes of Mesopotamia and beyond, within Turkey and Iran, were parts of exchange systems, but the precise relationship between the means of procuring the raw material and the different kinds of exchange systems they supplied is still wholly obscure, even in the case of lapis lazuli and obsidian (pp. 64 ff, here).

The most common and persistent role for stone in Mesopotamian building was as door-sockets. Although the tougher types of limestone were used, these recurrent fittings are much more commonly of the darker, igneous rocks regularly used and reused in the natural shape of a boulder. A very large number of the surviving examples with royal palace and temple inscriptions appear not to have been quarried, but to have been retrieved as boulders eroded from outcrops by the action of either the sea or rivers. The more ordinary ones in domestic contexts are likely to be riverine boulders from the debris of local rivers; the more unusual, as with those of fine diorite or related stones, may have been retrieved from the shores of the Gulf (cf. Damerji 1987: 146–55). There is, as yet, no systematic philological study of the inscriptions on door-sockets. The first date towards the end of the Early Dynastic period, when hard dark stones were being obtained from the Gulf for royal sculpture; the latest from the second half of the first millennium BC. Of all the stone used for building purposes they were the most indispensable and the most often recycled. One example of this must suffice to indicate both the practice and the dangers of using such evidence for chronological purposes before the exact context of the door-socket has been securely identified. In the palace at Dur-Kurigalzu (Aqar Quf), for instance, successive reconstructions over a period of 150 to 200 years from the later fourteenth to the mid-twelfth centuries BC made use of the same stone door-sockets inscribed for its founder Kurigalzu (Brinkman 1976: Q series).

As the role of stones in *foundation deposits* does not modify the primary conclusions offered by other evidence, and has been well reviewed by Ellis (1968), it is not discussed here.

(ii) HISTORICAL SURVEY

(a) The prehistoric period

Aurenche (1981: 11 ff.; table 2; maps 3–4, 11) has provided a concise survey of the use of stone in house building in Mesopotamia from the earliest appearance of settled communities in the region down to the early fourth millennium BC. It was almost invariably employed only for foundations or footings under a superstructure of mud or clay *pisé*; 'cobbled paths', like those at Arpachiyah (Mallowan 1935), are rarer. It is not yet clear whether stone defensive walls, like that

at Tell Maghzaliya in the Sinjar Plain, were exceptional or not (Munchaev *et al.* 1984: 49). In the published sources the type of stone is rarely identified, though, when it is, it is most often limestone. Virtually nothing is said about the degree and method of working the stone. As no metal tools were available at this time for stoneworking and the stone was at foundation level, it is not surprising to find minimal working, with the stone most commonly used as natural pebbles or boulders. As the evidence for this period is largely concentrated in central and northern Mesopotamia, the use of local stone is of no great significance.

Even in the north, in the *tholoi* of the Halaf period, some examples were built on foundations of river boulders and pieces of conglomerate, or of limestone and sandstone (Mallowan 1935: 25–7; Hijara 1978: 127; Al-Soof 1971: 4), some were not (Merpert and Munchaev 1971: 10–11; Tobler 1950: 42–3, 47). Only where stone was easily available does it even seem to have been considered for use and then only as footings, whilst there are many examples in the north of houses without them. Hijara (1978: 178) commented, of the *tholoi* at Arpachiyah, that 'during the second part of the third phase large river boulders were used for the foundations . . . These are thought to have been brought from the river Khosr, some 3 km. to the west. Since each stone weighs 5–10 kg., and 650–800 were needed for each tholos, a considerable investment of energy was involved.' At Yarim Tepe II, in the Halaf period, there was ambiguous evidence for the use of Mosul Marble slabs on the interior of a *tholos* (cf. Merpert and Munchaev 1987: 21). In the south, outside the prehistoric settlements of Khuzistan, the use of stone for wall-bases in houses appears to have been the exception rather than the rule.

Margueron (1988) has pointed out that even in foundation levels stone is very rare in Mesopotamia compared to Syria. Although archaeological evidence deals almost exclusively in foundation levels, had stone been used higher in walls it would have been evident to a degree in debris, even allowing that stone was constantly robbed out and reused in the south at sites like Ur and Uruk.

Long ago Woolley (1934: 228) observed of Sumer that 'the further we go back in time the more does stone seem to be the normal material for the builder. But it was never the normal building material for the country.' It is not always fully appreciated that stone was most extensively used in Sumer for building purposes in some of the earliest public buildings excavated there. This stone is almost certainly of local origin (see above). The stratigraphic complexity of the architecture of phases VI–III in prehistoric Uruk, and the manner in which the results of excavations there have been published in the past sixty years, to some extent conceals what is immediately evident to anyone who visits the site itself.

It needs, however, to be emphasized, even allowing for the very restricted nature of archaeological evidence for architectural elevations, that stone was not used above the lowest levels, save very exceptionally, and was confined to major public buildings.

The earliest coherent temple plan so far recovered at Uruk has been variously attributed within the range of strata VI–IV, in the middle of the fourth millennium BC. This, the German excavators' *Steinstiftempel* ('Stone Cone Temple'; variously *Mosaiktempel*) and its court wall were built of limestone, probably from Samawwa, about 30 km. from Uruk. The reports are full of uncertainties about the earliest history of this structure and its often remarkable features (Lenzen 1959: 8 ff.; pls. 36, 40; Heinrich 1982: 70 ff.). Much of the difficulty arises from subsequent stone-robbing and later intrusions. The building has recently been reassessed by Boehmer (1990; cf. Nashef 1992: 315–16) after fresh excavations and identified as a shrine for a water cult.

In examining the substantial late prehistoric terrace (*Alte Terrasse*) under the *Bit Resh*, Heinrich (1939: 22, 30; pl. 30b) found a paving of limestone fragments which had served as foundations. Lenzen (1961: 17) believed this stone, and some gypsum plaster blocks in it, had all been robbed from the 'Stone Cone Temple' (cf. Schmidt, J. 1972: 20–1). Blocks of limestone, crudely cut, laid in mud mortar, had been used for the wall foundations above a level of asphalt sealing the terrace of packed earth (Lenzen 1959: pls. 3a, b, 5b, 6a, b, 7a, b). Some parts of the structure were paved with limestone (Lenzen 1959: pl. 36, fig. 10) and the lower walls lined with stone blocks set in bitumen (Lenzen 1959: 13, 15–16). The walls of the structure above the foundations were neither of mudbrick nor of stone, but of moulded gypsum plaster into which pulverized mudbrick had been mixed (Lenzen 1959: 13). In other words, the walls had been made, presumably with the help of wooden frames or casings, of an artificial material specially reinforced, a variant of *terre pisé* (cf. Lenzen 1967: 35, pl. 21a, b).

The external faces of these walls had been decorated with cones of stone set firmly in it and contrasting in colour: bluish-grey (?bituminous limestone), white (gypsum/alabaster), and red (sandstone). An important element in the construction of these walls was a series of flat baked-clay plaques with rounded ends, pierced with a vertical hole at either end. Such fittings have also been found, out of context, at Larsa and at Tell el-Oueili. They appear to be stabilizers; but no absolutely convincing explanation of their precise role has yet been given (Huot and Maréchal 1985).

In Uruk V the foundation courses of the *Kalkstein-tempel*: 'Limestone Temple' in the Eanna Complex (Heinrich 1982: 74–5, fig. 114), in the first phase of building only, were constructed of flat, very irregularly

shaped pieces of limestone about 10 cm. thick. This temple (at 30 × 80 metres in size) is larger than the Parthenon in Athens (30.8 × 69.5 m.). It is not known whether any walls were built of stone above the lowest courses; parallels elsewhere at Uruk suggest not (Jordan 1931: 48 ff., pl. 4; 1932: 16 ff., fig. 2). Significantly, many of the limestone pieces had been removed when the structure was reconstructed with foundation courses in mudbrick and, according to Heinrich (in Nöldeke *et al.* 1934: 7) this stone was reused elsewhere on the site in foundations.

The north corner of the Stone Cone Temple was destroyed by the *Riemchengebäude*, probably in Uruk IV (Heinrich 1982: 72 ff.). It stood on a platform of limestone blocks taken from the Stone Cone Temple. To the same building phase belongs the *Bau mit den vier Sälen* (*Empfangspalast* or *Tempel E*; Heinrich 1982: 77–8, fig. 115), which had at least one room with mudbrick walls set on limestone blocks (Lenzen 1968: pl. 9b).

As its name suggests, the *Steingebäude*, at the foot of the Anu Ziggurat on the east side, is the building in prehistoric Uruk in which stone appears to have been employed most extensively; not only for the foundation platform, but also in the walls, in the fittings on the floor of the central chamber, and as packing (Schmidt, J. 1972: pl. 7a). This strange structure consisted of three concentric rectangular rooms, each with an entrance on a different side, set in a great pit. The walls were preserved to a height of 3.20–3.40 m., perhaps their full height. The walls of the outer and of the inner rooms were constructed of limestone blocks, whilst those of the central room were built of gypsum plaster blocks topped by one or two courses of limestone slabs. All the walls were set upon a pavement of well-jointed limestone slabs. Eventually the building was filled with alternating layers of stone and mud in the central room; in the outer corridors only the lowest stone packing had survived. As was often the case at Uruk where evidence had survived undisturbed, even this stonework had been concealed with layers of gypsum plaster and sealed against the damp with bitumen (Schmidt, J. 1972: pl. 9a; in general, Heinrich 1982: 67–8).

Limestone was also used for a water channel in Uruk IVb (Heinrich 1935: 6 ff.). Intermittent traces of stone in buildings were attributed to Uruk III at the end of the fourth millennium BC (Lenzen 1960: 11; 1961: 14; 1962: 10); but thereafter, as elsewhere, the practice of using stone architecturally at Uruk passed into eclipse.

The architectural use of stone in the temples of the later fourth millennium in Sumer is as well exemplified at Eridu as at Uruk, for, in Lloyd's succinct description, 'the whole mound had been surrounded by a retaining wall of undressed white limestone in gypsum mortar, to make an emplacement for a new sacred *temenos*. Above this, the temple-platform rose at a sharp angle,

its face constructed of pale pink limestone in small stepped courses in gypsum plaster. At a point some 15 m. above the surrounding plain, this stepped face gave way to a vertical façade' (Lloyd 1954: 464; for details cf. Safar 1981: 54, figs. 5–7, 9; 78 ff., figs. 30–1). One of the stones involved was geologically identified long ago: 'at Eridu . . . the city-walls and bastions (Lloyd's retaining wall) are partly built of rough masses of gypsum (identified as such by Mr Campbell Smith, of the Natural History Museum) which is found not far off in the desert' (Hall and Woolley 1927: 66 n. 1).

The most recent excavators at Eridu were unable to investigate the late prehistoric levels underlying the enormous baked brick ziggurat of the Ur III period, but in one case they did uncover a structure of stone: 'a wall two-and-a-half metres thick, standing to an average height of a little under a metre and built entirely in small bricks of white gypsum (sizes 42–45 x 10 x 10; 22 x 10 x 10 cms.)' (Safar 1981: 81, fig. 32). That these might be gypsum plaster bricks, rather than blocks of the stone itself, is suggested by their standard sizes.

At many other excavated Sumerian sites the use of stone in the second half of the fourth millennium BC is obscured by later structures, so the precise role and chronological attribution of stonework may be debatable. As Delougaz (1940: 42) pointed out, the traces of stone walling found at Tell al-Ubaid below the east angle of the temple platform may belong not, as Hall and Woolley argued (1927: 66), to an Early Dynastic structure, but to a building of the late prehistoric period. Then again, at Ur, the precise role of the 'masking' of limestone rubble against the mudbrick retaining wall of Archaic I in the area of the Ziggurat is obscure (Woolley 1939: 8, pls. 1–2a, cf. 35, pl. 20a). This may also be late prehistoric rather than Early Dynastic in date. At Ur, in pit F between stratum H and the 'kiln stratum', Woolley reported mudbrick walls on stone foundations of the later prehistoric period (Woolley 1956: 61, pl. 74).

At Tell Adab (Bismaya) Banks noted the discovery of stonework beneath levels of plano-convex brick: 'in a tunnel which I have dug into the foundation from the S.W. side, four meters below the surface we came upon a dozen white limestone blocks of the size of large paving stones' (Banks's Report No. 8 to President Harper, Chicago University, 28 Jan. 1904; cf. Banks 1912: 237). This find establishes that the phenomenon was not confined to the south-west part of Sumer, but also appeared further north and east. The contemporary network of canals and waterways already facilitated transport of locally available limestone and gypsum within Sumer.

In the late prehistoric period stone-cone mosaics were used to decorate mudbrick walls in religious buildings as at Uruk and Eridu (Nöldeke 1938: 28, pl. 34; Safar 1981: 66, 81, 240, figs. 118–19). Red, black, and

white limestone were the primary materials. They may be the precursors of terracotta cones (p. 309). Sometimes roundels of stone, rather than cones, were used, pierced for suspension with copper wire, as at Merejib near Ur (Woolley 1939: 83). Associated with the stone cones in many of their appearances are rosettes consisting of a central disk and separately cut petals in variously coloured calcium-based stones and sometimes shell. A variety of examples were found in the *Sammel-fund* at Uruk (Heinrich 1936: 43–4, pl. 32).

The fashion penetrated along the line of the Euphrates and its tributaries to appear at Brak. There the stone rosettes, originally on baked-clay stalks driven into the wall, were found fallen from the outer face of the south wall of the 'Eye-Temple'. They were described as being of eight petals alternately of 'white marble and black shale, with a centre piece of pink limestone' (Mallowan 1947: 95, pl. V; cf. pl. XXX. 1–2). Their association with cone mosaics suggested that both had formed part of a single scheme of decoration (Mallowan 1947: 96, pl. VI. 3). To judge from finds at Tell al-Ubaid, stone rosettes, but not it appears cone mosaics, survived as an element of temple decoration until Early Dynastic III (Hall and Woolley 1927: 40–1, 81–2, 118 ff., pls. XII.5, XXX.1, XXXIV.1).

(b) The historic period

(1) Sumer and Babylonia

Stone continues to appear sporadically in buildings of the Early Dynastic period in Sumer. It is unfortunate that the most remarkable, the so-called *Construction inférieure* at Telloh (*Girsu*), was excavated so long ago that it is not always easy to unravel the information provided by inadequate reports of relatively uncontrolled digging (Sarzec and Heuzey 1884–1912: 411–12; Parrot 1948: 56, fig. 13; cf. Crawford, H. E. W. 1987). This building, consisting of two rooms of differing sizes set back to back, was erected on a pavement of gypsum slabs, which had originally extended for some distance beyond the structure. Foundation deposits associated with this building were found beneath specially marked gypsum slabs (cf. Ellis 1968: 51). At some point in its use part of this building was encased in a *massif* of plano-convex brick and gypsum slabs like those used in the pavement, set in bitumen mortar. The whole complex was eventually concealed beneath a platform covered by a pavement of gypsum blocks. This appears to have been the setting for a temple of the time of Ur-Nanshe, c.2500 BC. In many ways this construction recalls the earlier, no less enigmatic, *Steingebäude* at Uruk (cf. Heinrich 1982: 67–8; 134–6).

In the Early Dynastic period, as thereafter, the only consistent use of stone in the south in buildings was for door-sockets (cf. Woolley 1934: 228); otherwise its

appearances are sporadic. At both Khafajah (Delougaz 1940: 21) and Tell al-Ubaid (Hall and Woolley 1927: 13, 70) the treads of steps were either of gypsum or limestone. At Kish in chamber 31 of Palace A Mackay (1929: 90, 94) reported 'four large blocks of limestone' which he thought were part of a pavement: 'The average thickness of these blocks is 17 cm. and their average length 78 centimetres. They were roughly smoothed, but no tool-marks are visible.' An irregular block of limestone (74 x 35 x 10 cm.) was found elsewhere in the palace. Mackay also reported (1929: 107) 'evidence from other parts of Kish that this schistose rock (gypsum), besides being burnt for plaster, was used for the lintels of narrow doorways and door sills'.

At Ur stone played a conspicuous part in the construction of the Royal Tombs in Early Dynastic IIIA: 'the stone employed is a coarse white limestone; the blocks are unshaped, simply split and broken in the quarry, and vary greatly in size, the largest being rather more than a metre in length' (Woolley 1934: 229). Woolley noted that this stone was available at no great distance from Ur. These blocks were invariably laid in plain mud mortar. For walls set against the sides of tomb pits a mixture of mud and stone had been rammed down into a wooden form, as with standard *terre pisé*. No cross-walls were well enough preserved to reveal their method of construction. Corbel vaulting in stone was used in a number of the tombs (Woolley 1934: 232-3; Besenval 1984: 81 ff.).

Entemena, ruler of Lagash, recorded that 'he built the foundations of *Namnunda-kigarra* in stone' (Steible 1982: 243); some three centuries later Gudea reported doing the same for the *Enimma*-temple (Statue B: VI. 59-63). As archaeological knowledge of Sumerian temples is scarce, much may remain to be discovered about foundation levels of stone (cf. Tunça 1984: 118).

At Mari on the middle Euphrates where stone was readily available it was used rather more often for the footings, and perhaps for the higher courses, of religious buildings (Parrot 1956: 6-7; cf. Tunça 1984: 56-7, 118) and for tombs (Jean-Marie 1990). Even in the later palace at Mari the use of stone, gypsum or limestone, is sporadic: for the pavement in the palace portico (Parrot 1958^a: 7, figs. 1, 3, pl. X); for door-sockets (ibid.: pl. XII, figs. 123-4, 309); in isolated traces of earlier buildings (ibid.: 28-9, figs. 26-7); in fittings of uncertain purpose (ibid.: 59 ff., pl. XXI); for thresholds (ibid.: 75-6, 117 n. 1, pl. LIV.3, fig. 80); in isolated foundation courses of well-cut stone in very specific contexts (ibid.: 115-17, figs. 118 ff.; figs. 406, 413, pl. LXIV.1); in drains, steps, and wells (ibid.: figs. 337-8, 408, 409-10, pl. LXIV. 2).

For almost two millennia after the middle of the third millennium BC in Sumer and Babylonia the use of stone in buildings, save as door-sockets and the occasional threshold or sill, is absent from the archaeological

record. This is often surprising when stone was readily available. As Starr (1939: 44) reported of Nuzi: 'stone was practically never used as a building medium. Except as the most valued material for door-sockets . . . With an unlimited supply of stone in the hills behind Kirkuk, it is strange that so little use was made of this permanent material.'

Exceptionally, before the Middle and Neo-Assyrian kings, Gudea of Lagash, c.2100 BC, detailed the procurement of stone for his temple-building programme (Cylinder A and Statue B; translations in Oppenheim 1969: 268-9; Jacobsen 1987: 407-8; cf. Pettinato 1972: 139-42). These inscriptions indicate that Gudea was using the Euphrates and Tigris river systems, with their related canals, to bring building and sculptural stone both from outcrops adjacent to the middle Euphrates between modern Deir-ez-Zor and Jerablus, and from the upper course of the Adhaim, a tributary of the Tigris. Unfortunately, translations of the stone names remain debatable or impossible at present. The archaeological evidence reinforces the philological view that these were primarily, if not exclusively, light-coloured, calcium-based stones: various types of calcite, gypsum (Mosul Marble), and limestone rather than the hard dark volcanic rocks, which Gudea obtained from the Gulf for sculpture (see Chapter 1). However, the inclusion of large 'NA-stones', which were also used for millstones, indicates the import of basalt from Syria (cf. Stol 1979: 87).

The history of stone building in Babylonia does not reopen until fifteen hundred years later when the centralized Neo-Babylonian state was geared to providing a much wider range of stone for temple building through use of river and canal transport. Of the sites in Babylonia in the sixth century BC where the extensive building activities of the Neo-Babylonian rulers have been traced, it is only Babylon that offers substantial evidence for the use of stone, presumably imported at royal command down the Euphrates. 'There are only two places where hewn stone occurs in any large quantity in the Vaulted Building [identified by Koldewey as the undercroft of the 'Hanging Gardens'] and on the north wall of the Kasr, and it is remarkable that in all the literature referring to Babylon, including the cuneiform inscriptions, stone is only mentioned as used in two places, in the north wall of the Kasr and in the hanging gardens' (Koldewey 1914: 95). Such stonework is unprecedented in southern Mesopotamia.

The finest standing stonework, part of Nebuchadnezzar's defences on the river side of the Kasr, is of 'immense blocks of limestone bound together with dove-tailed wooden clamps laid in asphalt' (Koldewey 1914: 374 ff., figs. 109-12). Limestone and breccia slabs formed the surface of the great processional way, laid over baked brick and bitumen (Koldewey 1914: 25, fig. 14). Some of the stone slabs used at Babylon have Sen-

nacherib's (c.704-681 BC) name on the underside (Koldewey 1914: 53, 191, fig. 36), indicating, perhaps, that it was the Assyrians who had originally brought the fashion for such stonework to Babylon. Nebuchadnezzar's (604-562 BC) inscriptions (Langdon 1912: *Steinplatten* inscription 5:12) relate that his father had used similar slabs in Babylon. In the main citadel the paving slabs in courtyards were of white and mottled sandstone, of limestone and of black basalt. They measure 66 centimetres square and bear most often the name of Nebuchadnezzar; in one case at least that of Evil-Merodach (c.561-560 BC) was noted (Koldewey 1914: 159).

It is hardly surprising that it is also at Babylon that the only architectural stonework has survived that is in any way comparable with that commissioned by the Achaemenid Persian kings at Susa and at their two major creations in highland Iran, Pasargadae and Persepolis, where suitable building stone was available on site. In the eastern court of the southern citadel at Babylon Koldewey found fragmentary column-bases of two types in a grey-black limestone which had come from a royal palace of standard Persian design. The stone was almost certainly imported from western Iran for this building by its Persian builder, probably by Artaxerxes II (Vallat 1989).

What evidence there is for bridges in Babylonia (cf. Jacobsen and Lloyd 1935: 2 n. 1) does not corroborate the description given in Herodotus (i. 185) of the stone bridge built by Queen Nitocris at Babylon. Koldewey's excavations revealed a bridge built of baked brick with piers shaped like boats (Wetzel 1930: 55 ff.). If there had been a stone bridge, it may have been of Achaemenid date and remains to be located.

(2) Assyria

Long ago, following Layard's (1849: ii. 313 ff.) excellent initial description, Rawlinson (G. 1875: ii. 11) admirably summed up the stone resources of Assyria:

Assyria is far better supplied with minerals than Babylonia. Stone of a good quality, either limestone, sandstone, or conglomerate, is always at hand; while a tolerable clay is also to be found in most places. If a more durable material is required, basaltic rock may be obtained from the Mons Masius (Kara Dagh)—a substance almost as hard as granite (Layard 1849: ii. 316). On the left bank of the Tigris a soft grey alabaster abounds which is easily cut into slabs, and forms an excellent material for the sculptor (Layard 1849: ii. 313-14). The neighbouring mountains of Kurdistan contain marbles of many different qualities; and these could be procured without much difficulty by means of the rivers.

Whereas for the south the rare availability of stone suitable for building purposes gives particular interest to all instances of its use, particularly after about 3000 BC, the same is not true of northern Mesopotamia where it was much more readily accessible to those who

chose to use it. It is, then, the more remarkable that a mud *pisé* or mudbrick architecture emerged so early and remained for so long as widespread in the north as in the south (cf. Aurenche 1981). As early as stratum XIV at Gawra (in the Uruk period) Tobler (1950: 36) commented that 'the use of stone as a foundation material, however, marks a complete departure from the building practices of earlier and later strata where stone is sparingly employed only as paving material'. At Brak for the late prehistoric 'Eye-Temple' Mallowan enumerated in some detail the mudbrick types, but with regard to stone he noted only that in some places the external walls of the temple were buttressed with a skin of heavy blocks of basalt and gypsum, both of which were available in the locality (Mallowan 1947: 10, 32 ff., 55, pl. XLVIII.5).

In the first half of the third millennium BC a slight trace of plano-convex brickwork at Brak was associated with part of a wall built of rough blocks of gypsum, a stone door-socket, and an alabaster foundation box (Mallowan 1947: 54-5), as might be expected then in Sumer. At Tell Chuera the foundation levels of the two religious buildings, the *Aussenbau* and the *Nord Tempel*, were entirely of local stone (cf. Tunça 1984: 79 ff.), whilst a series of buildings whose function is unclear, *Steinbauten* I, III, and V, had substantial bases or foundation courses of blocks cut from local limestone outcrops. At Assur, where later stone was to have a considerable role in architecture, it is virtually absent from the Archaic Ishtar Temple in phases H and G, save for a threshold in cella 18-17 (Andrae 1922: 28, 29, 31). The area SS complex of the Akkadian period at Tell Brak had a vast Mosul Marble dais at the north side of the South Courtyard (Oates and Oates 1989: pl. 23). In the later third millennium at Tell Taya (Reade 1973; Farrant 1978) the local limestone was only used for foundation courses, in largely unworked blocks of irregular size and shape.

A stone fortification wall, perhaps of the earlier second millennium BC, has been reported at Hamad Aga as-Saghir in the Sinjar Plain (Nashef 1990: 269-70). At Tepe Gawra the Old Assyrian level VI is the earliest to be distinguished by the extensive use of stone in buildings (Speiser 1935: 14). Once a sequence of major building levels becomes evident at Assur (Andrae 1977: 119 ff.), in the same period, this city, above all, offers recurrent evidence for a steady, but restricted, use of stone, predominantly local limestone, in building, primarily in foundation courses, for plinths, wall-linings, and pavements, for major retaining walls and quays, all public buildings undertaken in the king's name. From the Old Assyrian period onwards, as in the Sumero-Babylonian tradition, foundation tablets inscribed with building inscriptions were cut on limestone or 'alabaster' (gypsum/calcite) (cf. Ellis 1968: 188 ff.). It is not until the Middle Assyrian period that

these inscriptions reveal much evidence for the materials used.

Adad-nirari I (c.1305–1274 BC) 'cleared that site [the Step Gate of the temple of the god Assur] down to the bottom of the foundation pit. I built (the new structure) with limestone (*pulu*) and (bitumen) mortar from the city of *Ubase*' (Grayson 1972: 63). When they found this the German excavators described it as built of 'grosser Semman-Kalksteinblöcke mit Asphaltmörtel' (cf. Andrae 1913: 152–3). *Ubase* is usually identified with Tell Hawaish, overlooking the Tigris, 20 km. north of Assur (cf. Oates, D. 1968^a: 59 n. 5). Adad-nirari I again used limestone to face the quay wall along the Tigris with stone (Grayson 1972: 63 ff.; cf. Andrae 1913: 149–52) and to strengthen the foundation levels of the Temple of Ishtar, as did his immediate successors (Grayson 1972: 68, 86, 89, 107; 1976: 18, 28). Rather more unusual, and reminiscent of very ancient custom, is Assur-reš-iši's (c.1132–1115 BC) account, when restoring the mudbrick towers of the Ishtar Temple at Nineveh (Grayson 1972: 148), of putting 'stone rosettes' all round them.

Evidence for other stonework from Assyria before the reign of Tukulti-Ninurta I (c.1243–1207 BC) is sparse; but sculpture and inscribed stones are predominantly of white or black limestone (Moortgat 1969: 236; Grayson 1972: 60: inscription of Adad-nirari I). Of unusual significance are the earliest in a long series of inscribed stelae set up in rows at Assur (Andrae 1913). It is not known precisely when they began, since the earliest installation was destroyed, but the first dated royal stela is that of Adad-nirari I (c.1305–1274 BC). There is room for the series to have gone back originally many generations before him. Assurnasirpal II (c.883–859 BC) is the last king in the royal row; thereafter a few women continued to add to the royal line into the eighth century BC. Of the twenty-eight published royal stela seven are of basalt, the rest of calcium-based stones identified variously as limestone or gypsum. Two of the three basalt stelae, dated to the eleventh century BC, are finely carved columns unique in the Assyrian tradition (cf. Andrae 1913: nos. 15–17; 1977: figs. 125–7). The row of officials' stelae contains the earliest example, of the fourteenth century BC, and also continues down into the eighth century BC. Of the 110 published examples only two are carved of basalt rather than calcium-based or conglomerate stones (Andrae 1913: nos. 41 and 129) and one of these is for a client ruler.

The history of the use of stone in architecture and sculpture in Assyria begins most explicitly to form part of one and the same story from the reign of Tiglath-Pileser I (c. 1114–1076 BC). The connection was defined by Moortgat:

They (guardian colossi) are architectural sculpture in the true meaning of the term, because they are not just scul-

ptured wall decoration: the giant building blocks from which they were carved, partly as sculpture in the round and partly as high relief, still keep their essentially tectonic function as they support the brick walls above them and form the inside surface of the mighty gateways. One should not really describe Assyrian wall relief, which is clearly bas-relief on relatively thin slabs of alabaster (i.e. Mosul Marble), as architectural sculpture in the same way . . . nor should we refer to orthostats in this way, though it is often done. The stone blocks flanking the doorways are in fact building blocks placed on end, whereas the wall relief slabs are decorative slabs to protect the lower part of the walls of the hall and court and have no real tectonic function. They are actually wall painting transformed into stone, and this is further emphasized by their polychrome colouring, which has survived on many fragments.

(Moortgat 1969: 130–1; for details of relief-cutting techniques see p. 34 ff. here.)

Even the reliefs cut on altars for Tukulti-Ninurta I (c.1243–1207 BC) (Moortgat 1969: pls. 246–7) and the early obelisks, which open the great sequence of these monuments in Assyria, belong more to the world of architecture than to that of sculpture as usually defined (Börker-Klähn 1982: nos. 130 ff.).

The techniques of Assyrian sculpture, from quarry to palace wall, have been reviewed here in the section on sculpture in Chapter 1 (see pp. 32 ff.). The following paragraphs are concerned only with which stones were used by Assyrian builders, from which sources, and for what purposes. There has not yet been a study comparable to Nylander's (1971) on Achaemenid masonry for Neo-Assyrian stonework. He demonstrated how Anatolian masons were employed on royal works by the early Achaemenid kings in the absence of a local Iranian tradition of monumental stone masonry finely executed. As there was no Assyrian tradition either, it is currently assumed that the Neo-Assyrian kings likewise drew upon the skills of foreign craftsmen, in this case from Phoenicia or Syria. So, before considering the various building stones in turn, brief attention will be paid to the most significant instances of western contact.

There are three major occasions when there is a conscious imitation and emulation of architectural and sculptural fashions encountered by kings campaigning to the west of the Euphrates: under Tiglath-Pileser I (c. 1114–1076 BC), Assurnasirpal II (c.883–559 BC), and finally in the last quarter of the eighth century BC. In the first instance emulation extended to using basalt, the stone favoured for monumental sculpture in Syria. Speaking of his palace at Assur, Tiglath-Pileser I records that he constructed one part of it in wood and 'entirely surrounded it with basalt (*atbaru*) slabs'. He goes on to record that he also made replicas in basalt of a *nāhiru* (sea creature) from the Mediterranean and a *burhiš* (a bovid) from Iran or Anatolia, and placed them flanking the palace entrance (Grayson 1976: 28–9). When the palace was completed, as recorded on the

later 'Broken Obelisk' of his son Assurbelkala (c.1073–1056 BC), there were replicas of 'two *nāhiru*, four *burhiš*, (and) four lions in basalt (*atbaru*), two genii (?human-headed winged bulls) in *parātu*-stone, (and) two *burhiš* in white limestone (*pīlu pēšu*)' (Grayson 1976: 56). A fragmentary basalt animal figure, not of monumental size, found at Assur was inscribed '(Property of) the palace of Assurbelkala . . .'. It is thought to represent a monk-seal (*muraena helena*) (Gadd 1948: 21 ff., pl. VI).

Assurnasirpal II is the first Assyrian ruler known to have commissioned extensive series of carved stone orthostats to line the lower walls of the courts and public rooms of his palace. When this king campaigned across the Euphrates, c.870 BC, he was the first Assyrian ruler to do so. In the course of this campaign he would have seen an established tradition of relief sculpture and colossi carved in local basalt with royal inscriptions, lining the lower walls of royal palaces, notably at Carchemish. It is also known that he took prisoners from the Neo-Hittite kingdom of *Khatti* (Carchemish) and settled them in his new capital at Nimrud. It is then probable that his initiative in developing relief sculpture in his own palace there was directly inspired by his encounters with comparable earlier work in Syria (Hawkins 1982: 390). In this case, unlike his predecessor Tiglath-Pileser I, he used a local stone ('Mosul Marble'), much more easily carved than basalt. Rather than directly imitating the Syrian work he had seen, he redirected established Assyrian skills in carving colossi and relief sculpture on altars and obelisks to developing large-scale programmes of architectural sculpture in the Neo-Hittite manner on orthostats set against the lower courses of walls.

The third case is rather different and concerns architectural fittings rather than sculptures. The period of maximum interaction between Mesopotamia and Syria falls in the seventy years that begin with the reign of Tiglath-Pileser III (744–727 BC), who completely reorganized the administration of the western provinces of the Empire. Already under Adad-nirari III (c.810–783 BC) it may be possible to detect the impact of Phoenician skills in architectural stoneworking at Nimrud, as Mallowan (1978: 158) argued. A special finesse then appears in the traditional Assyrian use of limestone for foundations and the facings of lower walls and quays. But it is under Sargon II (c.721–705 BC), particularly, that columns of cedar set on carved stone bases, often of basalt, were introduced. The two primary types of column-base then adopted are Syrian in origin. The simpler form, used in Palace F at Khorsabad and at Assur, is to be found earlier at Arslan Tash and Sinjirli in the west, whilst the more elaborate, used in Residence K at Khorsabad and at Nineveh, is paralleled at Carchemish in the west (Collon 1969: 12 ff.). Moulded stone plinths and columned front entrances, elaborated

with occasional slabs of black basalt, may have been typical though not invariable features of the *bit-hilani* mentioned in texts. This architectural feature, of uncertain form, was introduced into Assyrian palaces from Syria, as Neo-Assyrian royal inscriptions specifically indicate, first in the reign of Tiglath-Pileser III in the eighth century BC (cf. Winter 1982: 357 ff.).

Neo-Assyrian royal inscriptions offer significant information on the stones used for building and for architectural sculpture, but translation of terms used for stones remains hazardous in any specific case, particularly for the calcium-based stones which were those most commonly employed. Even if scribes may be assumed to have used terms consistently over an extended period of time, which is unlikely, these stones are deceptively similar in appearance to an inexperienced eye and that alone is what the ancient terms were based on, not on the chemistry that is the ultimate arbitrator for modern descriptions. Even modern terminology is regularly compromised by loose use of 'alabaster' or 'marble' for stones in this range. Accurate translation is often further complicated by the fact that when inscriptions clearly identify the stone on which they are cut, there is usually no modern geological identification of it and, when mineralogical studies have been made, the associated inscriptions only offer indirect evidence for the ancient terms for the stones sampled. Broadly speaking, the vocabulary for building stones distinguishes them by colour (white or light-coloured; red or reddish; black or dark-coloured), with special tones indicated by metaphorical or analogous descriptions of texture.

Pīlu (AHw II: 864; Campbell Thompson 1936: 158), perhaps the commonest term, is conventionally translated as limestone, specifically designated in some cases (cf. Lackenbacher 1982: 90) as a stone strong enough to replace rock and regularly used for foundations and fortifications. *Pīlu*, qualified as white or light-coloured (*pēšu*), was used for architectural sculpture. Whether this term always describes a type of limestone or whether it may sometimes indicate 'Mosul Marble' (gypsum), as Mitchell (forthcoming) suggests, is an open question. *Parātu* and *gišnugallu*, both used to describe a foundation tablet deposited by Sargon II at Khorsabad identified by Berthelot as magnesite (pure magnesium carbonate) (cf. Bjorkman 1987: 90–7), are usually translated 'alabaster', a non-technical term which usefully, if strictly inaccurately, embraces both calcite and gypsum. Calcite (calcium carbonate) and magnesite belong to a range of carbonate minerals, including aragonite and dolomite, so the ambivalence of ancient scribal usage in this case is hardly surprising and reflects a dilemma still current. This case illustrates how dangerous it is to assume that terms like *pīlu*, *parātu*, or *gišnugallu*, often used for a precious white stone (CAD 'G': 106), were consistently used to

describe the same calcium-based stones in Neo-Assyrian building inscriptions.

Both in the case of the great throne-base of Shalmaneser III found at Nimrud, made of 'this *parûtu*-stone, Mount Tunu stone' (Hulin 1963: 55–6), and in that of the Kuba'il Statue of the same king, also from Nimrud, described in the text cut into it as made of *gišnugallu* (Kinnier Wilson 1962: 91), no geological determination of the stones was made at the time of publication. The former is described as a 'yellowish-brown limestone' and the latter as 'white limestone or calcite'.

Occasionally, a calcium-based stone with an unusually distinctive appearance may be more readily categorized in ancient and in modern terms. Although the majority of the slabs/colossi analysed from Sennacherib's Palace now in the British Museum were gypsum (Mitchell: forthcoming) a distinctive group of slabs from Room XXXIII were not. They were a fine-grained fossiliferous limestone ('calcite + gypsum'), whose unusual appearance has often been commented on, particularly since the text carved on the winged lion-sphinxes of the same stone at the entrance to Room XXXIII refers to the stone used for them (cf. Reade 1972: 110–11) in the following way: '*Ašnan/pindû* (NA₄. "SE.TIR)-stone whose structure is as finely granulated as if it were made of barleygrains (*variant*: "cucumber seeds") which in the time of the kings, my fathers, was solely valued for necklaces made its appearance at the foot of Mt. Nipur and I had colossi made of it and transported to Nineveh' (cf. Luckenbill 1924: 127d). Lexical lists give the phonetic reading of NA₄. "SE.TIR as *pindû*, a valuable kind of red stone used for jewellery and of SE.TIR as *ašnan*: 'grain' (CAD 'G': 104). The stone used in Room XXXIII has iron impurities in it, which give it a reddish-brown colour, so that the Akkadian reading as *pindû* (rather than *ašnan*) stone may be appropriate in this context.

It may be noted that the term *abnu*: 'stone' (Sumerian NA) is regularly used to describe the various calcium-based stones employed by Assyrian builders and sculptors (cf. CAD 'A': 54; AHw I:6; Campbell Thompson 1936: *passim*). *Gašsu* rarely refers to the stone gypsum, as for thresholds at Nimrud in the time of Tiglath-Pileser III (Lackenbacher 1982: 90), more often to the plaster made from it. It is therefore still not clear precisely what the standard term was to describe the 'Mosul Marble' (gypsum) so commonly used for relief sculptures, whether *pîlu pēšu*, *parûtu*, or some other word.

A text of Sennacherib (MacGinnis 1989), in which he describes the hardcore laid round a set of white limestone horse-troughs installed at Nineveh, draws a distinction between '*sievings* of my precious stones', which include *pappardilû*, *pappardildilû* and *hulâlu*, perhaps all types of quartz, and '*chippings* from the slabs of my palace'. These include *elallu*, *engisû*, *girim*

hilibû, *gišnugallu*, *haltu*, *jašpû*, *pindû*, *turminû*, and *turminabandû*. When Esarhaddon had slabs and paving stones cut for his palace he records using *elallu*, *girim hilibû*, *pindû*, *turminû*, *turminabandû* (Borger 1956: 61, 78–82), illustrating a recurrent pattern in Neo-Assyrian architecture of using calcium-based stones of varying colour and texture with breccias.

In the sixth century BC the processional road at Babylon was paved with slabs of fine hard limestone and of red breccia. On the edges of each slab, concealed when laid, was an inscription of Nebuchadnezzar II mentioning the stones: *šadu* ('mountain') on those of limestone, *turminabandû* on those of red breccia (Koldewey 1900). Koldewey believed that the limestone might have been brought from the neighbourhood of Anah or Hit; but he could not place the breccia (Koldewey 1914: 25). Earlier, Sennacherib had recorded that *turminabandû* 'used for all kinds of great jars such as had never been seen before' was obtained from Kapridargila, 'which is on the border of Til-Barsip'; that is, on the Euphrates in the region of Carchemish (Luckenbill 1924: 121). Breccia is indeed reported at Birejik, a few miles to the north of Carchemish (Ainsworth 1838: 94). The same king reported how 'great slabs of *t*-stone I fashioned and I cut out both stones in their quarry and had them dragged to Nineveh for the construction of my palace' (Luckenbill 1924: 108: 72–3; modified after CAD 'K': 354, cf. Russell 1985: 144 n. 35), a reference to the close-grained magnesian limestone slabs lining Room LIII of Sennacherib's palace at Nineveh.

Other building stones characterized by their red or reddish colour include *sābu* and *šammu*. Sennacherib (Luckenbill 1924: 133: 83–4) records that the bronze pillars of his palace were set on pedestals of *sābu*-stone: 'the stone that looks like unboiled ox blood' (CAD 'S': 5), of *pindû*-stone, and of *turminabandû*-stone. *Šammu*-stone was received as tribute, with *parûtu*-stone, by Assurnasirpal from the town of Hindana on the Middle Euphrates (Grayson 1976: 125). Campbell Thompson (1936: 192) suggested that this might be a hard red sandstone, the stone used for a stela found at Nineveh that commemorated the gift of the province of Hindana to Nergaleresh by Adad-nirari III (Campbell Thompson and Mallowan 1934: 113). Earlier references from texts found at Mari (Heimpel *et al.* 1988: 198 ff.) indicate that *šammu* also designates the impure form of corundum (emery) widely used as an abrasive. It is described as 'Sutean *šammu*', a reference to the Syrian steppe that would correspond well with Assurnasirpal's source for this stone.

The terms for dark stones used for building and architectural sculpture are only relatively less confusing. As basalt was anciently categorized primarily by its colour, there are a number of words in Akkadian that describe it. As in Arabic, the term 'black stone' (*šallamtu*) might at times serve for the more specific *atbaru* which is the

word used for the material in the inscription on an Iron Age sculpture of a bull at Arslan Tash in Syria carved from the local grey basalt (cf. Campbell Thompson 1936: 160 ff.; CAD 'A': 492; AHw I:86; Stol 1979: 83 ff.). Specific types of basalt, or closely related stones, may be meant by the words *kašurrû* ('from Gasar': CAD 'K': 296) and *šimurrû* ('from *Šimurrûm*': AHw II:1046); both were regions east of the Tigris in Mesopotamia. Sennacherib (Luckenbill 1924: 1273) recorded that he 'brought back with me a costly *kašuru*-stone (quarried) in faraway mountains and set it up under the pivots of the door leaves (of the gate of my palace)'.

Sennacherib is the only Assyrian king to provide detailed information on the quarries whence he obtained stone for building or for architectural sculpture. The quarry in Tastiye 'which lies across the Tigris', that is on the right bank of the river, provided him with *pîlu pēšu* as it had his predecessors (Luckenbill 1924: 104:65; 118:9). However, the quarried blocks were brought to Nineveh by water, at least when they had to cross the river to the left bank on which Nineveh lay. Not only was this hazardous, but it may have been confined to the time of the spring floods. This prompted Sennacherib to seek alternative sources 'near Nineveh, in the district of Balatai' (Luckenbill 1924: 108:62). This is usually identified with medieval Balad, modern Eski Mosul, on the right bank of the Tigris. The series of reliefs from Court VI of Sennacherib's palace at Nineveh, showing the quarrying and subsequent transport of bull colossi, include some slabs with inscriptions identifying the quarry as that of Balatai. Russell (1985: 128–30) has convincingly argued that these reliefs indicate that the quarry itself was on the left, not the right, bank of the river and thus within reach of Nineveh by land all the way. If this is so, the 'district' of Balatai included land on both sides of the Tigris.

It appears that on his fifth campaign Sennacherib himself observed the fine quality of *ašnan*-stone at Mt. Nipur, which is identified with the Judi Dag in south-east Turkey by two (of the six) inscriptions of Sennacherib inscribed there (Luckenbill 1924: 63–6). This is about 25 km. from the Tigris and then about 200 km. by river to Nineveh. This distinctive limestone has been identified among the stones used in Sennacherib's palace (p. 344).

Sennacherib attributed his *turminabandû*-stone to the region of Til-Barsip in Syria. He brought *gišnugallu*-stone from a quarry on Mt. Ammana (Luckenbill 1924: 107: 56; 121: 43). This stone, probably calcite, is recorded by Assurnasirpal II from Suru on the Habur river and by Tiglath-Pileser III from Tabal (Hawkins and Postgate 1988: 32, 34). Shalmaneser III reported 'immense quantities' of it from Mt. Muli, probably in the Taurus-Bokkar Dag massif (CAD 'G': 104–6). Sennacherib's Mt. Ammana may be the Akkadian equivalent of 'Mt. Amana' in the Song of Solomon 4:

8 and thus part of Mt. Hermon in the Anti-Lebanon range. It appears, then, that the primary building stones including basalt, when not available locally, came from quarries to the west or north-west in Syria or Turkey. It does not appear that Neo-Assyrian kings exploited sources to the north or north-east to anything like the same extent.

With this unusually explicit textual evidence in mind, the archaeological evidence for the main common stones may be rapidly reviewed.

Basalt occurs in many places in Syria and Anatolia, to a greater or lesser extent accessible to Mesopotamia, along the Tigris and Euphrates and their tributaries (Stol 1979: 86–7). Layard (1849: ii. 316–17) was specific about the use of basalt in Assyria:

The sitting figure [of the god Kidudu] from Kalah Shergat [Assur], and fragments of sculpture from the same ruins, are of black basalt. This appears to have been the material most generally employed in Assyria and Babylonia, for public monuments, when alabaster and limestone were not to be obtained: in the absence of granite it may, indeed, have been preferred to any other stone, as being more durable. It abounds in the Kurdish hills, particularly in the neighbourhood of Jezirah . . . and in that part of the Taurus through which the Tigris, and Euphrates, find a narrow and sudden outlet into the plains of Assyria . . . Several figures, and fragments of sculpture in it, have been at different times discovered in Babylonian ruins . . . The black basalt of Armenia was best suited to this purpose ["large and durable monuments"], and could without difficulty be floated down the Euphrates and the Tigris on rafts made of skins.

Tiglath-Pileser I and his son employed basalt for sculptures in the royal palace at Assur, a city where this stone is particularly evident throughout the reign of Shalmaneser III (cf. Reade 1981^a: 145 ff.). Although not well suited for extensive friezes of relief sculpture on orthostats, basalt was particularly used for obelisks. The basalt 'Rassam Obelisk' from Nimrud is the earliest dated Assyrian monument (c.873/67–859 BC) with multiple sculptured scenes of narrative type (Reade 1980). From the reign of Shalmaneser III two basalt statues have survived from Assur, one of the king standing (Strommenger 1970: 3, 16, pl. 6a), the other of the god Kidudu seated (ibid.: S1, 15, pls. 2–3). Basalt was used in the construction of the royal tombs at Assur and for some of the royal sarcophagi (Assurnasirpal II/Shamshi-Adad V: Haller: 1954: pl. 41d, 44d, cf. also p. 177). At Khorsabad in the reign of Sargon II basalt was employed most commonly for pivot stones and column-bases and, exceptionally, for orthostats in a small isolated building situated near the west corner of the palace platform at Khorsabad (Botta's 'Monument X'; Place's 'Temple'; cf. Loud and Altman 1938: 15).

Limestone is regularly encountered in Assyrian buildings. As Xenophon described the retreat of the Greek mercenaries northwards, in the late fourth century BC,

along the line of the Tigris, he reported that 'from here (i.e. Larissa: Nimrud) a day's march of eighteen miles brought them to a large undefended fortification near a city called *Mespila*, which was once inhabited by the Medes. The base of this fortification was made of polished stone in which there were many shells' (*Anabasis*, III. iv. 10). Ainsworth, who knew the country well, commented on this passage: 'it is a curious fact, that the common building stone of Mosul is highly fossiliferous, and indeed replete with shells . . . and the same limestone does not occur far to the north or to the south of Mosul, being succeeded by wastes of gypsum' (Ainsworth 1844: 140). These sharp-eyed observations on the common limestone of the Nineveh area provide a good introduction to the primary local building stone of varying quality and appearance that had been the usual resource before Neo-Assyrian times, and was long to remain so.

Limestone was widely available in outcrops that are a common feature of the landscape of the heart of Assyria, along river banks as well as away from them in the hilly hinterland. These sources were reasonably accessible to all major towns. Two famous early Neo-Assyrian monuments were carved in limestone, both from Nineveh: the 'Broken Obelisk', now generally attributed to Assurbelkala (c.1073–1056 BC) (cf. Borker-Klähn 1982: no. 131), and the 'White Obelisk', probably made for Assurnasirpal I (c.1049–1031 BC) rather than for the more famous second king of that name, though this is still debated (Borker-Klähn 1982: no. 132). White limestone appears as the medium for sculptures in the round such as deity statues from the Nabu Temple at Nimrud (Strommenger 1970: 18 ff.) in the time of Adad-Nirari III (c.810–783 BC) and from Esharhaddon's (South-West) Palace at the same site (Barnett and Falkner 1962: 20 ff.). Sennacherib used a distinctive hard fossiliferous limestone in Room XXXIII of his Nineveh Palace, whose source outside the Assyrian homeland he recorded (p. 345.). Later colossi are of a coarse limestone rather than of the Mosul Marble used earlier.

The use of limestone for masonry is particularly well recorded at Khorsabad where, in the reign of Sargon (c.721–705 BC), a coarse white limestone from quarries close to the site was employed for utilitarian exterior purposes (Loud and Altman 1938: 15): to face the palace terrace and for its crenellated parapet; in the bridge linking the Nabu Temple and Palace; for paving and drainage covers; for stair-treads and thresholds with decoration or inscription. Inside it was used for the orthostats of dados, when they were not carved with reliefs, for kerbing, and for pavements in gateways. Undressed blocks were used in the foundations of town and citadel walls; and for roughly dressed blocks or slabs in the construction of large drains and sewers. Where evidence is available elsewhere, this pattern of

use is consistent at Assur (Andrae 1977: *passim*), Nimrud (Mallowan 1966: *passim*), and Nineveh (Campbell Thompson and Hutchinson 1929: *passim*).

The most spectacular stonework in limestone of the Neo-Assyrian period is the canal constructed by Sennacherib (c.704–681 BC) to bring fresh water from Bavian to Nineveh, a distance of some 80 km. This involved the construction of an aqueduct to take it across a valley: 'in its construction, something over two million blocks (of stone) were used. Each measured approximately 50 × 50 × 65 cm., and in the centre five pointed arches, formed by corbelling, spanned the bed of a wide stream. The treatment of the façades of this great structure was curiously haphazard. Groups of closely dressed square blocks alternated with others heavily rusticated but having a carefully drafted margin. A heavy deposit of stone chips along the base showed that the faces had been dressed *in situ*' (Lloyd 1954: 469).

The work of Sennacherib's masons, in limestone, in the dam at Ajila (Campbell Thompson and Hutchinson 1929: 78, 114 ff., pl. LVIII.1, 2, 4, and 5) and the new defensive system attributed to him at Assur (Andrae 1977: pl. 206; 1913: 51, fig. 68, pl. 26) is equally impressive. It was in the unusually fine stonework of Sennacherib and Esarhaddon's masons that Mallowan (1978), particularly, sought to detect the influence of Phoenician stoneworkers, men long renowned for their skills in this craft.

In sculpture, if not also at times in building, certain coloured limestones were specifically chosen. The *yellowish-brown limestone* identified by Shalmaneser III as 'this *parūtu*-stone, Mount-Tunu-stone' has already been discussed (p. 344). A shoulder fragment from a large statue of Assurnasirpal II, now in the British Museum, is of a distinctive limestone unusual in the Neo-Assyrian repertory described as '*pink limestone* containing many nummulites'. Unfortunately, the Akkadian word describing this stone is missing from the surviving portion of its inscription (Reade and Walker 1981–2: 119).

A *black limestone*, which takes an attractive polish, used in Kassite times for *kudurrus* ('boundary stones') and in Middle Assyrian times for some royal inscriptions, was employed in the Neo-Assyrian period for such well-known monuments as the 'Black Obelisk' of Shalmaneser III found at Nimrud (Börker-Klähn 1982: no. 152) and for fragmentary later monuments at Nineveh (Reade 1981^a: 151 ff.). Reade (1981^a: 154) has suggested that sculptured wall-slabs from a detached building of Sargon's at Khorsabad, sometimes described as basalt, may also be a black limestone. The source of this stone is still unknown; the use of comparable stone by Achaemenid sculptors at Pasargadae and Persepolis in Iran, where it is readily available, has suggested to some scholars that it came from somewhere in the Zagros mountains. Rees Williams,

reporting on a piece of black limestone found at Eridu, referred to 'a bold scarp of similar black limestone . . . in the foothills of the Avroman mountains N.E. of Halabja' (in Safar 1981: 313). It is not known whether the Assyrians had a special term for it or whether it fell into the 'black' category with stones like basalt.

From the reign of Assurnasirpal II (c.883–859 BC) a stone variously described in the past as 'alabaster; alabastrous or gypseous limestone; gypsum', and now most commonly as *Mosul Marble*, was the principal medium for the sculptured reliefs lining the lower walls of apartments in royal palaces and temples, for throne-bases, and for some free-standing statuary. It is a type of gypsum and thus soft and easy to carve, but in need of protection if used out of doors. It is most readily available in the Nineveh region and to the west. Its use prior to the ninth century BC is not conspicuous. Its particular virtues appear not to have been appreciated until a stone was required suitable for unprecedented royal programmes of architectural relief sculpture.

Layard (1849: ii. 313 ff.) described it well after the first extensive revelation of Neo-Assyrian royal reliefs:

It abounds in the country, and being very soft is easily quarried and sculptured. It is still extensively employed in the country, chiefly cut, as in the time of the Assyrians, into slabs, and forming in that state a casing to walls of sun-dried or baked bricks . . . When first taken from the quarry, this alabaster is of a greyish white; but on exposure it soon changes, growing darker, and ultimately becoming a deep grey, the colour of the slabs now in the British Museum. It is extremely fragile, easily decomposes, and wears away, if subjected to the action of water, or even to damp . . . On exposure to fire, this alabaster becomes of a milky whiteness, as in the ruins of Khorsabad, Kouyunjik, and the south-west corner of Nimroud. The outline of the sculptures becomes, at the same time, sharper and more defined. They have consequently a more pleasing appearance, than in the grey slabs of the unburnt edifices; but they crack into numberless pieces, which fall off in flakes, so that it is impossible to move, and even frequently to preserve them. The sculptures from Khorsabad in the British Museum show this appearance, and are easily distinguished by it from those of Nimroud.

This is an appropriate point at which to close the survey of the use of stone in buildings in Mesopotamia, where, when it was used, it was as often for decoration as for structure and when for structure only in lower courses. Even when used for royal projects in the Middle and Neo-Assyrian period in the north of the region it was primarily employed structurally for platforms, for quays, and for revetments rather than for free-standing structures. For them mudbrick retained its supremacy. In passing from stone to wood this survey passes to another major building material which was not exploited as much in Mesopotamia as might be expected and to one for which the material evidence is eclipsed by documentary sources. What archaeological evidence there is, is still little more than sporadically

illustrative of practices and trends evident from texts; but with the increasing retrieval of charcoal and wood from excavations the potential contribution from archaeobotanists is growing all the time.

5. Building with Wood

(i) THE RANGE OF TIMBER

Although timber is not a resource much associated with lowland Mesopotamia, it is easy to underestimate its availability and the intensity and range of its use there. Timber had been widely used in building in Iraq until it was superseded in recent decades by breezeblocks, concrete, and other modern materials. Even the most cursory examination of building practices up to recent times will reveal a widespread use of wood in mud or mudbrick structures, not on the outside, where it would be obvious, but on the inside or within roofs, where it is structurally important yet inconspicuous. There is every reason to suppose, as this section will seek to show, that this was also characteristic of ancient Mesopotamia, in the south and in the north, where it was more readily available (cf. Margueron 1992).

Wood and other organic building materials are rarely retrieved by excavators in recognizable form, since they decay rapidly and their imprints or 'ghosts' demand an eagle eye to detect them and fine excavation technique to retrieve them for study. Fire, above all, preserves wood, as the debris of early second-millennium palaces at Mari and Uruk, the Iron Age citadel of Hasanlu IVB in Iran (see p. 361), and the Neo-Assyrian palaces and temples at Khorsabad and Nimrud particularly exemplifies. But charcoal is little more than powder and only in the best of recent excavations has special care been taken to retrieve it, primarily for Carbon-14 dating and only secondarily, if possible, for a wood identification. (cf. Willcox 1992; Kuniholm 1992).

Historical and administrative texts, when they refer to building timber, tend to relate to major projects sponsored by the great organizations of state, rather than to routine domestic architecture. Even then the ancient terminology for timbers, as for stones, is fraught with uncertainties since it may not be assumed that the ancient categories are our categories nor that terms were constant across space and through time. Nor would scribes have recorded timber with quite the same precision that comes naturally to expert timber merchants, foresters, or carpenters. With the aid of a botanist today it may be possible to distinguish species of a particular tree, but ancient classification was less sophisticated. A single ancient word may have described many species or embraced trees of diverse types (for Sumerian, see Powell 1992: 107 ff.; for Akkadian, see Postgate 1992^a: 179 ff.)

Care is needed in using textual evidence as a guide

to sources in particular periods. A sharp distinction needs to be drawn, as in the case of other materials, between contemporary or near-contemporary administrative or historical texts and literary compositions of uncertain date. They were recurrently copied as part of a canonical tradition to the point when lists of mountains and the trees growing on them were still being retailed when some of those mountains were deforested and knowledge of where they lay had been lost.

Scientific identifications of timber from archaeological sites in Mesopotamia are steadily increasing, but the present database is tiny and extremely variable in value. Many of the older identifications were no more than judgements by eye, or smell, made by the excavators or their workmen, familiar in their daily lives with local timber. The scientific determinations are set out on p. 360 here. Short as the list is, when checked against recent practice and the ancient documentary record, this evidence will be seen to take account of the major timbers used in building. A distinction needs to be drawn between those woods most in demand for major public buildings, which had to be imported from a distance by state authorities, and the more common timber like palm, poplar, and tamarisk in the south, ash, oak, elm, and plane in the north, more readily available for use in domestic architecture.

Palm, despite its fibrous structure and weaknesses, is (and was) widely used for supports and for roof-beams, particularly where the roof is intentionally light. Textual evidence indicates the equally diverse roles its wood, fibres, and leaves played in the domestic architecture of southern Mesopotamia in antiquity (Landsberger 1967; Cocquerillat 1968). In central and southern Iraq equal popularity is (and was) enjoyed by the poplar for structural and roofing purposes, on account of the straightness of its trunk. It is a tree that grows rapidly; the bark is easily stripped; and it dries without splitting. It is the only timber universally used in the Near East for building purposes, except where the oak is readily available and then it has usually been preferred. Mulberry is used when a hard, homogeneous, and durable wood is required, as in the well-heads at Nimrud (Mallowan 1953: 25 n. 2). Tamarisk and willow are commonly used in the roof structure. Brushwood from poplar and tamarisk was a regular source of fuel. Unique finds from Shahr-i Sokhta in south-east Iran (Costantini 1979: 108–9) showed that fire was made by friction between a fire-stick of soft poplar and a board of harder tamarisk; a device that might well also have been made from these timbers in Mesopotamia.

The wood of cedar is very strong, resistant to rot and insects. It has an aromatic smell, a close straight grain that is easy to work, and is very durable. Cypress and juniper have similar qualities. Like cedar their wood is reddish-brown in colour, remains sound for centuries, and has a pleasant smell. Juniper is stronger than cedar

in potential length of trunk (to over 100 feet). Fir is more vulnerable to rot and to insects. It grows more rapidly than cedar and is normally slimmer. It has a good straight grain and, being lighter than cedar, is easier to work, but it is not so long-lived. It is widely regarded as the most useful timber for general construction and boats. The mountain pines are those most used in construction. Mallowan (1966: 639 n. 12) thought that the scaly bark of *Pinus brutia* could be recognized on Assyrian reliefs. As the Aleppo pine, *Pinus halepensis*, tends to be twisted by the wind, rarely grows above fifty feet, and the wood is not strong, it is often preferred for its resin.

Since the fertile land of the plain was too valuable to allow for extensive forestry, even where it was feasible, timber in Mesopotamia is primarily associated with the surrounding highlands.

Meiggs (1982: 53–4) offered a usefully brief appraisal of a varied range of evidence for the character of Lebanese forests in antiquity, 'and what is valid for Lebanon will be valid, with minor modifications, for the Taurus and Amanus mountains, which enjoy a very similar climate'. Three broad bands of timber may be postulated in ascending order:

1. *The lower slopes (up to 500 metres)*. Here were the trees resilient in the rainless months, such as evergreen oak, cypress, and coastal pine: *Pinus halepensis*, *P. brutia*, and probably *P. pinea* (umbrella pine), none of which normally grows higher than about 20 metres.

2. *The middle slopes (c. 500–1,200 metres)*. Evergreen oak, cypress, and coastal pine were joined by deciduous oak with a wide range of hardwoods including ash, elm, two of the smaller junipers (*J. Oxycedrus/J. phoenicia*), and maple. Cypress and pine become rare above 1,000 metres and different oaks occur.

3. *The upper slopes (over 1,200 metres)*. This was primarily the zone for the tallest conifers, cedars, and firs, and of the junipers (*J. foetidissima/J. excelsa*), growing exceptionally up to some 25 or 30 metres. No cedar has been recorded over 2,000 metres; junipers occur higher. This was the zone where cedar, fir, and pine were best suited. The relative distributions of these timbers is virtually impossible to estimate. Meiggs (1982: 57) advanced the witness of Theophrastus, in the Seleucid period, to suggest that 'cedar was by far the commonest tree in Lebanon and that pine was a minor constituent and fir negligible'. In considering these timber sources it needs to be remembered that the Lebanon was difficult of access for those seeking wood that had to be felled and transported where water was not to hand. Consequently, from their earliest quest for foreign timber, the rulers of Sumer were concerned more with the forests to the north of Lebanon, particularly those of the Amanus.

The study of seed and pollen remains from southern

Mesopotamia has not reached the point where it is possible even to present a sketch of the timbers locally available from archaeological sources. Texts remain the primary source.

Half a century ago the pattern of timber in southern Mesopotamia was described thus:

At certain places along the rivers, occurring in small belts, are found the Euphrates poplar (*Populus euphratica*) and a willow (*Salix acmophylla*). Another willow, *S. alba*, is less common. They are seen generally on islands and at curves and bends of the river, more frequently on the Euphrates than on the Tigris. The willow is less common than the poplar, but is found further south . . . The wood of the poplar, when mature, can be used for planking and boat building; that of the willow is soft and of little value. Neither provides very good fuel . . . As an undergrowth in these riverain thickets, in addition to numerous annuals, grasses and sedges, there often occurs species of tamarisk (*Tamarix pentandra* and *T. Meyer*) and the shrubby *Prosopis Stephaniana*.

(Mason: 1944: 190)

Broadly speaking, this pattern of woodland growth correlates closely with that evident in those texts which offer sufficient information on the ancient distribution of species to allow for sound conclusions.

Steinkeller (1987^a) has analysed some Ur III texts relating to a group of workers who harvested trees and wild plants in thickets or copses located on waterways in the province of Umma. Three types of timber are listed in a descending order of frequency: first what is almost certainly the Euphrates poplar; then a wood of inferior quality mainly supplying branches and twigs, used in building or for furniture, possibly willow; and finally a small hardwood of uncertain identity used for tools. The work consisted of felling trees, turning them into timber and simple tools, and collecting branches, foliage, and grasses. The wood of the poplar was also used to produce a type of charcoal. Among the timber and tools produced by these foresters Steinkeller (1987^a: 92–3) identified logs, roof-beams, levers, pegs, pointed sticks, rungs, posts, rods for reed baskets, planks, boards, boat's ribs(?), hoes, hoe-blades, ploughshares, sickle-handles, and keels(?). 'Although we know that the riverain thickets of southern Iraq have been utilized, more or less haphazardly, from ancient through modern times, it is only in the Ur III period that one finds evidence for planned and organized exploitation of this ecological niche' (Steinkeller 1987^a: 101; cf. Powell 1992).

Much remains to be discovered about the range of trees which might have been available in ecological niches in Sumer and Babylonia. The textual evidence, implicitly and explicitly, indicates that trees regarded as foreign were successfully cultivated in plantations in the south (Powell 1992; Kupper 1992; Mieroop 1992) and in the North (Postgate 1992^a).

Tiglath-Pileser I in the eleventh century is the first

Assyrian king who reveals in his inscriptions a clearly utilitarian interest in establishing gardens outside his capital at Assur to cultivate foreign trees for timber and fruit. He records that he 'took cedar (*erēnu*), box-tree (*taskarinnu*), Kanish oak (*allakanish*) from the lands over which I gained dominion [in the west]—such trees which none among previous kings, my forefathers, had ever planted—and I planted [them] in the orchards of my land. I took rare orchard fruit which is not found in my land [and therewith] filled the orchards of Assyria' (Grayson 1976: 17).

In the ninth century Assurnasirpal II, in the remarkable text on the so-called Banquet Stela, recorded the trees, seedlings, and plants which he had seen on his military campaigns and then imported for planting in the irrigated gardens which he had created in his new capital at Kalah (Nimrud). Here pleasure and utility were blended. The range of species is wide, many at present untranslatable, extending from trees like cedar/pine, cypress, and juniper valued for constructional timber, to fruit and ornamental trees and shrubs (Grayson 1976: 17 ff.). Oppenheim has suggested that it was Sargon II in the later seventh century BC who changed the motivation of the royal patrons of gardening 'from utilitarian to display purposes, from an interest in assembling the largest possible variety of specimens to incorporating a garden into the palace precinct for the personal pleasure of the king. This change is expressed in the replacement of the ancient term for garden, *kirû*, by *kirimāhu*' (Oppenheim 1965: 331). The attempt to replicate the natural setting is emphasized by Sargon's reference to 'a pleasure garden [made] like Mount Amanus' (CAD, s.v. *kirimāhu*).

(ii) SOURCES OUTSIDE MESOPOTAMIA

(a) In the west and north-west

The witness of the Old Testament has ensured a special place for the 'cedar of Lebanon' in any study of the timber resources available to the west of Mesopotamia (cf. Lipshitz and Biger 1991). Until scientific determinations of wood from excavations are far more numerous than they are at present, the primary information on this subject is textual. However, ambiguity surrounds the words for 'cedar' in ancient Egyptian and Akkadian. Egyptian *ash*-wood, the commonest of Egypt's imported timbers, has been widely translated as 'cedar' since the nineteenth century, although Loret (1916) forcefully challenged this rendering in favour of 'fir' or possibly 'pine', which has been increasingly adopted by archaeologists in recent years. Meiggs (1982: 405–9) reviewed Loret's arguments in the light of more recent wood identifications and the purposes for which *ash*-wood was used according to Egyptian records. He noted especially that many more Egyptian coffins have been shown to be of cedar than of fir, not

least the coffin of an 'overseer of the storehouse of ash-wood', now in the Hildesheim museum.

Meiggs thought the balance of the evidence was still in favour of 'cedar', though he qualified his argument: 'One final point may be tentatively suggested. Since cedar and the tall junipers grow at the same altitude, and since the properties of their wood is very similar, is it not possible that the same word was used for both species?' (Meiggs 1982: 409). On this reading, Egyptian *wahn*-wood, particularly found in medical texts and commonly taken to be juniper, would be *Juniperus oxycedrus*. In advancing this argument, Meiggs may have been mindful of Greek and Latin, where the same word (*Kedros/cedrus*) is used for cedar and juniper.

Sumerian and Akkadian present a parallel problem. Lambert (W. G. 1987: 46-7) has pointed out that 'though "cedar" is the usual translation of the Sumerian EREN and Akkadian *erēnu* (CAD 'E': 274; AHw 237), written sources indicate only that it yielded timber suitable for roofing beams, that it had a pleasant aroma, and that it was a source of incense'. He approvingly noted that George Smith in the nineteenth century regularly translated this word as 'pine'. Although this translation has been strengthened by a number of identifications of pine as the timber used for roof-beams in Assyrian royal palaces, cedar was certainly also used (Loud 1936: 97, n. 10). As with *ash*-wood in Egypt, it may not yet be assumed that *erēnu*-wood was invariably 'pine' rather than 'cedar', since both were available to Assyria and both were used by her craftsmen as they had been earlier in Sumer and Babylonia (cf. Postgate 1992^a: 182 'cedar'; Elayi 1988 on 'Cedars of Lebanon').

Meiggs (1982: 416 ff.) examined in detail the terminology for cypress and juniper in Akkadian and in Hebrew. He accepted the current view that *burāšu* (Hebrew *beros*) refers to juniper rather than to cypress (as it was translated in Luckenbill 1926-7) and *šurmēnu* to cypress (Rowton 1967: 268); *burāšu* (CAD 'B': 326; AHw 139) is taken to be *Juniper excelsa* and *daprānu* (CAD 'D': 189; AHw 162) *Juniper drupacea*, which is rarer (cf. Postgate 1992^a: 180-1).

With the exception of Ur-Nanshe and Gudea in the third millennium BC (see below), rulers before the later second millennium BC generally omit from their building inscriptions any specific reference to the origin of the raw materials. Administrative texts, often rich in information on the repertory of woods and wooden objects in use at any one time, had little need to concern themselves about where the raw material had come from for their workshops. At most they refer, as for instance in the Old Babylonian texts from the palace at Mari (cf. Kupper 1992), to shipping stations on major waterways.

Rowton (1967), as part of a series of pioneering studies, assembled the evidence in cuneiform sources for the woodlands of western Asia in antiquity, omitting

only the Lebanon (cf. Brown, J. F. 1969) and the Amanus (cf. Alkim 1965) as sufficiently well treated by other scholars. He drew his information primarily from royal inscriptions recording the recovery of timber, usually in the course of military expeditions, and from 'tree-toponyms' in a wide variety of texts. These are the designations of specific mountains by their timber cover. The best-known of them are the frequent references to the Lebanon, the Amanus, and Mt. Hermon (or Sirira) in the Anti-Lebanon range as the 'Mountain of *erēnu*-wood': the 'Cedar or Pine Mountain'. The Annals of Tiglath-Pileser III (c.744-27 BC) call the Amanus the 'Mountain of *taskarinnu*-wood': the 'Boxwood Mountain'.

Rowton (1967: 271) summed up his body of evidence primarily dating from the fourteenth to sixth centuries BC as follows (allowance must be made for the problem of translating *erēnu* as cedar):

Very tentatively one can suggest the following 'phytogeographical' pattern for the region west of the Euphrates. The great stand of mixed coniferous timber in the Maras region (n. 61: '... has the greatest concentrated variety of coniferous trees in Western Asia ...') ... was known as the Cedar Forest, later Cedar Mountain, a term ultimately extended to the whole of the Amanus. The mountainous country between the Cedar Forest and the Euphrates was known as the oak and terebinth region. From the Lebanon, a cypress mountain, all the way up into the southern Amanus, the coastal mountains constituted the cypress and boxwood region. The utilitarian element is conspicuous. It can be seen in the emphasis on boxwood [a cabinet-maker's wood] which was in great demand but was nowhere a dominant tree, and it shows also in the designation of the Lebanon as a cypress mountain, certainly never a dominant tree there. The great stands of cedar in the Lebanon were of no particular interest since cedar was available much closer, in the Maras region.

It might be thought that an analysis of the Neo-Assyrian palace reliefs which represent trees in scenes of campaigning, east and west of Mesopotamia, would assist in reconstruction of ancient woodlands. However, they are so schematic (cf. Bleibtreu 1980) that identification of the various trees suitable for constructional timbers is extremely hazardous—pine alone perhaps excepted—and does not offer a sound basis for any assessment of distribution of species.

Rulers of Sumer in the middle of the third millennium BC (Sollberger and Kupper 1967: 1c6) sought timber 'from the mountain (or distant land)'. Akkadian kings campaigned north-westwards to the '*erēnu* Forest or Mountain', sometimes more specifically to the Amanus range (Sollberger and Kupper 1967: IIA1b; IIA4e), though timber procurement is not specifically mentioned in the available texts. It was Gudea of Lagash, c.2150 BC, who was the first ruler to be more specific in his account of the wood he sought

for building the temple of Ningirsu (Lambert and Tournay 1951: 55-7, 59: Statue B inscription, with comparative passages from Gudea's other inscriptions):

In the Amanus, the Cedar Mountain, he formed into rafts (cedar) logs 60 cubits long, (cedar) logs 50 cubits long (and) *KU*-wood logs 25 cubits long, and brought them (thus) out of the mountain ... In the town of *Uršu*, in the mountains of Ibla, he formed into rafts the timber of the mountain region: *zabalum*-logs, great *U.KU*-wood logs and *tulubum* logs. He made them into roof beams.

(Oppenheim 1969: 269)

Uršu probably lay on the west bank of the Euphrates within range of Tell Mardikh (Ebla). Which woods, apart from a selection of coniferous timbers, are represented here is still concealed by uncertainties of translation.

The timber procured by Gudea was floated some 1500 km. down the Euphrates to reach Lagash lashed together as rafts or perhaps on rafts. This supply pattern may be traced through the Ur III and ensuing periods (Leemans 1960: 126) for pine (or cedar), cypress, juniper, and fir, though documentation on sources is always sparse. A text from Mari has a consignment of *burāšu*-wood (juniper) and *erēnu*-wood (cedar/pine) en route for Mari detained at Carchemish, whilst others deal with floating timber down the Euphrates (Kupper 1992). From the mid-third to the mid-second millennium it appears that rulers in Sumer and Babylonia were concerned in the north-west almost exclusively with woodlands to the north of Lebanon, particularly in the Amanus mountains.

It is not until the twelfth century BC that the timber resources in this region drawn upon by Assyrian kings receive regular notice in their inscriptions. Thereafter, since it was a primary royal interest, their campaign records yield considerable evidence on timber procurement. This may be selectively tabulated, as by Meiggs (1982: 416 ff.) and Postgate (1992^a: 187-92), on the basis of the accessible texts, to provide a guide to the pattern of procurement for constructional timber. It is difficult to assess the real significance of the dominance of pine/cedar and cypress in these Neo-Assyrian campaign records. They were clearly the most desirable woods, but the nature of the texts does not necessarily mean they alone were taken when they alone were listed. *Burāšu* and *daprānu*, types of juniper, appear regularly; the former is never associated with the Lebanon and only Sennacherib and Assurbanipal refer to it for doors; its great strength is best employed in roofing. But usage is apparently so free that it is impossible to 'decide in many cases whether it is the tree-name, or the geographical names, or both, that are being used loosely' (Brown, J. F. 1969: 195). It is the inscriptions of Nebuchadnezzar, carved *in situ* on the rocks of the Wadi-Brisa, that emphasize the logistical and practical difficulties of procuring and moving

timber for use in Mesopotamia from the Lebanon, explaining why earlier kings concentrated on the Amanus forests, which were adjacent to the Euphrates. 'What no former king had done [I achieved]: I cut through steep mountains, I split rocks, opened passages and (thus) I constructed a straight road for the (transport of the) cedars. I made the *Arahtu* (Euphrates) flo[at] (down) and carry to Marduk, my king, mighty cedars, high and strong, of precious beauty and of excellent dark quality, the abundant yield of the Lebanon, as (if they be) reed stalks (carried by) the river' (Oppenheim 1969: 307).

Once the timber reached the Euphrates it was easily floated to Babylon, but before that transport overland from Lebanon was a formidable undertaking.

(b) In the eastern Taurus and the Zagros

There is no explicit textual evidence for timber procurement from the eastern highlands before an advanced date in the Neo-Assyrian period. Hansman's (1976) arguments for placing the episode involving the cutting of *erēnu*-wood in the Sumerian version of the *Epic of Gilgamesh* (translating it as 'juniper' rather than 'cedar') to the south-west in Iran rather than to the north-west, in Syria or Anatolia, is based on a debatable use of literary allusions. The formidable problems involved in transporting such timber from this region to heartland Sumer, and its apparent absence from the historical and administrative texts relevant to the area, indicate that the Old Babylonian location of this episode to the north-west of Sumer was indeed the traditional one (cf. Malamat 1965: 372 ff.) and a more reliable indicator of whence such timber actually came from the third through into the first millennium BC. In this respect it is important to notice that when Darius I wanted 'cedar' for the construction of his palace at Susa he sought it far to the west in the Lebanon rather than in the Zagros. 'The Assyrian (Syrian) people brought it to Babylon; from Babylon the Carians and Ionians brought it to Susa' (cf. König 1930: 52-4). It has been said that some of the trees shown on the Persepolis reliefs may be recognized as *Pinus Heldarica* (Mallowan 1966: 639 n. 12).

Since so much of the evidence in texts for the timber procured by Neo-Assyrian kings comes from campaign records, it is not until these begin to relate more often to the eastern frontier, in the later eighth century BC, that textual evidence for Zagros woodlands is available. These references are now usefully complemented by the timbers identified amongst the burnt debris of the destruction of level IVB at Hasanlu (Harris, M. V. 1989: 15, table 1; p. 361). Here the timbers certainly used in construction were maple for beams and poplar for columns, though cedar and cypress were present. The northern Zagros and the Eastern Taurus mountains are likely to have yielded oak and cypress lower

down, pine and juniper higher up the slopes. Sargon's (721–705 BC) campaigns laid this region open to exploitation, but his records report little of timber, and when they do it is not so much to get timber for Assyria as to deprive her enemies of their resources: 'High mountains covered with all kinds of trees, whose surface was a jungle, over whose area shadows stretched as in a cedar/pine (*erēnu*) forest . . . Great juniper (*burāšu*) beams from the roof of his substantial palace I tore out and carried to Assyria . . . The trunks of all those trees which I had cut down I gathered them together and burnt them with fire' (Luckenbill 1927: sections 142, 161). Both Tukulti-Ninurta I and Assurnasirpal II take *mihru*-wood (conifer) from a land of the same name, probably east of the Tigris into the Zagros (cf. Postgate 1992^a: 183). Sargon II lists *dulbu*-wood (plane) and *šurathu*-wood (unidentified) together in the Zagros (Postgate 1992^a: 190). He also lists a *burāšu* (juniper)-mountain in the Urmia region (Postgate 1992^a: 187).

(c) *In the Gulf and regions beyond to the Indus Valley* By at least Early Dynastic III, c.2500 BC, timber was reaching Sumer from regions along the shores of the Gulf or further east as far as modern Pakistan. Urnanshe, King of Lagash, 'had ships of *Dilmun* transport timber from foreign lands (to Lagash)' (Cooper 1986: 22–3; La 1:2; cf. La 20, La 1:22–3, 25). Two or three centuries later, Gudea of Lagash refers to timber from the mountains of *Magan* and *Meluhha*, from *Dilmun* and from *Gubin*, perhaps in south-eastern Arabia (Falkenstein 1966: 47–9). In Ur III texts varieties of wood for furniture manufacture are designated 'of *Meluhha*', 'of *Magan*', and 'of *Dilmun*' (cf. Ratnagar 1981: 97 ff.).

The lexical lists include woods imported from *Magan* and *Meluhha* (Powell 1987; cf. Pettinato 1972: 86–7, 114–17). Although wood from *Meluhha* is not listed in texts of the Larsa period at Ur, it appears then at Eshnunna as the material of a throne (Leemans 1960: 125). *Mes* (*musukkannu*) wood from *Magan* and *Meluhha*, *haluppu*-wood from *Magan* and *Gubin*, and *kušabku*, known as a product of *Meluhha*, were used for furniture in the Ur III period and continued in use to the Old Babylonian period. These woods disappear from texts towards the end of the Old Babylonian period. *Ešu* (*ušu*)-wood, mentioned by Gudea as a product of *Meluhha*, appears in the Amarna period as an import from Egypt. In later times, *ešu*-wood, *mesu*-wood, and *haluppu*-wood feature as local products in Mesopotamia (Leemans 1960: 126). The identities of these woods remain controversial.

In the lexical lists two varieties of *kušabku* (cf. CAD 'K': 597; AHW 516) appear, one local, the other from *Meluhha* (Powell 1987: 148). It was probably a hardwood used for building (Gudea; Hammurabi), for furniture, and for tools. Ratnagar (1981: 100–4) rejects

Hansman's (1973: 560 ff.) arguments for the common 'mangrove', preferring 'teak', which has been identified among archaeological debris at Lothal. Taylor (cited Woolley 1939: 133) reported finding in the mudbrick core of the Ziggurat of Nabonidus at Ur 'two rough logs of wood, apparently teak, which ran across the whole breadth of the shaft', possibly timber reinforcement of the brickwork. But the identification of these logs is not certain; it may be pine (see list on p. 360 here; if these are the timbers found by Taylor).

The so-called foundation charter of Darius I at Susa provides evidence for the equation of Old Persian *yakā* with Akkadian *musukkannu* (Vallat 1971: 58; Postgate 1992^a: 183). Gershevitch (1957; 1958) identified *yakā* as *Dalbergia sissoo* Roxburgh, which grows in Oman, southern Iran, and Pakistan (ancient *Magan* and *Meluhha*). The Sumerian equivalent for Akkadian *musukkannu* in the lexical texts is given as the 'mes-tree of *Magan*' (CAD 'M': 237; AHW 678; Powell 1987: 149). In the Ur III and Old Babylonian periods *musukkannu* was imported and used particularly for furniture and household utensils (Mierop 1992: 159–60). By the first millennium BC *musukkannu*-wood was available locally in both Assyria and Babylonia (Maxwell-Hyslop 1983: 70–1), when it was used in the interior construction and decoration of royal buildings. Nebuchadnezzar's inscriptions (cf. CAD, s.v. *musukkannu*) reveal that individual timbers were of considerable size. The beams of *musukkannu* (= *yakā*) used in the palace of Darius at Susa were recorded as coming from Gandara and Karmana, on the north-west frontier of Pakistan. At Mohenjo-daro, the ceiling of Room 17 in House VIII was 'carried on rafters of deodar (*cedrus deodara*) and *dalbergia sissoo*, the charred ends of which were found still embedded in the walls' (Marshall 1931: i. 19). Sissoo was reported at Shahr-i Sokhta in eastern Iran in the third millennium (Costantini 1979).

It is likely that the fine, expensive dark woods of eastern origin, sissoo and ebony, were from time to time, for reasons good and bad, confused with cheaper types of dark wood, which might be used for many of the same purposes, such as the Nettle tree (*Celtis australis*), perhaps Akkadian *mēsu* or *šulum meluhhi*, 'blackwood from *Meluhha*' (CAD, s.v. *šulmu*). Even if carpenters and timber merchants could tell the specific dark woods apart, ignorance or deception may well have confounded scribal references. Nor should terminology be regarded as consistent through time. The *ešul* *ušu*-wood might be a case in point, particularly in the Amarna Letters. The Egyptian word *hbny* refers most probably to African blackwood (*Dalbergia melanoxylon*) not to ebony (*Diospyros ebenum*) (cf. Lucas 1962: 435). In the Ulu Burun shipwreck there were logs of African blackwood and this wood was also combined with ivory in the inlays of a sword-hilt (Bass *et al.* 1989:

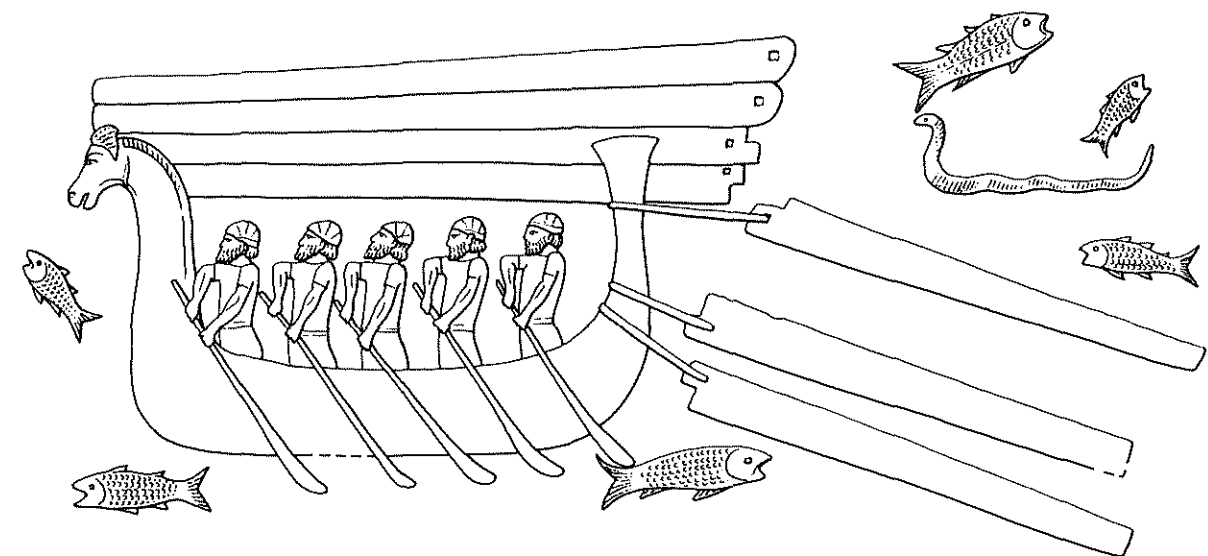


Fig. 23. Transport of timber by water as illustrated on Sargon II's (721–705 BC) reliefs at Khorsabad (detail after Botta and Flandin 1849–50: i. 32–5).

fig. 17). *Haluppu* (CAD 'H': 55; AHW 314) disappears at the end of the Old Babylonian period, with the break in trade to the Indus, and reappears growing in Babylonia in the first millennium BC. It is listed as a tree from *Magan* and Gudea imported it from *Gubin* (Statue B: VI.46–7). It seems primarily to have been used for furniture and vessels, though Gudea used it for building. It has been tentatively identified as an eastern species of oak (CAD A/i: 355b; Postgate 1992^a: 182).

Date-palm (*gišimmar* = *gišimmaru*) is associated in the lexical lists with *Dilmun*, *Magan*, and *Meluhha* (Leemans 1960: 9). Why palm should have been imported to southern Iraq, where the tree flourished, awaits explanation. Ratnagar (1981: 105) suggests that this term simply described a variety of timbers, but *Dilmun* was certainly as much the home of the palm as southern Mesopotamia.

(iii) ILLUSTRATIONS OF TIMBER PROCUREMENT AND WORKING METHODS

Neo-Assyrian reliefs provide illustrations of timber processing, but rarely. A fragmentary relief of Assurnasirpal II (Barnett and Falkner 1962: 25, pl. CXIV) and pieces of decorated ivory from the same reign (Mallowan and Davies 1970: 17–18, pl. IV) show Assyrian soldiers hewing timber with axes in a heavily forested area. In some cases the axes have spiked butts. A scene on the 'Rassam Obelisk' of Assurnasirpal II of oxen pulling a solid-wheeled cart, loaded with a tree-trunk, shows how smaller timbers were moved overland (Reade 1980: 14, pl. VII). A fragment from the bronze gate overlays of Shalmaneser III from Balawat, now in

the Walters Art Gallery, Baltimore, illustrates Assyrian foot soldiers carrying logs in a forested mountain landscape (Canby 1974, no. 18B and cover picture). On the same king's throne base at Nimrud (Mallowan 1966: 446, pl. 448b) heavy timber is brought as a tribute, carried by teams of four men using ropes.

The most comprehensive scenes of timbering are those carved on the walls of Sargon's palace at Khorsabad, which show the transport of timber by water in the following stages:

1. Manpower is used to haul logs down a mountain; they are piled up at the water's edge to await transport.
2. The timbers are stacked in boats or drawn behind them. As the timbers have rounded or angular cut ends they had clearly been shaped to some extent before being moved.
3. The wood is transferred from ships to land by teams of men.

Albenda (1983) has interpreted this as transport of timber from the Lebanon by sea. Linder (1986) cogently challenged this interpretation, identifying the boats as rivergoing vessels and the region of timber procurement as the Amanus. He demonstrated that all Neo-Assyrian representations of boats comparable to those shown on this series of reliefs are riverine watercraft, not seagoing merchant ships (cf. Graeve 1981, for illustrations). This had already been argued, in 1847, soon after these reliefs were discovered (A. Jal, cited by Linder 1986: n. 48). The lumberjacks wear the 'leather caps' of western vassals, perhaps in this case hard hats to protect them from the more obvious hazards of forestry. Linder (1986: 278–9) points out that the practices shown 'disregard basic shipping prin-

ciples of open sea navigation. It is in river traffic, with steady currents prevailing, that paddling in an upright position is feasible, and, for relatively short distances, the towing of logs behind the boat can be controlled.' Although neither the inscription nor the landscape detail allows the location to be securely identified, the fauna is freshwater rather than seawater (Linder 1986: 279; contra Albenda 1983: 27–8).



Fig. 24. Detail from a scene carved on an Akkadian cylinder seal (c. 2350–2100 BC) showing a deity using an adze to trim or cut a tree (after Tallon 1987: i, fig. 17).

Since the tools of the lumberjack are unlikely to be readily identifiable in palaces, whence most finds of Neo-Assyrian metalwork have so far come, the pictorial evidence is again invaluable. It corroborates the evidence of ancient classical sources, which do not mention saws for tree-felling; the logging tool was the axe, of stone, of copper alloys, and eventually of iron. The men carrying saws on the reliefs of Sennacherib (Curtis *et al.* 1979: fig. 31b, c) are involved in stonecutting or at most in modifying the logs used to transport colossal sculptures. They are not lumberjacks. Early iron saws were probably quick to dull and difficult to sharpen, most of all under the conditions to be expected in forestry. The axe was also used for lopping and barking, perhaps with the help of the butt spikes shown on some of the axes employed by Assyrian lumberjacks (cf. Mallowan and Davies 1970: pl. IV). An Akkadian period cylinder seal shows a deity stripping the branches of a tree, perhaps also the bark, with an adze (Williams-Forte, in Muscarella (ed.) 1981: 87, no. 43; Tallon 1987: i, fig. 17). However, large trimmed and

cross-cut tree-trunks for use in construction were probably not barked or hewn in their mountain homes before transport as they are likely to have suffered heavy pounding as they travelled. The wedge was also used to split trees. It, like the axe, is designed so that the edge splits the timber on a tiny front between the fibres of the wood.

It is no easier to identify with confidence the tools used by carpenters involved in construction work, save from the most meagre and scattered clues. On the stela of Ur-Nammu of Ur (c. 2112–2095 BC) the king as 'builder' is shown carrying a heavy copper-alloy axe of a type well known from excavations (cf. Moorey 1971: pl. XXII.1–3), together with a basket, builder's dividers, ladle for bitumen mortar, and a flat wooden trowel (Woolley 1974: pl. 41a: centre, right; FIGURE 19). Axes of the type shown are normally used to split and dress timber. Adzes would have served many purposes, not least for shaping. This is well illustrated on an Old Babylonian terracotta plaque in the Louvre where a man shapes a chair-leg with one (Barrelet 1968: 393, pl. LXXVI:779; Tallon 1987: i, fig. 16; PLATE I B). The basic range of awls, chisels, drill-points, gouges, and punches evolved early in the history of copper metallurgy and were carried over into iron (cf. Deshayes 1960; Tallon 1987; Curtis *et al.* 1979). Salonen (E. 1970: 59–77) analysed the terminology for woodworkers and their craft skills.

Since the screw and the vice, as well as the work-bench clamp, were not known to craftsmen in Iraq before the Seleucid period, considerable ingenuity would be required in working timber, not least in sawing planks. A variety of short copper or bronze saws have been reported from excavations at sites like Farah, Kish, Ur, and Susa (Deshayes 1960: 'Scies' A2:II:152; Tallon 1987: i. 184 ff., ii. 252–3; cf. Neve 1989) and iron examples are known in the Neo-Assyrian period (Curtis *et al.* 1979: fig. 31a–c). Egyptian reliefs (Montet 1925: pl. XXIII.1) illustrate how a timber was set vertically and secured with rope and a weight so that a man using a saw, held by both his hands, might cut it vertically without buckling the saw. There is also no evidence that either the plane or the file was known before the post-Achaemenid period in Mesopotamia. It is difficult to isolate copper or bronze tools that might have served carpenters as scrapers, but possible examples may be identified by the late third millennium BC (Deshayes 1960: i. 375 ff., ii. 161). A 'two-handled' scraper was found at Nuzi (Starr 1939: 471; 1937: pl. 124F). There is still no certainty as to when the lathe was first introduced into Mesopotamia. Childe believed, but could not definitely prove, that it was in use in Mesopotamia in the Bronze Age; 'there is no direct evidence for its use till classical times' (Childe 1954: 193 n. 1). Since so little timber has survived, and the use of the lathe in shaping stone vessels is extremely

difficult to establish with certainty, identifying its use from material evidence remains controversial (see p. 47 for stone vessels).

(iv) TIMBER IN BUILDING

(a) Roofing

The pattern of roof construction in Mesopotamia from prehistoric times until the advent of modern materials has been remarkably consistent. Timbers, worked or unworked, have been placed across the space to be spanned supported by the mudbrick walls enclosing it. The extensive use of free-standing columns for roof support is a highland phenomenon not evident in Mesopotamia until the Achaemenid period; before then their use was considerably more restricted and rarely, if ever, to carry roofing (cf. Koldewey 1914: 108; Collon 1969). Smaller timbers were laid over the beams and then over them was set brushwood or reeds sealed by successive layers of mud, annually repaired. 'It is probable that the ceilings of the ground-floor rooms and the floors of the rooms above were of the same nature as the roofs' (Woolley 1976: 21). At Shahr-i Sokhta in south-east Iran in the third millennium BC Costantini (1979: 106–8) has identified roof-beams as 30–40-year-old poplar trunks, stripped and sawn, set with some 50 to 60 cm. between each beam. Trunks varied in length from 2 to 5 m. and in diameter from 10 to 30 cm.

In a conflagration such structures rapidly caught fire and collapsed into the rooms below as charred debris, ashes, and baked clay fragments. It is from such remains that excavators have commonly deduced the widespread use of wood, perhaps more widely used than the natural resources of this region might initially suggest, since it was constantly recycled and only caught fire *in situ*. The purchase of roofing timber constituted a major expense in mudbrick buildings, so sound timbers were never abandoned. As Stone (1981: 20) noted in a study of Old Babylonian texts: 'since the presence of wooden items such as doors, ladders and even locks greatly enhanced the value of a piece of house property, it is clear that then, as in Southern Iraq today, the significant and valuable part of a house was its wooden roof-beams'. Such fittings were the basis for assessment of value and were taken out of a house when it was abandoned.

For general purposes in the south, split palm logs formed adequate rafters, although the fibrous structure of this wood makes it ill-suited for load bearing. Such logs cannot effectively span more than 3.5 m. (McCown *et al.* 1967: 37). Where palm is mentioned as roofing in excavation reports it is often identified by the excavator's eye, not scientifically; when it is scientifically, as at Nuzi where 'the bulk of the charcoal was derived from poplar' (Starr 1939: 494), the context is not clear. It is likely, as more recently in Iraq, that poplar was

the wood most favoured for roofing by house-builders. It has long been the practice in central and southern Iraq to line the main waterways with poplars to provide good, straight structural timbers and in the process to consolidate canal banks. In the north it was employed from prehistoric times for roofing timber. Margueron (1992) has attempted to reconstruct the use of roofing timbers in two buildings at Uruk, the late prehistoric *Kalksteintempel* and the palace of Sinkashid of the Old Babylonian period, to demonstrate that timbering was much more extensive in mudbrick architecture than is sometimes realized.

The Neo-Assyrian (and earlier) kings imported a number of woods for use as 'beams' or 'roof-beams'. The following woods are listed:

burāšu (juniper): (CAD 'B': 358; AHW 144; Postgate 1992^a: 180–1, 187) Shalmaneser III (from the Amanus).

erēnu (cedar/pine): (CAD 'E': 274; AHW 237; Postgate 1992^a: 182, 187–8) Adad-nirari I; Assurnasirpal II (Lebanon); Shalmaneser III (Amanus); Tiglath-Pileser III (Lebanon: Amanus; Ammanana); Sargon II; Sennacherib (Amanus; Sirara); Esarhaddon (Lebanon; Amanus; Sirara); Ashurbanipal (Lebanon: Amanus; Sirara); also the Neo-Babylonian kings (Lebanon).

miḫru (a conifer): (CAD 'M': 60; AHW 641; Postgate 1992^a: 183, 188) Tukulti-Ninurta I and Assurnasirpal II (*miḫru*-land; east of the Tigris).

musukkannu (sissoo): (CAD 'M': 237; AHW 678; Postgate 1992^a: 183, 188) Ashurbanipal (no source listed).

šurmenu (cypress): (AHW 1284; Postgate 1992^a: 184, 188) Sennacherib (Amanus and Sirara); Esarhaddon (Lebanon; Sirara); Ashurbanipal (Lebanon; Amanus).

At present the best evidence is that from Nimrud. 'As regards the timber used in the roof it is interesting that one specimen from the Fort [Shalmaneser] examined by the Forest Products Research Laboratory, Princes Risborough, proved to be *pinus halepensis* var. *brutii*, that is Aleppo or Calabrian pine. And it is curious that up to date all the examined specimens of roofing timber have proved to be pine, and not . . . cedar' (cf. Mallowan 1966: 377 n. 12). In view of the uncertainty over the identity of *erēnu*, and the possibility that it might well be 'pine' rather than 'cedar', earlier reports should be read in the light of Mallowan's evidence. Layard (1853: 357) had identified roof-timbers in the Temple of Ninurta at Nimrud thus:

Standing one day on a distant part of the mound, I smelt the sweet smell of burning cedar . . . The Arab workmen, excavating in the small temple, had dug out a beam, and, the weather being cold, had at once made a fire to warm themselves. The wood was cedar . . . After a lapse of nearly three thousand years, it had retained its original

fragrance. Many other such beams were discovered . . . and the greater part of the rubbish in which the ruin was buried, consisted of the same wood.

Pine is available today on the Zagros slopes accessible from heartland Assyria. This is the only species native to Iraq. It may then have been available in antiquity rather closer than is sometimes assumed. In the Old Babylonian period at Tell ed-Der it is reported as a door-hinge and what may have been shelving for tablet storage. At Brak it was identified from house ruins attributed to the middle of the second millennium BC (see p. 360).

Oak provided over fifty samples in the village at Jarmo in the seventh millennium BC (Braidwood, L. S., *et al.* 1983: 541), where it is likely to have been easily accessible. Where available it was enduringly popular in the north, recognized among fragments at Brak and Nuzi (see p. 360), and used at Nimrud for well-fittings. Samples of *ash*, *elm*, and *plane*, at Brak, all potential constructional timbers, do little more than illustrate the range of timber relatively accessible in the north. Whether or not the securely identified examples of *tamarisk* in north and south were from roofing is not apparent from the reports published so far.

In most cases where archaeologists have reported the debris from roofing from prehistoric sites like Umm Dabaghiyah (Kirkbride 1973: 3) through to Neo-Assyrian palaces no detailed reconstructions have been attempted. The isolated exceptions illustrate timeless practice. In Room L43:9 of House D in the Early Dynastic temple enclosure at Khafajah fire had preserved substantial portions of the roof ('ceiling') in debris east of the doorway from the courtyard (Delougaz 1940: 49–51, 133–6, figs. 121–3). It was made of a timber framework covered by mud-plastered reeds ('mats'); no timber identifications have been published. Similar structures were less explicitly described at Khorsabad (Loud 1936: 5–7, 9–10, fig. 85). A later, and rather more specialized, type of roofing was described by Koldewey at Babylon in what he had identified as the undercrofts of the renowned 'Hanging Gardens'. His account incorporates classical descriptions of the roof, designed to prevent penetration of water from above, and it is not easy to assess how much of this he actually found in the course of excavation:

A layer of reeds and asphalt was placed over a strong roofing of hewn stone, part of which has been found in the ruins, and above this rested two courses of bricks laid in mortar. A lead covering again separated these from the deep layer of earth placed on top.

(Koldewey 1914: 100)

A fragmentary ceiling ('un caissonnage de plafond') was recognized in the debris of a room in the 'palais des Shakkanakku' at Mari at the outset of the second millennium BC, preserved by fire. A network of stakes

of standard lengths linked by ropes running horizontally to form square apertures had been combined with matting and clay to form a wattle-and-daub construction (cf. Margueron 1985; 1992).

(b) Walls

Since remote prehistory timbers had provided the reinforcement for moulded *terre pisé* walls, as at Mureybet (Aurenche 1981: 87, fig. 48). In historic times the use of timber within the stone or brickwork of major structures has generally been reconstructed either from 'ghosts' left in clay or bitumen, or from cavities assumed from structural logic to have originally accommodated beams; occasionally vestiges of wood remain *in situ*. As Loud and Altmann (1938: 16) reported of Khorsabad, 'innumerable traces of planks and beams have been disclosed, usually in the form of mere imprints or "molds", which often give the size of the piece and the direction of the grain but nothing else. They do, however, definitely establish the use of wood for roofs, door leaves, lintels, and vertical shafts flanking temple entrances; and in some instances they tell the size.' Such was also the case in Babylon, where Koldewey (1914: 170) describes a gateway in the north wall of the main citadel: 'roofed over at the very moderate height of 1.5 metres with beams of palm wood. Bricks placed upright formed the cavities for inserting the beams, and in them the print of the wood in the asphalt can still be seen.'

Only close examination of the anatomy of mudbrick walls reveals the role of timber in construction. On the Temenos at Ur in the earlier second millennium BC the 'practice of reinforcing mudbrick construction with transverse timbers' was evident. 'The wood of the logs had perished, but the brickwork is found in good condition and in the round holes the imprint of the grain of the timber is perfectly preserved in mud casings' (Woolley 1976: 39–40). Comparable uses were recognized in the palace at Mari (Margueron 1992: 81). At Babylon Koldewey revealed that in the Palace of Nabopolassar near the citadel, 'Nebuchadnezzar jointed his brickwork with grid-like insertion of beams of poplar wood laid lengthways and crossways to strengthen it' (Koldewey 1914: 116; cf. also 122–3, fig. 69).

The timber at times was preserved with bitumen. In the door-frame of the Ninmakh Temple at Babylon 'the angles of the walls at the gates were secured by the insertion of pieces of wood washed over with tar. A plank of wood, the height of a brick course, lay in the jamb, and another, one course higher on each side, thus forming a frame, which probably also served as an attachment for the door or door casing' (Koldewey 1914: 62–3). In an arched entrance, perhaps earlier than the time of Nebuchadnezzar II, 'the central bricks were covered with asphalt. The inner imposts are

bound together by clamps made of poplar wood soaked in asphalt on a system which can no longer be clearly worked out' (Koldewey 1914: 70, fig. 45).

Timber was also used to consolidate the internal structure of ziggurats (cf. Mari: Parrot 1940: 23–4, fig. 17). Woolley, in reporting on the Ziggurat of Nabonidus at Ur noted that 'Taylor reports finding "two rough logs of wood, apparently teak, which ran across the whole breadth of the shaft" in the heart of the mud brickwork . . . it is probable that at certain intervals the brickwork was reinforced by a framework of timber' (Woolley 1939: 133; see p. 352 here).

(c) Columns

'On account of the scarcity of timber their buildings are finished with beams and pillars of palmwood. They wind ropes of twisted reed round the pillars; and then they plaster them and paint them with colours, though they coat the doors with asphalt' (Strabo, xvi. i. 5; for actual examples at Babylon see Koldewey 1914: 108).

Since free-standing columns of mudbrick or stone are so rare in Mesopotamian architecture as to evoke special comment when they do appear (cf. Collon 1969), there is a tendency to underestimate the role of timber columns, which leave so little trace. Wooden supports played a role in simple prehistoric architecture and were an established part of monumental structures by the Early Dynastic period, when imported woods were already used for them. Although the palm does not have the necessary girth strength or height to provide weight-bearing pillars, the appearance of fancy brickwood (see above) by about 2000 BC, which clearly imitates the palm, may be taken to indicate a much earlier tradition in which wood or wood and mud (brick) structures included the actual tree-trunks, at least for decorative effect. The discarded fittings of the Early Dynastic temple at Tell al-Ubaid, perhaps from the interior rather than the exterior, as Hall and Woolley assumed, included at least three palm-log pillars coated with bitumen and decorated with mosaics and four overlaid with sheet copper secured by rivets. They were 3.3 to 3.6 m. high and 20–30 cm. in diameter (Hall and Woolley 1927: 100–3, pls. IV, XXXIV.3, XXXV.6–7).

It is almost two thousand years before the extant record again illustrates comparable use of wood. At Khorsabad, in what he termed the 'Harem' (Sin Temple), Place found the remains of a 'tree' on either side of the main entrance (Place 1867–70: i. 120–2; iii, pl. 24; cf. Loud 1936: fig. 99). A cylindrical bronze case, enclosing a shaft of well-preserved wood, was found lying horizontally to a length of nine metres. The bronze overlay, secured with nails, was decorated in *repoussé* with a scale pattern resembling the bark of a tree. Gold leaf of the same pattern found nearby suggested that the bronze had originally been gilded. The American excavators at Khorsabad found a single 'tree'

in a comparable position at the entrance to the Shamash Temple. It was identified scientifically as cedar (Loud 1936: 97 n.10). This was 'decorated with bronze rings or bands extending around its circumference and overlapping at their joints. Within the distance covered (4.5 metres) we find two of them, each 0.70 m. wide, separated from each other by a slightly narrower interval' (Loud 1936: 104, figs. 111–12). In this case the bands, probably set low down on the 'trees' where they could be easily seen, bore designs of men (perhaps including the King), animals, and trees.

The value of such imported wooden columns is illustrated by the history of some examples in the Middle Assyrian period. An unusual text from Assur (Grayson 1972: 77) describes pillars of *erēnu*-wood included in booty from Nahur near Haran. In the time of Tukulti-Ninurta I (c.1243–1207 BC) these pillars, with an inscription of Adad-nirari I (c.1305–1274 BC) stating their origin, stood in the chapel of the 'palace of the Craftmen's Gate' (New Palace) at Assur. Tukulti-Ninurta had them taken to his new capital across the Tigris at Kar-Tukulti-Ninurta. The following Neo-Assyrian kings list the wood they used for columns as *burāšu* (juniper), Sennacherib; *dapranu* (juniper), Sennacherib; *erēnu* (cedar/pine), Shamshi-Adad I; Sargon II, Sennacherib, and Esarhaddon; *šurmēnu* (cypress), Sennacherib; *ušu* (ebony), Sennacherib (Postgate 1992a: 187–9).

(d) Doors

In the earliest villages of Mesopotamia there are traces of the use of wood for door-frames, lintels, and for the construction of the door itself. At Bouqras small doorways retained traces of their wooden frames (Aurenche 1981: 89). At Tell es-Sawwan there were vestiges of lintels and traces of the doors themselves made of reeds fortified with bitumen (Yasin 1970: 4; Al-Adami 1968: 59, photo 2). In the historical periods evidence is sparse from archeological contexts, but is already sufficient to indicate the primary, continuing role of timber in door construction (see, in general, Damerji 1987).

A number of features in the late third-millennium BC *Giparu* at Ur illustrate the basic arrangements that changed little with time. 'Against the S.E. door-jamb was a hinge-box with socket-stone of Amar-Suen; in the box was found the lower part of the wooden hinge-pole, unburnt . . . the upper part of the pole, 2.00 m. long, bound with copper, lay outside the room; it had been burnt' (Woolley 1976: 57). Here the light doors between rooms were made of 'a wooden frame with panels filled with parallel reed-stems, originally covered with bitumen' (Woolley 1965: 40, fig. 2). Reed screens in wooden frames also served other purposes within houses and shrines (cf. Delougaz *et al.* 1940: 22; McCown 1967: 15, pl. 10B, 25: 6; Woolley 1976: 127,

pl. 51b, 142–3, fig. 39) and it is not always clear in any specific case whether a door was intended. In a number of cases in private houses at Ur in the earlier second millennium BC Woolley deduced the use of wooden door-fittings from appropriate slots and holes in the mudbrick opening (Woolley 1976: 104). In the 'Mausoleum of Shulgi' he interpreted heavy ash deposits as evidence of 'raised wooden thresholds and wooden jambs' (Woolley 1974: 3).

In chapel 150 of the Old Babylonian palace at Mari a carbonized door was well enough preserved for the structure to be reconstructed in some detail, though no wood identifications were published. The door was made of seven vertical planks braced on the reverse by four cross-beams; the face was ornamented with four narrow vertical bands of ivory or bone secured with bronze rivets (Parrot 1958^a: 268 ff., figs. 322–3, pls. LIV.4, LV.1). Fire had again preserved substantial portions of a door in passage T23 of the south wing of Fort Shalmaneser at Nimrud over a millennium later:

The width of the door between the socket and the bolt hole was c.1.30 m., and measurement of the surviving remains suggested a height of c.3 m. It was composed of vertical panels, c.20 m. wide, inset between ribs of approximately cylindrical section, 6 cm. in diameter, which projected from both faces of the door. Each panel was apparently two planks thick, and between the two planks we found traces of a substance which may have been an adhesive. This identification has not yet been confirmed by analysis, but the double panelling would have lessened the danger of warping, and was the more necessary because the door did not appear to have been cross-braced. The ribs were made up of alternate cylinders of wood and ivory, each 12.5 cm. long, joined longitudinally by axial dowels and with mortices cut in their sides to house tenons set along the edges of the adjoining panels. (Oates, D. 1963: 26–7)

Royal inscriptions of the first millennium BC and occasionally earlier, list the timbers preferred for the tall doors used in palaces and temples (cf. Salonen, A. 1961: 96 ff.; Postgate 1992^a: 187–9):

ašūhu (CAD 'A' 478; AHW: 85; Postgate 1992a: 180: 'pine'; as it is not mentioned in campaign records, it may have been available close to, or in, Assyria): Adad-nirari I; Tiglath-Pileser I; Assurbelkala; Assur-dan II; Assurnasirpal II; the Neo-Babylonian kings.

burāšu (juniper): Sennacherib; Ashurbanipal.

dapranu (juniper): Assurnasirpal II; Tiglath-Pileser III.

erēnu (cedar/pine): Adad-nirari I; Assurnasirpal II (Lebanon); Tiglath-Pileser III; Sennacherib (Amanus); Ashurbanipal; the Neo-Babylonian kings.

liāru (a conifer: Postgate 1992^a: 182): Sennacherib; Ashurbanipal.

musukkannu (sissoo): Assurnasirpal II; Tiglath-Pileser III; Sargon II; Ashurbanipal.

sindu ('Indian Wood': CAD 's': 284; AHW 1045): Sennacherib.

šurmenu (cypress): Assurnasirpal II (Amanus); Tiglath-Pileser III; Sargon; Sennacherib; Esarhaddon; Ashurbanipal.

Cedar and cypress were the favourite woods in the Graeco-Roman world for monumental doors (cf. Meiggs 1982: 420).

A number of attempts have been made to elucidate Mesopotamian door-locking systems, particularly since it was realized that seal impressions can preserve significant details of them on their reverses. Zettler and Leichty (Zettler 1987), on the evidence of clay sealings from door-locks found at Nippur, and Scurlock (1988), using archaeological information from Tchoga Zanbil in Khuzistan, assume simple systems based on latches or bolts to translate the Sumerian and Akkadian vocabulary for locks and locking. Potts (D. 1990^a) has argued that a more sophisticated model, involving keys, is required for any convincing explanation of the ancient terminology, citing particularly the surviving evidence from ancient Egypt for systems involving wooden keys with teeth. When the archaeology and the philology are combined it is evident that there was a range of wooden locking devices, some involving keys, in pre-Achaemenid Mesopotamia. Layard (1853: 596) reports finding a metal key at Kuyunjik, which he compared to that used in Egyptian locks; but the date of this key may not be assumed to be as early as the Neo-Assyrian period.

(e) Internal fittings

The use of wood for interior decoration and fittings is sporadically evident in the archaeological record and was probably significant in monumental buildings. In the 'White Temple' at Uruk (IV) slender wooden beams (*Konifersholz*) were laid horizontally into the back walls of the facade niches (Heinrich 1937: 35, pl. 22). Whether a fragmentary architectural model in stone, also of the Uruk IV period, shows half-timbered work is debatable (cf. Heinrich 1982: 10–11, 64). Indeed, the role of timber in the remarkable late prehistoric structures at Uruk, where timber prototypes have been postulated for various decorative features in developed mudbrick architecture, is controversial. But-tresses had, however, been part of mudbrick buildings from the beginning, as at Tell es-Sawwan, and they were already elaborated in the Ubaid period. If wood was used more extensively at Uruk than elsewhere, like the unusual use there of stone for construction, it may have been more a matter of conspicuous consumption than the final vestiges of an earlier wooden architecture.

In buildings of the earlier third millennium BC found in the 'Y' sounding at Kish, Watelin (1934: 9, pl. XI.1)

identified 'a series of boards placed against the wall'. This may have served as panelling in the manner Woolley observed in at least one of the private and two of the royal graves at Ur (Woolley 1934: 83, 133, 178). Wooden panelling for wall decoration was noted in the Akkadian levels at Nuzi (Starr 1939: 68 ff.).

Woolley's report on the private houses at Ur in the earlier second millennium BC illustrates very well both the potential and the limitations of seeking negative indications of the use of wood in domestic buildings. It is now generally agreed that Woolley's reconstructions (notably no. 3 Gay Street) were too influenced by the use of wood for galleries in the Ottoman architecture of Baghdad; but he had a sharp eye for those significant details which might indicate the use of wood for less structural internal fittings (Woolley 1976: *passim*). At Tell ed-Der some of the wood retrieved from among large groups of tablets has been identified as the remains of wooden containers or shelves (Zeist and Vynckier 1984). Woolley (1974: 3) argued that some of the walls of the 'Mausoleum of Shulgi' had been panelled with rich inlays set in the woodwork of which the merest traces survived.

There were traces of elaborate timber structuring in Court IV of the Pre-Sargonic Palace at Mari, including some wood said to be cedar, with fragments of beams and supports preserved as charcoal (Parrot 1965: 19–21, fig. 18). In the Old Babylonian palace wood was also evident in a number of places, notably in Court 106 and in the 'throne-room', used within walls and for free-standing fittings (Parrot 1958^a: 106, n.2, fig. 108; 113, fig. 116; 159, fig. 180, including traces of rope). The most spectacular wooden wall-fitting(?) was found face-down on the floor of Room 46 in the private royal apartments. This 'retable' consisted of a rectangular wooden framework; the upper elements decorated with scenes: 'Il avait été sculpté d'une scène historique cantonnée entre deux guirlandes en pâte rouge . . . Le travail avait été exécutée en creux et les personnages silhouettés en pâte rouge.' Wooden bands, inlaid with carved rosettes, divided up the lower half. Preservation was too poor for any clear reconstruction (Parrot 1958^b: 5–7, 182, fig. 4, pl. III. 1–3). Traces of carved wood fittings in Mesopotamia are at present negligible (cf. Woolley and Moorey 1982: 56) and reference has to be made to the mid-third-millennium palace at Ebla for evidence of what has been lost in this medium. There fire had preserved fragments of elaborately carved wooden friezes (Matthiae 1989: 107 ff., pls. 35–43). In the Kassite reconstruction of *Emurianabaag* at Ur Woolley (1965: 7) believed that he had traced timber panelling on the internal walls.

One of the best-preserved screens so far excavated is that in level III of the temple of Enlil at Nippur, of

the Kassite period; this screen had been erected as if to prevent a direct view from one cella to another (Rooms 10 to 13: McCown *et al.* 1967: pl. 10B, 25:6). 'The screen was preserved for its entire width (1.40 m.) and to a height of 47 cm. It was framed in wood with horizontal panels 27 cm. high filled with vertical reeds, of which only the black outer shells remained . . . little was left of the . . . post to which the screen was fastened except traces of carbonized wood covered with a mud-plaster coating 1 cm thick . . . the door-socket indicates that the screen did swing, although the mud plaster shows that eventually it was left in a fixed position' (McCown *et al.* 1967: 15).

It is Neo-Assyrian royal inscriptions which once again provide the most direct evidence for the varied timbers used for internal fittings in palaces and temples. One of the most remarkable single passages is that in Assurnasirpal's 'Banquet Stela', where it may be implied that various wings or suites of the palace were characterized by the wood employed in them, probably above all for wall-panelling of various kinds, sometimes inlaid with other materials like ivory and limestone/calcite (Grayson 1976: 173; Postgate 1992^a: 190; chart 3).

It is not always easy to distinguish the woods intended specifically for architectural fittings within palaces and temples, but they embrace a wider range of timbers than those listed previously for construction, since characteristics other than strength and durability come into consideration. Salonen (A. 1963: 213 ff.) has listed timbers for 'furniture' (bed/couch; chair/stool; table). The standard cypress, cedar/pine, and juniper occur, but with the addition of:

buṭnu (CAD 'B': 358; AHW 144): terebinth: Tiglath-Pileser I; Assur-bel-kala; Assurnasirpal II; Sargon; Sennacherib.

miḫru (*mehru*): species of fir: Assurnasirpal II.

musukkannu (sissoo): Assurnasirpal II; Sargon II; Sennacherib; Esarhaddon.

tar-pu'u (AHW 1382): tamarisk: Tiglath-Pileser I; Assurbelkala; Assurnasirpal II.

taskarinnu: (AHW 1336): box: Tiglath-Pileser I; Tiglath-Pileser II; Assurnasirpal II; Sargon II; Sennacherib; Esarhaddon.

'Box' is particularly popular in this context, since its colour, durability, and texture were particularly prized for interior work and fine furniture, as is evident from at least the early second millennium BC. It was sometimes combined with *ušu*-wood, not apparently from the west or north-west. The light colour of the box combined effectively with ebony or other dark woods which may also be embraced by the term *ušu*-wood, listed by Sargon II, Sennacherib, and Esarhaddon (Postgate 1992^a: 190).

(v) WOOD IDENTIFICATIONS FOR MESOPOTAMIAN SITES (PREHISTORIC TO SELEUCID)

Ash	Brak: sample from Court 2 of Naram-Sin's Palace (E. W. J. Phillips, in Mallowan 1947: 15). (Syrian) Larsa (E. BABBAR Temple) (Neef 1989: 152).
Box	Nuzi: shaft of an adze from a grave of the Akkadian period (I. W. Bailey, in Starr 1939: 494).
Cedar	Nuzi: door in Nuzi II Palace: 'coniferous, probably cedar of Lebanon' (I. W. Bailey, in Starr 1939: 494). Khorsabad: 'tree' on temple façade ('Director of the Royal Gardens at Kew', in Loud 1936: 97 n. 10). There are a number of less clearly authoritative botanical identifications: Mari: column, Early Dynastic III (Parrot 1965: 19-20). Nimrud: Layard 1853: 357. Uruk: structural: late prehistoric (Lenzen 1965: 17).
Cypress	Ur: Neo-Babylonian ziggurat (Burleigh <i>et al.</i> 1982: 248); these may be the timbers described as 'teak' by Taylor (see below).
Elm	Brak: sample from Court 2 of Naram-Sin's Palace (E. W. J. Phillips, in Mallowan 1947: 15).
Mulberry	Nimrud: 'at least three' Neo-Assyrian pulley-wheels for a well-head in Room NN of the North-West Palace (E. W. J. Phillips, in Mallowan 1953: 25 n. 2; cf. Wiseman 1952: 27 n. 1).
Oak	Brak: sample from Court 2 of Naram-Sin's Palace (E. W. J. Phillips, in Mallowan 1947: 15). Jarmo: 'over 50 samples' (Braidwood R. J., <i>et al.</i> 1983: 541). Mureybet: domestic, vertical support (Aurenche 1981: 49 n. 15; cf. receptacle of oak, <i>ibid.</i> 36). Nimrud: 'large pieces of oak beams': well-head in North-West Palace (E. W. J. Phillips, in Mallowan 1952: 14; 1953: 25). Abu Qubur: probably building timber, Achaemenid to Seleucid (Zeist 1989). Larsa: Neo-Babylonian ziggurat (Neef 1989: 151). Nuzi: samples (I. W. Bailey, in Starr 1939: 494). Oueili: from flotation (Neef 1991). (Eridu: date stones (J. B. Gillet, in Safar 1981: 318)). There are many references to recognition

Pine

Plane

Poplar

Tamarisk

'Teak'

Walnut

Willow

of this timber, where no expert identification is cited. cf.:
Nippur: roofing: McCown *et al.* 1967: 36-7, pl. 40A; Gibson 1978: 67.
Uruk: Singashid's Palace (Lenzen 1961: 21).
Brak: 'Late houses, c.1500 BC' (E. W. J. Phillips, in Mallowan 1947: 15).
Tell ed-Der: 'from the rooms of the archives'; Old Babylonian (Zeist and Vynckier 1984: 130-3).
Nimrud: Neo-Assyrian palace: roof timbers (Forest Research Projects Laboratory, Princes Risborough, England: Mallowan 1966: ii. 377-8 n. 12).
Ur: Neo-Babylonian ziggurat (Burleigh *et al.* 1982: 248).
Brak: sample from Court 2 of Naram-Sin's Palace (E. W. J. Phillips, in Mallowan 1947: 15).
Abu Salabikh (J. N. Postgate: personal communication): Early Dynastic III.
Brak: roof-beams (E. W. J. Phillips, in Mallowan 1947: 15): 'wooden beams which probably roofed a portico in the entrance courtyard . . . in an Akkadian building' (Bowman and Ambers 1989: 213).
Tell ed-Der: roof-beams, Old Babylonian (Zeist and Vynckier 1984: 130-3).
Larsa: Hellenistic and Parthian houses (Neef 1989: 154).
Mefesh: Ubaid period (E. W. J. Phillips, in Mallowan 1946: 126-8).
Mureybet: domestic structural elements (Aurenche 1981: 45, fig. 19).
Nuzi: 'the bulk of the charcoal' (I. W. Bailey, in Starr 1939: 494).
Oueili: from flotation; Ubaid period (Neef 1991).
Abu Salabikh (J. N. Postgate: personal communication): Early Dynastic III.
Arpachiyah: Halaf period (Burleigh *et al.* 1982: 248).
Tell ed-Der: 'from the rooms of the archives', Old Babylonian (Zeist and Vynckier 1984: 130-3).
Larsa: roof-beams (Neef 1989: 154-6).
Oueili: from flotation; Ubaid period (Neef 1991).
Ur: Neo-Babylonian ziggurat: identification of Taylor in 1853 (cited by Woolley 1939: 133; see 'Cypress', above).
Nimrud: Neo-Assyrian writing-board (Forest Research Projects Laboratory and others: Wiseman 1955: 3 ff., n. 14).
Mefesh: roof debris (E. W. J. Phillips, in

Mallowan 1946: 128).
Abu Salabikh (J. N. Postgate: personal communication): fragments; willow or poplar; Early Dynastic III.

(vi) WOOD IDENTIFICATIONS FOR LEVEL IVB AT HASANLU, NORTH-WEST IRAN (Harris, M.V. 1989).

Acer	Maple	Construction beams Furniture Mace-shaft Small carved object
Buxus	Box	Furniture Weapon-shafts Small carved object ?
Cedrus	Cedar	Bowl
Crataegus	Hawthorn	?
Cypressus	Cypress	Sculptured head
Eronymus	Spindle tree	Furniture
Fraxinus	Ash	Furniture
Juglans?	Walnut	Small carved object
Juniperus	Juniper	Mace-shaft
Malus or Pyrus	Apple or Pear	Small carved object
Platanus	Plane tree	Columns
Populus	Poplar	Furniture Small carved object
Prunus	Almond, Peach	Furniture
Ulmus	Elm	Furniture Spear-shaft

6. Building with Reeds

In southern Mesopotamia reeds have always been plentiful in marshes and other wet regions. The two species most widely employed there today are *Phragmites australis* and the less common *Arundo donax* (cf. Hepper 1992). The reeds may grow as much as 4.50 m. high, with flat leaves that grow up the length of the stem. Together they are used for building shelters, fences, partitions, etc.; but it is now more common for the leaves to be stripped off leaving a long, stiff rod. These rods are used singly or in bunches for creating the distinctive buildings of the Marsh Arabs (Thesiger 1964: *passim*; Aurenche 1981: 79 ff.). They also play an important role in construction as mats, woven from split and flattened stems with the outside of the plant forming the primary surface. In roofing, for which their toughness is particularly prized, this side is laid downwards so that it is exposed between the poplar beams of a ceiling to create an attractive effect familiar in the Iraqi countryside (cf. Ochsenschlager 1992; Postgate 1980^a).
Textual sources (cf. CAD, s.v. *qanu*) indicate that a mat measuring six metres square would take six days

to weave; one measuring three by two metres would take one day (Sachs, in Goetze 1948: 181-2). Mat impressions found in prehistoric villages (cf. Ali Kosh: Hole *et al.* 1969: fig. 95, pl. 37; Hassuna: Lloyd and Safar 1945: fig. 38; Uruk: Westphal-Hellbusch and Westphal 1962: fig. 5) indicate that methods of mat manufacture have changed little since remote antiquity.
It will be obvious, as previously with wood, that reed construction is archaeologically elusive. It is to be expected particularly in southern Mesopotamia, where in regions at the head of the Gulf it provided the primary building material from time immemorial. Representations in prehistoric art reveal its enduring character (cf. Amiet 1961: nos. 385-9, 623-32, 1613). The extent to which this way of building left an indelible impression on the formative stages of mudbrick architecture has been much discussed. Even if it did, as seems probable, the effect is not strong enough to support deductions, independent of the evidence of scenes carved on stone vessels and seals, about prehistoric reed structures. Texts suggest that in historic times certain temple fittings were entirely of reeds, reproducing the form of primitive shrines like that of Enki at Eridu (Charpin 1986: 292 n. 17, 294, 355). An Early Dynastic III inscription on a stone slab from Lagash is an incantation to ensure the efficiency of reeds used in a dedication ceremony for temple construction (Cooper 1986: 32-3; La 1.32).
Aurenche (1981: table 9, map 9) has plotted the meagre and scattered evidence for the use of reeds in prehistoric domestic architecture, where they played a role in roofing and in the structure and in fittings like doors that was to endure. In a deep sounding made in the Eanna Precinct at Uruk (Nöldeke *et al.* 1932: 6-7), directly above virgin soil in level XVIII (Ubaid period), the excavators found layers of trimmed, crossed reeds with many sherds. They were interpreted as the remains of platforms created in the marshes to support simple dwellings. In the same period at Hajji Mohamed, the excavators report traces of reed structures (Nöldeke *et al.* 1938: 37). Woolley (1956: 7) is more explicit in reporting on the earliest structures at Ur: 'in the corrugations could be seen the imprint of the fibrous stems of reeds. It was obvious this was the way clay plaster had been applied to the side of the hut built of reeds precisely as reed huts are built in Lower Iraq today.' At Tell al-Ubaid itself, in the sounding down to the early village settlement, 'there occurred layers of reed matting thickly plastered with clay mixed with dung or, less often, with a mixture of earth and bitumen' (Hall and Woolley 1927: 149; cf. also at Uruk: Nöldeke *et al.* 1934: 17).
The tensile qualities of matting and beds of reeds made them specially useful as binders in mudbrick structures from foundation level upwards. The practice of putting reeds or reed mats on the ground before

bricks were laid or between old wall stumps and the rebuilt upper levels is evident in Early Dynastic structures (cf. Postgate 1980^a; 1984: 105; Hansen 1973: 67–8). What may be a comparable practice seems to be evident in the late prehistoric monumental buildings at Uruk (cf. Lenzen 1963: 9, pl. 16; Schmidt, J. 1978: 20). By the second millennium it is widespread (cf. Ur: Woolley 1976: 21; Diyala: Delougaz *et al.* 1967: 151) and was standard practice for Neo-Assyrian (Loud and Altman 1938: 17) and Neo-Babylonian builders (Reuther 1926: 128 ff.). In the walls of the Ishtar Gate and the Processional Way at Babylon, for example, Koldewey describes the role of reeds in some detail:

In every fifth course a matting made of reeds, the stalks of which have been split and rendered flexible by beating, is substituted for the mud [as a layer of mortar over a thin layer of bitumen]. The matting itself is rotted, but the impression left in the bitumen is still perfectly fresh and recognisable. In appearance it corresponds exactly with the ordinary matting in use in the neighbourhood today. (Koldewey 1914: 30–1)

The use of reeds in architecture most familiar to all visitors to ancient sites in central and southern Iraq is in the brickwork of ziggurats, where decay has often reduced them to a white powdery substance (Langdon 1924: 46 n. 1: Kish). Woolley's (1939: 104) idea that spontaneous combustion explains this phenomenon is most unlikely (cf. Postgate 1980^a: 104 and Gibson's comment on p. 111 there). Such layers apparently do not appear in ziggurats in northern Iraq, where the reeds would have been less readily available, nor in that at Tchoga Zanbil in Khuzistan. Their precise function is debated.

Although these layers are often referred to as 'mats', and the Eanna ziggurat at Uruk was known locally as *al-buwariyyah* (from *buwari*: reed mats) (Loftus 1857: 168), this needs to be checked in every case. Since the reeds are usually laid in two directions they easily give the impression of having been originally woven as mats; but closer examination suggests they may sometimes, if not invariably, have been just layers of natural reeds (cf. Postgate 1980^a: 104). They appear to have been laid horizontally in bands at more or less regular intervals in

the brickwork, though counts suggest that the sequence varies from ziggurat to ziggurat and perhaps also within single examples. Gullini, who studied the fourteenth-century ziggurat at Aqar Quf, reported that there the reeds:

were laid at more widely spaced intervals as the building grew higher. Their purpose was both to distribute and to bind the mudbrick materials. We have been able to make out the constant recurrence of what may be called tie-rods consisting of (straw) ropes plaited [*sic*] running alternately N.E.–S.W. and N.W.–S.E.

It was also found that the (straw) mats were placed straight on the rows of bricks without levelling and are thus not exactly horizontal; again, at the point of contact between the mudbrick core and the baked brick façade the thickness of the matting was little more than 1 cm., as opposed to about 10 cm. at the centre of the building. (Gullini 1985: 135)

Twisted ropes may also be seen in the structure of the Eanna Ziggurat at Uruk (Jordan 1930: pls. 9–10). At Larsa a cereal straw was used for layering in the Ziggurat (Neef 1989).

Apart from the use of reeds in the construction of doors and screens (Reiter 1991) inside buildings, they were used as support or stiffening, often in contexts where their presence may be concealed by plaster. In the archive room of the Shamash Temple at Sippar tablets were arranged vertically on shelves set in alcoves constructed of mud and reeds (Al-Jadir and Al-Adami 1987: 30). There is considerable evidence for the processing and use of reeds in texts (cf. Mieroop 1992^a; Waetzoldt 1992).

(i) REED IDENTIFICATIONS

Aqar Quf ziggurat: *Phragmites australis*: *Flora of Iraq*, ix, 376. (cf. Postgate 1980^a: 105; same result for reeds from the ninth-century AD structure at Zibbiyyat near Nippur).

Mefesh: *Phragmites communis* Trin. (J. S. L. Gilmour, in Mallowan 1946: 128).

Oueili: *Phragmites australis* (animal feed; basketry; building houses and granaries in the Ubaid period) (Huot 1989: 26).

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| AAAS | <i>Annales archéologiques arabes syriennes</i> (Damascus) | JEOL | <i>Jaarbericht 'Ex Oriente Lux'</i> (Leiden) |
| AASOR | <i>The Annual of the American Schools of Oriental Research</i> (New Haven, Conn.). | JESHO | <i>Journal of the Economic and Social History of the Orient</i> (Leiden) |
| Acta Or. | <i>Acta Orientalia Academiae Scientiarum Hungaricae</i> (Budapest). | JFA | <i>Journal of Field Archaeology</i> (Boston) |
| AfO | <i>Archiv für Orientforschung</i> (Graz) | JGS | <i>Journal of Glass Studies</i> (Corning, NY) |
| AHW | <i>Akkadisches Handwörterbuch</i> (Wiesbaden) | JHMS | <i>Historical Metallurgy: Journal of the Historical Metallurgy Society</i> (London; known as <i>The Bulletin of the Historical Metallurgy Group</i> until 1974) |
| AJ | <i>Antiquaries Journal</i> (London). | JHS | <i>Journal of Hellenic Studies</i> (London) |
| AJA | <i>The American Journal of Archaeology</i> (Cambridge, Mass.) | JNES | <i>Journal of Near Eastern Studies</i> (Chicago) |
| AMI | <i>Archäologische Mitteilungen aus Iran</i> (Berlin) | JOS | <i>Journal of Oman Studies</i> (Muscat) |
| APA | <i>Acta Praehistorica et Archaeologica</i> (Berlin) | JRAS | <i>Journal of the Royal Asiatic Society</i> (London) |
| ARM | <i>Archives royales de Mari</i> (Paris) | LAAA | <i>Liverpool Annals of Archaeology and Anthropology</i> (Liverpool) |
| AS | <i>Anatolian Studies</i> (London) | MARI | <i>Mari Annales de Recherches Interdisciplinaires</i> (Paris) |
| BA | <i>Biblical Archaeologist</i> (American Schools of Oriental Research) | MASCA | <i>Museum Applied Science Center for Archaeology</i> (University Museum, Philadelphia) |
| Bag. Mitt. | <i>Baghdader Mitteilungen</i> (Berlin) | MDAIK | <i>Mitteilungen des Deutschen Archäologischen Instituts: Abteilung Kairo</i> (Mainz am Rhein) |
| BAR | <i>British Archaeological Reports</i> (Oxford) | MDO-G | <i>Mitteilungen der Deutschen Orient-Gesellschaft</i> (Berlin) |
| BASOR | <i>Bulletin of the American Schools of Oriental Research</i> (Jerusalem and Baghdad) | MDP | <i>Mémoires de la délégation en Perse</i> (Paris; including those volumes with slightly different titles in the same sequence) |
| BCH | <i>Bulletin de Correspondence Hellénique</i> (Paris) | MDVG | <i>Mitteilungen der Vorderasiatisch-Agyptischen Gesellschaft</i> (Leipzig) |
| Bib. Or. | <i>Bibliotheca Orientalis</i> (Leiden) | MJ | <i>Museum Journal</i> (University Museum, Philadelphia) |
| BJV | <i>Berliner Jahrbuch</i> (Berlin) | Mon. Piot | <i>Monuments et Mémoires</i> (Foundation Piot; Paris) |
| BM | British Museum (London) | NABU | <i>Nouvelles Assyriologiques Brèves et Utilitaires</i> (Paris) |
| BMOP | <i>British Museum Occasional Paper</i> (London) | Num. | <i>Numismatic Chronicle</i> (London) |
| BMQ | <i>British Museum Quarterly</i> (London) | Chron. | |
| BSA | <i>Annual of the British School at Athens</i> (London) | OA | <i>Oriens Antiquus</i> (Rome) |
| BSOAS | <i>Bulletin of the School of Oriental and African Studies</i> (London) | OIC/OIP | <i>Oriental Institute Communications/Publications</i> (Chicago) |
| BSTN | <i>Bead Study Trust: Newsletter</i> (London) | OJA | <i>Oxford Journal of Archaeology</i> (Oxford) |
| CAD | <i>Chicago Assyrian Dictionary</i> (Chicago) | OLZ | <i>Orientalistische Literaturzeitung</i> (Berlin) |
| CAH | <i>Cambridge Ancient History</i> (Cambridge) | Opus. Ath. | <i>Opuscula Atheniensia</i> (Lund) |
| CRAI | <i>Comptes Rendus des séances de l'année: Académie des Inscriptions et Belles-Lettres</i> (Paris) | PACT | <i>Journal of the European Study Group on Physical, Chemical and Mathematical Techniques Applied to Archaeology</i> (Strasbourg) |
| CRAS | <i>Comptes Rendus de l'Académie des sciences</i> (Paris) | PEQ | <i>Palestine Exploration Quarterly</i> (London) |
| CJA | <i>Cambridge Journal of Archaeology</i> (Cambridge) | PPS | <i>Proceedings of the Prehistoric Society</i> (Cambridge) |
| DAFI | <i>Cahiers de la délégation archéologique française en Iran</i> (Paris) | PSBA | <i>Proceedings of the Society of Biblical Archaeology</i> (London) |
| FuB | <i>Forschungen und Berichte</i> (Berlin) | RA | <i>Revue d'assyriologie et d'archéologie orientale</i> (Paris) |
| IA | <i>Iranica Antiqua</i> (Leiden) | RAS | <i>Revue d'Archéométrie</i> (Rennes) |
| IEJ | <i>Israel Exploration Journal</i> (Jerusalem) | | |
| Ist. Mitt. | <i>Istanbuler Mitteilungen</i> (Mainz am Rhein) | | |
| JAOS | <i>Journal of the American Oriental Society</i> (New Haven, Conn.) | | |
| J.Arch.Sc. | <i>Journal of Archaeological Science</i> (Academic Press) | | |
| JCS | <i>Journal of Cuneiform Studies</i> (New Haven, Conn.) | | |

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- RGZM *(Jahrbuch) Römisch-Germanischen Zentralmuseums, Mainz*
- RHA *Revue hittite et asianique* (Paris)
- RLA *Reallexikon der Assyriologie und vorderasiatischen Archäologie* (Berlin)
- SPA *Survey of Persian Art* (Oxford)
- UET *Ur Excavations: Texts* (London and Philadelphia)
- UF *Ugarit Forschungen* (Münster)
- UVB *Vorläufiger Bericht . . . Uruk-Warka* (Berlin)
- WVDO-G *Wissenschaftliche Veröffentlichung der Deutschen Orient-Gesellschaft* (Leipzig)
- WO *Die Welt des Orients* (Göttingen)
- ZDPV *Zeitschrift des Deutschen Palästina-Vereins* (Wiesbaden)
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