

# THE ARCHAEOLOGICAL EVIDENCE FOR METALLURGY AND RELATED TECHNOLOGIES IN MESOPOTAMIA, *c.* 5500–2100 B.C.

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*For Seton Lloyd, on his eightieth birthday, in admiration of his outstanding contributions to the archaeology of Mesopotamia and Anatolia.*

In the remarkable expansion of archaeometallurgical studies in the last fifteen or twenty years Mesopotamia, where much pioneer work was done fifty years ago, has steadily slipped from view. This is in marked contrast to the time when Woolley's discoveries in the " Royal Cemetery " at Ur gave the Sumerians an assured place in general studies of early metallurgy.[1] As research priorities in archaeometallurgy in the Near East moved to the investigation of the primary processes of metal exploitation and the development of support technologies, the source zones of Anatolia, of the Negev and Sinai, and of Iran inevitably eclipsed a region which had always been an importer of metals, to a greater or lesser degree already processed. This excluded Mesopotamia from a role as innovator in the basic techniques of metal recovery, and also probably in pioneering the skills of smelting and of alloying copper. Nor, for the same reasons, has Mesopotamia been drawn into the lively debate about the relative significance of external forces and internal transformation mechanisms in the development of metallurgy in prehistoric Europe, for which the primary eastern point of reference was Anatolia.[2] But the certain fact that Mesopotamia had to import all her metal has kept metallurgy among the factors considered in current debates over explanatory models for the emergence of a complex society there in the later fourth and earlier third millennium B.C., sometimes giving rise to conclusions hard to reconcile with the sparse archaeological record.

If the " idea of metallurgy " was imported into Mesopotamia in the remote past, with the earliest imported metals, the precocious development there of urban communities with the means to import a range of metals, and to manufacture them, stimulated the local craft traditions to a point where by the middle of the third millennium B.C. at Ur metalwork from a small group of exceptionally richly equipped graves " reveals knowledge of virtually every type of metallurgical phenomenon except the hardening of steel that was exploited by technologists in the entire

[1] C. L. Woolley, *Ur Excavations* (*UE* hereafter) II (London, 1934), passim; L. Aitchison, *A History of Metals* I (London, 1960), this widely ranging book summarizes the state of research and interpretation at mid century; for a first class earlier reference book see the relevant parts of J. R. Partington, *The Origins and History of Applied Chemistry* (London, 1935). Regrettably, as many reviewers have pointed out, the books of J. R. Forbes in the series *Studies in Ancient Technology* (Brill, Leiden) are just not consistently reliable enough; the wise reader will always refer back to the basic sources quoted.

[2] C. Renfrew, *Proc. Prehist. Soc.* 36 (1969), 12 ff.; *Antiquity* 52 (1978), 199 ff.; various papers in the IX Congrès, Union Internationale des Sciences Préhistoriques et Protohistoriques, Nice 1976, Colloque XXIII: *Les Débuts de la Métallurgie*, particularly U. Esin on Anatolia. J. D. Muhly, *Supplement to Copper and Tin* (Transactions of the Connecticut Academy of Arts and Sciences, no. 46, 1976), 110, noted the absence of a recent survey of Mesopotamian metallurgy. I am grateful to Professor Muhly for comments on the first draft of this paper.

period up to the end of the 19th century A.D." [3] This is still not precisely matched anywhere else in the Near East at this time.[4] This paper seeks to survey current archaeological evidence for this remarkable achievement; the range of information from this source is extremely restricted. In a society like that of ancient Mesopotamia, where all metal had to be imported, it was regularly recycled. Consequently the actual amount of metal recovered through excavation at any period is no guide to the scale of contemporary use nor to the full range of techniques and the repertory of forms.[5] Nor is the study eased by the fact that metal finds are very rare, at the best of times, in temple or settlement excavations. What evidence there is, is primarily mortuary. When an archaeological period is ill-represented in the mortuary record its metalworking is likely to be more than ever obscure. This survey is not confined entirely to metallurgy, for the evolution of other fire-using mineral industries, such as the production of painted ceramics, of glazes and faience, are important guides to the status of metallurgy when direct evidence is sparse.

## (i) *Metal sources*

Whence the metals came which supplied Mesopotamia's smiths is a basic problem upon which there is no certain information before the appearance of texts, and even then the data they yield is imprecise and debatable. In the simplest terms there were three potential source areas: the highland zones of Anatolia, of Iran and of the Gulf. The close association of copper and lead in the earliest metalworking communities of Mesopotamia supports the view that raw materials first reached northern Mesopotamia in a trade parallel to that in obsidian from Anatolia.[6] Even if this was so, already by the sixth millennium B.C. the possibility of alternative sources in Iran, at least for central and southern Mesopotamia, complicates the question. In Iran native copper, perhaps even smelted copper, was available early. Alabaster objects have been found at Ali Kosh in Khuzistan identical to those found in graves at the bottom of Tell es-Sawwan in Iraq, whilst one sherd of Hassuna or early Samarra ware was recognized at Chaga Sefid. The presence of native copper in both areas might indicate a complementary movement of metals, as there are beads of what is taken to be Iranian turquoise at Tell es-Sawwan.[7] The penetration of Halaf and 'Ubaid pottery through sites in northern Syria into eastern Anatolia, along routes to mines in that area, has been seen as an indicator of a reciprocal metal trade running in that direction. Similar oblique evidence applies also to the Protoliterate period.

[3] C. S. Smith, *Technology and Culture* 11 (1970), 499.

[4] Anatolian workshops perhaps came closest, but lifesize copper castings, for instance, are not yet evident there and the dating of crucial finds is still debated. Egyptian craft traditions were less various and inventive. See the excellent review of Anatolian evidence: Prentiss S. de Jesus, *The Development of Prehistoric Mining* and *Metallurgy in Anatolia* (BAR International Series 74, Oxford, 1980).

[5] H. Limet, *Le Travail du métal au pays de Sumer au temps de la IIIe Dynastie d'Ur* (Paris, 1960) deals with the earliest period for which textual evidence highlights this disparity.

[6] G. A. Wright, *Obsidian Analyses and Prehistoric Near Eastern Trade 7500 to 3500 B.C.* (Anthropological Papers, Museum of Anthropology, University of Michigan, no. 37, 1969).

[7] F. Hole, *Studies in the Archaeological History of the Deh Luran Plain: The Excavation of Chaga Sefid* (Ann Arbor, 1977), 21; on turquoise trade: M. Tosi, *Studi di Paletnologia, Paleoantropologia, Paleontologia e Geologia del Quaternario* 2 (1974), 147 ff. (a reference I owe to Professor Muhly).

The penetration of distinctive " Uruk " ceramics and other artefacts along the line of the Euphrates deep into eastern Anatolia, and the existence of contemporary " colonial " settlements at sites like Habuba Kabira-Tell Qannas and Jebel Aruda, on the Syrian Euphrates, strengthens arguments for a persisting trade along such routes, directly controlled by Mesopotamian enterprise.[8] Changed political circumstances in eastern Anatolia and northern Syria in the course of the period may account for the desertion of the Uruk period sites on the Upper Euphrates, with the distribution of traded ores and artefacts passing into local control. It may be more than co-incidence that it is then (the Jamdat Nasr period in Mesopotamia) that evidence begins to accumulate for the growing sea commerce in the Gulf that was to be such a feature of the next millennium.[9] Although many of the metallurgical arguments in favour of Sumerian exploitation of copper from sources in Oman advanced by the Sumer Committee in the 1930s are no longer acceptable, the basic premise is by no means discredited.[10] There is ample evidence for copper in Oman,[11] though analyses so far reveal little trace of the nickel which played so large a part in the old discussions.[12] Grave groups in Oman and Abu Dhabi attributed to a " Jamdat Nasr " horizon, though their absolute dating is controversial, are located on the major lines of communication with the copper mines,[13] which may well have served southern Mesopotamia.

The ore sources upon which Mesopotamia drew in the third millennium B.C. are no more firmly identified than in earlier periods, though some documentary information is now available. Textual references (few contemporary) refer primarily to Iran; but this may be no more than a result of their Sumerian point-of-view. Central and northern Mesopotamia were more likely to have drawn their metals, as previously, from the west or northwest. The recently discovered Ebla texts contain valuable information on metals and metalworking,[14] which may be expected to illuminate this aspect of the question. Young's argument that platiniridium inclusions in the gold used in the " Royal Cemetery " at Ur indicated the Pactolus region of western Anatolia as its source has been disputed and a research programme in London is currently pursuing the problem.[15] No clearer is the role of Anatolian mines in the supply of silver and lead. The history of silver and lead are closely related and require much more careful documentation than

[8] For this period cf. U. Zwicker, " Investigations on the Metallurgy of Cu/Sb/As ... from Norsun Tepe on the Upper Euphrates (3500–2800 B.C.) in W. A. Oddy (ed.), *Aspects of Early Metallurgy* (British Museum, 1977), 13 ff.

[9] E. Heinrich *et al.*, *MDOG* 105 (1973), 6 ff.; M. van Loon, in *Ex Horreo* (ed. B. L. van Beek *et al.*, Amsterdam, 1977), 114 ff.; earlier links up the Gulf are increasingly evident, J. Oates *et al.*, *Antiquity* 51 (1977), 221 ff.

[10] J. D. Muhly, *Iraq* 39 (1977), 78.

[11] A. Hastings *et al.*, *The Journal of Oman Studies* (*JOS*) 1 (1975), 9 ff.; M. Tosi, ibid., 187 ff.

[12] G. W. Goettler *et al.*, *JOS* 2 (1977), 43 ff. For third millennium: A. Hauptmann and G. Weisgerber, *Revue d'Archéométrie: Supplément* (1981), 131 ff.

[13] I have benefited particularly from reading Daniel Potts, " Towards an integrated history of cultural change in the Arabian Gulf Area " (Harvard, 1978; manuscript); now *JOS* 4 (1978), 29 ff.

[14] G. Pettinato, *Orientalia* 44 (1975), 365; *Biblical Archaeologist*, May, 1976, 44 ff.

[15] R. Maxwell-Hyslop, *Iraq* 39 (1977), 83 ff.; N. D. Meeks and M. S. Tite, *Journal of Archaeological Science* 7 (1980), 267 ff.

present evidence permits.[16] The key question is simply stated, far less easily answered; when did it become possible to retrieve silver in workable quantities from lead ores? It is probable that much of the early " silver " used in Mesopotamia, perhaps also in Egypt, was the natural alloy commonly called electrum. Natural gold varies from a yellow metal, mostly gold, at one end of the scale, through various compositions of gold and silver in a range of yellowish-white colours, to a white metal, mostly silver, at the other. Dating the introduction of cupellation for separating silver from lead ores, and of a method for separating silver from gold in natural electrum alloys, in the Near East are both problems for which no unequivocal, direct evidence is yet available.

The Sumerian textual evidence for metal sources, such as it is, has been extensively discussed.[17] The role of *Magan* (? Oman and parts of Iranian Baluchistan) and *Meluhha* (? the Indus Valley region) as metal sources before the Akkadian period is unclear; but references to *Aratta* all hark back to the earlier third millennium B.C. if not earlier still. *Aratta*, whence it seems Mesopotamia may have received gold, silver, copper, and possibly even tin, lay to the east or northeast of ancient Anshan, now known to be at Tepe Malyan, about 46 kilometres north of Shiraz and an equal distance west of Persepolis.[18] Lapis-lazuli and carnelian are also listed among the riches of *Aratta*, recalling the resources of *Meluhha*. *Aratta* seems to have lain further to the south in central-eastern Iran than used to be argued. Excavations at Shahdad, Tal-i Iblis, Tepe Yahya and Shahr-i Sokhta have given ample evidence for the exploitation of locally accessible raw materials and of westwards trade in both minerals and some goods manufactured from them. It has also been suggested, on the evidence of the Sumerian epics, that the rulers of Early Dynastic Uruk were as interested in securing the services of skilled craftsmen from *Aratta* as they were in gaining raw materials.[19] Access to fine craftsmanship, as the " royal " graves at Ur show, is as much a mark of status as exotic raw materials. The military campaigns of the Akkadian kings, deep into Anatolia and into southwestern Iran, follow the same pattern in ensuring lines of supply for basic metals, and other raw materials.

### (ii) *Metal workshops and industrial debris*

Evidence for metalworking installations in Mesopotamia in the period considered here is negligible. Although the Uruk excavation reports contain references to

[16] K. Prag in *Archaeology in the Levant: Essays for Kathleen Kenyon* (ed. R. Moorey and P. J. Parr, Warminster, 1978), 36 ff.; T. Wertime, *Science* 182 (30th November, 1973), 883, n. 81, Prentiss S. de Jesus, op. cit. in note 4, 75 ff.

[17] J. D. Muhly, *Copper and Tin* (Archon Books, Hamden, Connecticut, 1973) and its *Supplement* (see note 2 here) give comprehensive bibliography for metal trade, sources, copper and copper alloys; see also M. Lambert, *RA* 47 (1953), 57–69, 105–120 (Telloh); *Sumer* 9 (1953), 198–213; G. Pettinato, *Mesopotamia* VII (1972), 43 ff.; see H. McKerrell, *Pact* 1 (1977), 167 for late appearance of tin-bronze in Bahrein.

[18] J. Hansman, *Iran* 10 (1972), 101 ff.; E. Reiner, *RA* 67 (1973), 57 ff.; on the vexed question of the source of Near Eastern tin see recently A. D. Franklin *et al.* (ed.), *The Search for Ancient Tin* (Smithsonian Institute, Washington, 1978); see M. Green, *JNES* 39 (1980), 16 ff., for what may be references to Aratta in the " Jamdat Nasr " texts from Uruk.

[19] See essays by D. Potts, C. C. Lamberg-Karlovsky and M. Tosi in J. Deshayes (ed.), *Le Plateau Iranien . . . à la Conquête Islamique* (Paris, 1977); J. D. Muhly, *Supplement*, 110.

prehistoric metalworking sites, the information presented is not conclusive. 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 ".[20] No 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 evidence for little more than secondary metalworking hereabouts.[21] In his excavations in Quadrant K/L XII (Kd, Ke) Nissen found a series of " fireplaces ", with drains and gullies, which he took to be part of a metalworking area, though here again there does not seem to have been any industrial debris to endorse this identification.[22] Madame Barrelet has convincingly associated this complex with many others of a similar kind at Uruk, probably used in the main for food production.[23] Stone moulds and pot-bellows do not appear in Mesopotamia until the later third millennium B.C.;[24] before that it is assumed clay moulds and bellows of perishable materials served instead, as they did throughout in many places, generally eluding the archaeologist. A pan-shaped vessel, said to be of mid third millennium date from Telloh, sometimes cited as a pot-bellows, has no ridge round the rim to secure a membrane, so is better classified as a fire-pan.[25]

### (iii) *The Repertory of metals, techniques and artefacts*

#### (*a*) *The Prehistoric phases*

The history of metallurgy in Mesopotamia is normally pushed back to the oval pendant from the Shanidar Cave, probably dating to the early ninth millennium B.C. or earlier.[26] Its position in this context is equivocal, as it is now completely mineralized and cannot be accurately described. It may illustrate the ornamental use of malachite rather than the earliest extant example of cold-worked native copper. The rolled bead of worked native copper from a pre-ceramic context at Tell Ramad on the Euphrates, with comparable objects from Çayönü Tepesi in Anatolia and Ali Kosh in Iran, provide a securer starting point, though, for Mesopotamia, all are peripheral sites.[27] Only with the early sixth millennium B.C. does there emerge a continuous, if initially thin, line of evidence from more central sites in Iraq. Low in Tell Sotto, copper beads were associated with an inhumation burial in a pot. Nearby at Yarim Tepe I, slightly later in the sixth millennium B.C., a range of base metal finds were distributed through all the occupation levels. They comprise what are described as fragments of " ore " as well as simple artefacts, primarily personal ornaments of copper and lead.[28] A few, near

[20] *UVB* XVI (1960), 10, Pl. 39. 3b, 4a–d.

[21] Ibid., Pl. 4d–e.

[22] H. J. Nissen, *Baghdader Mitteilungen* 5 (1970), 110 ff. pl. VI.

[23] *Paléorient* 2 (1974), 243 ff., esp. 293.

[24] C. J. Davey, *Levant* 11 (1979), 101 ff.; for tuyères see R. F. Tylecote, *Levant* 13 (1981), 107 ff.

[25] G. Cros, *Nouvelles Fouilles de Tello* (Paris, 1910), 151, Fig. D; M. Levey, *Chemistry and Chemical Technology in Ancient Mesopotamia* (Amsterdam, 1959), 17.

[26] R. Solecki, *Antiquity* 43 (1969), 311 ff.; C. S. Smith, *Metallurgical Transactions* (1975), 606–608, Fig. 2.

[27] H. Çambel, *Belleten* 38 (1974), 361–7; C. S. Smith in F. Hole *et al.*, *Prehistory and Human Ecology of the Deh Luran Plain* (Ann Arbor, 1969), 427 ff.; A. France-Lanord and H. de Contenson, *Paléorient* 1 (1973), 109 ff.

[28] N. I. Merpert *et al.*, *Iraq* 37 (1975), 65 ff.; *Iraq* 38 (1976), 77 ff.; *Sumer* 33 (1977), 82; the reference to " brass " here should read " lead ".

contemporary, pieces of worked copper, beads among them, were reported from graves and from level I at Tell es-Sawwan, southwards down the Tigris.[29] Russian scientists have analysed samples from Yarim Tepe I and Sawwan. These qualitative analyses indicated a relatively pure copper, though each site is claimed to show evidence for a different mineral source. As iron occurs in the range of 1–10% in the published analyses, slag may have been responsible. Here already, even if melted native copper was also in use, there was perhaps a supply of smelted copper.[30]

A massive open-ended lead bracelet, of very pure metal,[31] was found in the earliest phase of Yarim Tepe I, placed as if part of some kind of " foundation deposit ". Lead pendants were recorded in Level IX, of the seventh millennium B.C., at Çatal Hüyük in Anatolia.[32] It was long ago suggested that lead may have been exploited before copper was smelted; possibly, it would now appear, at much the same time, and in much the same area of Anatolia, as native copper was first melted. If a piece of galena had been dropped into a wood or charcoal fire it would be reduced to lead as its melting point is as low as 327° C.[33] Although it has been argued that the copper slag reported from level VI A1 at Çatal Hüyük may not be a smelting slag,[34] copper smelting was probably by this time understood in a number of mining areas of the Near East.

There are concentrations of two-tiered pottery kilns in Yarim Tepe I, and others at Tell es-Sawwan, capable of reaching temperatures up to and over 1100° C.[35] Although there is no reason to suppose malachite would ever have been associated directly with the firing of pottery at this time,[36] such kilns indicated man's ability to produce conditions and temperatures sufficient for reducing malachite and azurite. Firm evidence for the temperatures achieved in potting is now available from independent scientific determinations of firing temperatures for the major types of Mesopotamian prehistoric pottery.[37] Their pigments have also been carefully investigated and it is they, particularly, which link the applied chemistry of potter and metalsmith in the use of copper and iron-based minerals, sometimes in reducing conditions.[38]

The important cultural complex named after Tell Halaf in Syria is still singularly

[29] Al-a'Damai, *Sumer* 24 (1968), 59; also *Sumer* 20 (1964), p. 2; compare S. Fukai, *Sumer* 33 (1977), 48: from Telul eth-Thalathat, level XVa.

[30] For a full metallurgical report see *Sov. Arkh.* 1977 (3), 154 ff. (Russian with a French *resumé*); on detecting native copper see R. F. Tylecote, *A History of Metallurgy* (London, 1976), 1 ff.; native copper at Talmessi in Iran contains small quantities of arsenic; the presence of small quantities of tin in an analysis may always indicate smelted not native copper; R. Maddin *et al.*, *Journal of Archaeological Science* 7 (1980), 211 ff.

[31] N. I. Merpert, *Sumer* 33 (1977), 84, Pl. XII 2.

[32] J. Mellaart, *Çatal Hüyük* (London, 1967), 217, Pl. 104.

[33] L. Aitchison, *A History of Metals* I, 43, 184–5.

[34] R. F. Tylecote, *A History of Metallurgy*, 5 argues that the absence of iron silicates " suggests it is neither a crucible melting slag nor a smelting slag ".

[35] N. I. Merpert, *Iraq* 35 (1973), 96, 102, Pl. XXXVI; cf. the Iranian evidence: Y. Majidzadeh *Paléorient* 3 (1975–77), 207 ff.; modifying the conclusions of G. Delacroix and J. L. Huot, *Syria* 49 (1972), 35 ff.

[36] Glazed pottery was a second millennium innovation in Mesopotamia, closely associated in some way with the earliest manufacture of glass vessels. The earliest certain evidence of Near Eastern smelters are open hearths, cf. R. F. Tylecote, op. cit, 6–7; B. Rothenberg *et al.*, *Chalcolithic Copper Smelting* (Institute for Archaeo-Metallurgical Studies, London, 1978).

[37] M. S. Tite and Y. Maniatis, *Nature*, 127 (1975), 122–3.

[38] W. Noll *et al.*, *Angewandte Chemie* 14 (9) (September 1975), 602–13 (International Edition in English); *Acta praehistorica et archaeologica* 7/8 (1976–7), 15 ff.

devoid of metal finds in Mesopotamia. Yarim Tepe II, the Halaf period settlement, was far less productive in this respect than I.[39] Various copper implements and fragments at Arpachiyah were tentatively attributed to this period.[40] A fragment from Tell Shemshara proved on analysis to be a weathered piece of copper pyrite, with no trace of human working.[41] 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."[42] 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.[43]

Nor is the evidence for the subsequent 'Ubaid period much more revealing. There is some tendentious evidence for the first appearance of precious metal. At Tepe Gawra a few fluted, spherical gold beads were attributed to stratum XII, placed by some at the end of the northern 'Ubaid period, though it may be later.[44] Far away to the south at Ur a fragment of gold wire was reported from pit L at a level said to be part of the 'Ubaid horizon there.[45] Gawra XVII, of the later 'Ubaid, yielded a copper ring and a rectangular-sectional awl; level XIII a copper awl; level XII a hemispherical copper button and a flat copper blade with a splayed cutting edge.[46] Analysis of the latter indicated a relatively pure copper with only 0·05% arsenic. A copper blade from Arpachiyah falls late in the 'Ubaid;[47] at Nineveh a copper pin was attributed to " Nineveh 3 ".[48] In the south, at Ur, in a grave placed by Woolley in 'Ubaid III, was a solid, tanged spear point of very pure copper; but this object might belong to the Protoliterate horizon. It is evidence from Susa in Iran which indicates a more vigorous metal industry at this time than the Ur evidence allows.[49] It is not known if these objects are of melted native copper or of smelted ore, though the latter is likely; but casting is still only in simple open moulds and working methods are unadventurous.

The status of copper technology in southern Mesopotamia at this time is commonly 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.[50] No metal exemplar has yet been found and the hypothesis may be redundant. The much more common baked clay sickles of this and subsequent periods in the same area were definitely working tools. Their sizes, contexts and the condition of their working edges, make this clear.[51] With exactly the same criteria it may be shown that such was also the case with full-sized shaft-

[39] N. I. Merpert, *Sumer* 33 (1977), 95.

[40] M. E. L. Mallowan, *Iraq* 2 (1935), 104; cf. de Jesus, op. cit. in note 4, p. 207.

[41] C. S. Smith in P. Mortensen, *Tell Shimshara: The Hassuna Period* (Copenhagen, 1970), 123–4.

[42] M. E. L. Mallowan, *Iraq* 3 (1936), 26–7.

[43] H. Schmidt, *Tell Halaf* I (Berlin, 1943), Pl. CXIV 23–6.

[44] A. J. Tobler, *Tepe Gawra* II, 193; E. Ehrich (ed.), *COWA*, 145–6, 177.

[45] C. L. Woolley, *UE* IV, 185: U.16981; cf. K. R. Maxwell-Hyslop, *Iraq* 39 (1977), 83 ff. on Sumerian gold sources.

[46] A. J. Tobler, *Tepe Gawra* II, 213, Pl. XCVIIIa, 5–6.

[47] M. E. L. Mallowan, *Iraq* 2 (1935), 104, Pl. XI.

[48] M. E. L. Mallowan, *LAAA* 20 (1933), 145, Pl. LXVIII.5.

[49] C. L. Woolley, *UE* IV, 21, Pl. 30: U.14992; analysis: *UE* II, 291; for Elam, P. Amiet, *Antiquity* 53 (1979), 198.

[50] C. L. Woolley, *Antiquaries Journal* 10 (1930), 336; V. G. Childe, *New Light on the Most Ancient East* (4th. ed., 1952), 116.

[51] R. McAdams and H. J. Nissen, *The Uruk Countryside* (Chicago, 1972), 205 ff.

hole axes and hammers in baked clay,[52] though what they were used for is still an open question.[53] There certainly were such model tools; but they are clearly distinguished by size and condition. For instance, in grave 21 at Tell al-'Ubaid, a clay model of a flint hoe was found beside a real one.[54] The flared blades of baked clay shaft-hole axeheads may be explained by reference to stone tools, for there are pierced stone axeheads of this period with finely ground and flared cutting edges.[55] It may then not be assumed from the shaft-hole baked clay tools that bivalve casting of putative copper counterparts was practised at this time. It may have been; but more convincing evidence, of the kind now available from Iran, is still needed in Mesopotamia. It may be, as Deshayes argued,[56] that in this period Sumerian metalworking was as indebted to Iran for technical stimuli as for raw materials.

The earliest appearance of glazes and faience in Northern Mesopotamia during the 'Ubaid period indicates a knowledge of applied chemistry considerably greater than that reflected in the meagre record of metal artefacts just outlined.[57] The simple blue-green glazed steatite and faience beads of this period are almost certainly earlier than anything of the kind from Egypt.[58] The circumstances which gave rise to the invention of glazes and related artificial substances are inevitably matter for speculation rather than secure demonstration. Some scholars have seen them as a by-product of primitive copper smelting: an hypothesis given some substance by Perrot's observation that the clay on the insides of Chalcolithic furnaces at Abu Matar in Israel " had become glazed by the products of the combination of metal, silica and bases."[59] Others, Petrie among them, believed quartz pebbles glazed themselves when in contact with powdered malachite and wood ash in a fire or kiln. Lucas was sceptical of the smelting furnace association, favouring arguments along the lines Petrie suggested. He believed the answer lay with a simple process which recurred often enough for the glaze to be noticed and then reproduced as chance had revealed. For him it was pigment grinding which provided the clue; " Malachite, before being used as an eye-paint, was finely ground on hard stones, often quartz and quartzite, the grinding surface of which became coloured green in the process. In the presence of a little alkali, and if strongly heated, such grinding-stones would have become coated with a blue glaze ".[60] Be that as it may, the manipulation of materials and temperatures now evident in Mesopotamia strongly indicates that modern knowledge of the status of metallurgy by the end of the 'Ubaid period is severely compromised by the inadequacy of the surviving evidence.

Although at the outset of the Protoliterate (Uruk) period, in the later fifth or

[52] S. Lloyd, *JNES* 2 (1943), Pls. XVIb, XXIXa.

[53] Cf. BM 124492; 56–9–8, 137 from Ur; de Genouillac, *Fouilles de Telloh* I (Paris, 1934), Pl. 44.3; I am grateful to Dr. E. Sollberger for permission to study the British Museum examples.

[54] C. L. Woolley, *UE* I, Pl. XLVI: T.O.40.

[55] BM 56–9–8, 41 (from Ur; cf. A. J. Tobler, *Tepe Gaura* II, Pl. XCIVd, e: (Stratum XIA); for Khuzistan see the remarks of J. Deshayes, *Syria* 51 (1974), 262, n. 1.

[56] J. Deshayes, *Les Outils de Bronze de l'Indus au Danube* II (Paris, 1960), 408–9.

[57] Arpachiyah: M. E. L. Mallowan, *Iraq* 2 (1935), 38; A. J. Tobler, *Tepe Gawra* II, 187, 192, 193 (level XVI) = 248 (level XVII); J. F. S. Stone and L. C. Thomas, *Proc. Prehist. Soc.* 22 (1956), 37 ff.; the early glazes are part of the history of pigment processing and of evolving metallurgy.

[58] A. Lucas, *Ancient Egyptian Materials and Industries* (London, 1962), 464–5; a single bead of uncertain context at Tall-i-Muski in Fars, Iran, may indicate very early production there: S. Fukai *et al.*, *Marv-Dasht* III (Tokyo, 1973), 65 (English), colour plate, Pl. LV.35.

[59] *Israel Exploration Journal* 5 (1955), 79.

[60] A. Lucas, op. cit., 172.

early fourth millennium B.C., the metalsmiths' repertory in Mesopotamia appears to extend little beyond simple personal ornaments, such as pins, rings and beads, flat tools like awls, adzes or chisels, and metal stamp seals, by the end the range of techniques and artefacts is considerable. 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. Gold, silver and lead were used as appropriate, often with skill. 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. Local development is arguable in this case. Modelling in clay, both of animal and human figurines, had long been an established craft tradition, perhaps among potters; they had been painted and baked. The role of the bee, and of wax collection in prehistoric Mesopotamia, may only be extrapolated backwards from later sources; but there is no obvious reason to doubt that wax was available, at least as an import, if not locally produced. At a time when communities were still small enough to throw potters, metalsmiths and peasant bee-keepers into close contact the fusion of materials and skills required to develop this very ingenious technique, which was to be carried to a very high level of skill by the first half of the third millennium B.C. in Mesopotamia, is not so surprising as it might be in later conditions, when specialist master craftsmen were further removed from the daily routine of agricultural life.[61]

Artefactual evidence for this period has a strong bias at present towards luxury objects. The shrines explored at Uruk and the rich tombs at Gawra, the two key sites, present a weighted sample. The Uruk " Sammelfund ", buried in the Jamdat Nasr period, but largely consisting of heirlooms in the style of the Uruk period, contained sheet gold for overlays and what may be a gold spout.[62] Silver was used in the making of a spouted jar and to provide horns and other details for composite animal statuettes.[63] A particularly delicate usage may be seen in the stamen of a carnelian flower.[64] But its most significant role was in the casting, by the lost-wax process, of small recumbent calves set on pins of copper dowelled into two lapis-lazuli cylinder seals.[65] Since they are relatively compact figures more skill was demanded in the production of a free-standing lion ($4{\cdot}7 \times 3{\cdot}4 \times 1{\cdot}1$ cm), of copper with 9% lead.[66] This high lead percentage indicates that craftsmen were already aware that its presence facilitated casting. In another, later context (Eanna III), a comparable tiny statuette of a goat was made of sheet gold over a bitumen core. Here also were more traces of composite animal statuettes with hind legs of gold, silver and copper, carefully modelled and apparently also lost-wax castings.[67] Among the many small finds from the *Riemchen* Building, in the western corner of the Eanna sanctuary, built soon after the destruction of the " Stone-cone Temple " in

[61] The possibility of some kind of " lost bitumen " technique was suggested long ago in an Elamite context (de Mecquenem, *Mémoires de la Délégation en Perse* VII (1905), pp. 126–7), and deserves further research; for the moment I have retained the traditional explanation. Nor has the use of a " lost-lead " process in Mesopotamia ever been investigated.

[62] E. Heinrich, *Kleinfunde*, Pl. 30d, cf. 35d; on the dating, B. Goff, *Symbols of Prehistoric Mesopotamia* (New Haven, 1963), 265 ff.

[63] E. Heinrich, op. cit., 40, Pl. 29.

[64] Ibid., 41, Pl. 30c.

[65] Ibid., 28–9, Pl. 17a–b.

[66] Ibid., 25, 47, Pl. 13a.

[67] *UVB* VIII (1937), 13, 231, Pl. 23q–s, 24b.

Uruk IVA, were various copper animal horns and a silver " harpoon head ".[68]

The Uruk excavation reports rarely detail 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.[69] Worked copper was also noted in levels of Eanna XI.[70] Among objects of copper, and pieces of sheet gold in levels " D " and " E " of the Anu ziggurat, was a fragment of iron.[71] No details are given of a spear point analysed as: Cu: 99·13%; Fe: 0·27%; Ni: 0·14%; As: 0·17%; Zn: trace.[72] 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.[73]

Excavations in levels of the second half of the fourth millennium B.C. at Tepe Gawra in the north do not substantially alter the picture offered by Uruk. It is only with Stratum VIII, at the outset of the third millennium B.C., that an appreciable rise was observed in the number of copper objects retrieved. Thereafter they increased markedly with 22 copper specimens in VIII, 42 in VII and 334 in VI, towards the end of the third millennium B.C.[74] An adze-blade from XI was primarily copper with 1·63% arsenic and 3·34% nickel, an arsenical copper typical of this phase over much of the Near East. The exact method by which arsenical coppers were made is still debated; but they are unlikely to have been alloys in the exact sense, save in very exceptional cases where native arsenic was accessible.[75] By this time the smiths clearly had considerable knowledge of the results produced by a manipulation of various ores, selected by colour and sometimes by form, to improve the hardness of tools and weapons. So far there is no clear evidence in Mesopotamia, as there is slightly later from Egypt, Anatolia and Iran, for the use of arsenic compounds to give objects a surface colour like silver. At Gawra the repertory in base metals was standard and simple, save for a cast copper object which, to judge from bone parallels, may be a kohl tube. It looks like the " mouthpiece of a musical instrument " with ribbed sides and was in an Uruk period archaeological context.[76] A pin from level VIII, usually dated to the early third millennium B.C., contained 5·62% tin: arguably the earliest tin bronze yet reported from Mesopotamia.[77]

The use of precious metal, if relatively restricted, was inventive and skilful. Gold was used for sheet metal ornaments and cast beads, sometimes as part of composite animal or insect-shaped personal ornaments. Electrum beads from Stratum X were analysed as: 0·56% Cu; 61·39% Ag and 38·05 Au.[78] The most outstanding object was a tiny electrum wolf's head (30 × 23 mm), from tomb 114 attributed

[68] *UVB* XIV (1958), 9, Pl. 17, 18b.
[69] *UVB* IX (1938), 25; cf. *UVB* XV (1959), 10.
[70] *UVB* III (1932), 30.
[71] *UVB* VIII (1937), 53.
[72] E. Heinrich, *Kleinfunde*, 47.
[73] R. McC. Adams and H. J. Nissen, *The Uruk Countryside*, 205–6 .
[74] E. Speiser, *Tepe Gawra*, I, 103.
[75] I. R. Selimchanov, *Germania* 55 (1977), 1 ff.; E. R. Eaton and H. McKerrell, *World Archaeology* 8 (1976), 169 ff.: the general conclusions are sound in respect of the restricted sample, but details are arguable and the philology is largely unacceptable; H. McKerrell, *Pact* 1 (1977), 138 ff.; also in A. D. Franklin (ed.) *The Search for Ancient Tin* (Smithsonian Institute, Washington, 1978), 7 ff.
[76] A. J. Tobler, *Tepe Gawra* II, 213, Pl. CLXXXII. 2.
[77] E. A. Speiser, *Tepe Gawra* I, 102.
[78] A. J. Tobler, *Tepe Gawra* II, 88, n. 30.

to Stratum X, which seems to have been a wand or sceptre head. " The neck is hollow and tubular, forming a socket which has two holes through its walls . . . for insertion of tracks and dowels . . . 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 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 . . . The eye sockets contain bitumen . . . teeth . . . of electrum wire . . . inside the head was filled with bitumen ".[79]

For some guide to the routine production of the later Protoliterate (Jamdat Nasr) period recourse must be made to Ur. There the evidence comes from a number of graves and levels of occupational debris in Pit W.[80] Woolley divided the graves into three groups, early (A), middle (B) and late (C). Of the 54 graves assigned to " A ", 15 contained metalwork: of lead, 11 tumblers and 1 dish; of copper, 5 bowls, 1 vessel and 1 ladle. Of the 130 graves attributed to " B ", 26 contained metal objects: of lead, 13 tumblers; of copper, 14 bowls; 5 pins, 1 razor, 1 fish-hook, 1 harpoon. Of 148 graves classified in " C ", 22 contained metal artefacts: of lead, 12 tumblers and 1 bowl; of copper, 3 pins, 1 chisel (?), 5 bowls and 1 tumbler, 1 needle, 1 ladle and 1 mirror; of silver, 2 pairs of earrings.[81] The predominance of metal vessels in these graves is striking, notably those of lead, which is unusually common at this time.[82] Analysis revealed a relatively pure lead (100 grams gave 0·0255 grams silver). 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.[83] Predictably it is tools which predominate in the occupational debris: fishhooks, projectile points and spatulae; no vessels were reported there.[84] Such a pattern is evident elsewhere in this and the subsequent period. Techniques remain simple; arsenical coppers are current, but still, surprisingly, there is no published artefactual evidence for bivalve casting. Vessels were hammered, usually in one piece, though Woolley observed that lead vessels varied: " the base of the tumblers was sometimes soldered or sweated on, and in one instance at least was slotted into the walls ".[85] Metalwork from Jamdat Nasr itself was meagre, adding nothing to the evidence of Ur.[86]

The excavations of de 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 has provided a critical review of this material, which sifts it into groups.[87] Apart from a few gold beads, the finds are predominantly copper pins, mirrors and

[79] A. J. Tobler, *Tepe Gawra* II, 92, Pl. LIXb = CVIII, Fig. 65.

[80] The dating of these graves is controversial, some scholars dating the later ones into the Early Dynastic period; for an assessment of the sequence see: G. Korbel and H. Youzan, *Baghdader Mitteilungen* 10 (1979), 9 ff.

[81] *UE* IV, 104 ff.

[82] Cf. the earliest graves at Khafajah: P. Delougaz *Private Houses* . . ., 58 ff.

[83] C. H. Desch in *UE* IV, 165.

[84] C. L. Woolley, *UE* IV, nos. U.14439–40; 14447; 14460a; 14461a; 14497–9; 14922–4; 14952; 14969; 14980; see also U.18570 from pit " W ".

[85] *UE* IV, 30–1, Fig. 6: U.18556.

[86] E. Mackay, *Report on Excavations at Jemdet Nasr, Iraq* (Chicago, 1931), passim; for analyses: P. R. S. Moorey and F. Schweizer, *Archaeometry* 14 (1972), 180.

[87] de Genouillac, *Fouilles de Telloh* I (Paris, 1934), 44 f.; B. Buchanan, *JAOS* 87 (1967), 535 ff.

sheet metal vessels, some spouted;[88] but a pin topped by a pair of nude female "dancers" is an important early example of lost-wax casting.[89]

Before moving into the Early Dynastic period, after about 3000 B.C., a fine pair of statuettes representing men wearing moufflon horns must be considered, since in the prestigious *Propyläen* series they are still attributed to the Jamdat Nasr period[90] without qualification. They both appeared on the Baghdad antiquities market about 1952, said to have come from Telloh. One went to the Guennol collection; its virtual twin to the Albright-Knox Gallery in Buffalo.[91] The early dating must be regarded with the same caution as has always been given to the reported source. Both figures stand about 17·5 cm high, but are not exactly alike in details. Both are of cast copper, not of tin bronze. No cogent argument against their authenticity has been advanced; but they stand in such marked contrast to present knowledge of late prehistoric metallurgy in Sumer that another source and date is preferable. In so far as iconographic parallels may be adduced they are West Iranian.[92] There nature demons, half-man, half-beast, and boots with upturned toes, have a long history. If such arguments are treacherous chronological guides, so too is the use of cast copper. It is not an argument for an early date (see p. 34). For the present a dating in the later third millennium B.C., or thereafter, and a source in Western Persia, seems a more reasonable one. Whatever the case, these two statuettes must not influence the history of early Sumerian metalworking in the later fourth millennium B.C., until their date and source may be more certainly established.

It was during the Protoliterate period that the use of faience was significantly extended in the South to the production of small vessels. A jar with impressed ornament on the shoulder was found at Ur in stratum H of pit F.[93] Slightly lower in the same sounding were "fragments of a small vase of white frit covered with a pale turquoise glaze".[94] Contemporary vessels were found at Khafajah.[95] Scattered information from Telloh extends the evidence for simple vessel production in faience by the end of the fourth millennium B.C. The shapes are those used in contemporary potting and the glazes are simple blues and greens, where preserved,[96] coloured by the addition of traces of copper compounds during fusion. A very distinctive series of tall, slender cylinder seals in the "Piedmont Jamdat Nasr" style are of glazed steatite. Although particularly common in the Diyala Valley, they are known from as far afield as Nineveh, Fara, Telloh and especially Susa. A series of generally shorter contemporary cylinders, current also at sites like Ur and Kish, are of faience with glazes varying from pea-green to blue when well preserved.[97] It was not until the second half of the second millennium B.C. that cylinder seals would again be of

[88] de Genouillac, *Fouilles de Telloh* I, 50: two analyses.

[89] Ibid., 46, Pl. 10.2–5, grave XXV.

[90] M. J. Mellink and J. Filip, *Frühen Stufen der Kunst* (Berlin, 1974), Pl. XII, 163.

[91] E. C. Schenk, *Gallery Notes, Albright Art Gallery, Buffalo, New York* 17 (1953), 2 ff.; I. E. Rubin (ed.), *The Guennol Collection* I (Metropolitan Museum, New York, 1975), 33–7, with bibliography.

[92] Cf. R. D. Barnett, *Syria* 43 (1966), 265 ff.; W. Nagel, *Berl. Jb. Vorg.* 8 (1968), 116.

[93] C. L. Woolley, *UE* IV, 30, 63: *U.*14422, Fig. 9d.

[94] Ibid., 66, U.14908, Pl. 26g.

[95] P. Delougaz and S. Lloyd, *Pre-Sargonid Temples in the Diyala Region* (Chicago, 1942), 137, 142.

[96] de Genouillac, *Fouilles de Telloh* I, 36–7, 61.

[97] H. Frankfort, *Cylinder Seals* (London, 1939), 35; *Stratified Cylinder Seals from the Diyala Region* (Chicago, 1955), Pl. 11–15; Protoliterate "d"; B. Buchanan, *Catalogue of Ancient Near Eastern Seals in the Ashmolean Museum I: Cylinder Seals* (Oxford, 1966), 15–6; for analyses see P. R. S. Moorey, *Excavations at Kish 1923–33* (Oxford, 1978), microfiches, Appendix.

artificial materials in Mesopotamia, indicating the singularity of this extension of the faience industry late in the prehistoric period.

*(b) The Early Historic Period*

Consideration of Mesopotamian metallurgy in the earlier part of the third millennium B.C. will throw into greater isolation the two " Telloh " statuettes just considered. Now for the first time, in the archaic texts from Ur, there is mention of *zabar* (bronze) distinguished from copper (*urudu*), although analytical evidence of tin-copper alloys in Sumer is not available until Early Dynastic III. Although arsenical coppers were then slowly superseded, copper was long to remain the staple metal in Mesopotamia. Supplies of tin, from unknown sources to the east or north-east, were always unpredictable and its use in tools and weapons by no means constant whether for social or economic reasons.[98] To take but one example, it is hard to assess at present how indicative of fluctuating metal supplies archaeological variations really are when the evidence is exclusively mortuary. Sheetmetal axe-heads, once taken at Ur to be symptomatic of a tin famine in the Sargonid period, were already placed in graves in the Early Dynastic III period at a time when cast axeheads were similarly deposited. More subtle socio-economic factors may be at work. In the Sargonid period at Ur " gold " beads are no longer always solid, often they are of sheet gold over a copper or faience core, gold earrings are smaller and tiny gold beads and pendants became popular, with a rise in the occurrence of silver. This may reveal more about the declining social status of those buried in the tombs at Ur and the city's new political role, than it does about the general availability of gold in Mesopotamia at this time. Only when justified by as closely integrated, and as broad a range, of archaeological and textual evidence as possible may a decline or interruption of metal supply be postulated.

In the south the cemetery at 'Ubaid, despite its uneven state of preservation, covers the Early Dynastic I phase otherwise obscure in Sumer. A few of the graves there are late prehistoric and others, among them two with shaft-hole copper axe-heads, are of Early Dynastic II–III.[99] Out of the 94 recorded graves H. T. Wright believed " a majority . . . are of the earlier phase of the Early Dynastic period. In these graves the dominance of wide conical cups and the apparent scarcity of reserve slip and punctuate jar shoulders suggest a date late in the earlier phase . . .".[100] The metal tally contrasts with the "Jamdat Nasr graves " at Ur. There are no lead vessels; only 8 graves had copper vessels,[101] 2 copper daggers or knives,[102] 4 copper pins or kohl sticks,[103] 1 a copper harpoon head,[104] and 4 twisted copper wire

[98] E. T. Burrows, *UET* I, 11; P. R. S. Moorey and F. Schweizer, *Archaeometry* 14 (1972), 185 ff. for analyses; see note 77 on Gawra; the extent to which Mesopotamia used tin is a complex question for which far more analyses of both textual and artefactual evidence are needed before conclusions like those in H. McKerrell in A. D. Franklin (ed.), *The Search for Ancient Tin* (Smithsonian Institute, Washington, 1978), 7 ff. may be accepted as proven.

[99] H. R. Hall and C. L. Woolley, *UE* I, graves C.52, C.83.

[100] *The Administration of Rural Production in an Early Mesopotamian Town* (Ann Arbor, 1969), 77.

[101] *UE* I, graves C.11, 27, 37, 46, 63, 76, 77, 92.

[102] *UE* I, graves C.28, 91.

[103] *UE* I, graves C.3, 27, 65, 73.

[104] *UE* I, grave C.77.

earrings.[105] A copper flat axe, an adze blade and a fishhook loose in the soil do little to alter the overall sample.[106]

In central Iraq the earlier phases of the Early Dynastic period are covered by the ill-excavated, poorly recorded graves of the " Y " sounding on Tell Ingharra at Kish.[107] They are, for these reasons, best seen 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 5 yielded metal: simple sheet copper vessels and pins as well as 2 lead vessels and a lead ornament.[108] Of about 30 graves attributed to Early Dynastic I only 3 yielded metal: 2 copper mirrors and a pin.[109] Slightly over 30 graves were allocated to Early Dynastic II, 13 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 welded.[110] Silver appears once as a headband. It is only with Early Dynastic III that quantity markedly increases and the repertory in graves extends to include tools and weapons. But here the arbitrary witness of the archaeological record is all too clear when attention is switched, as in a moment it will be, from private graves to temple furnishings. 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 (Plate I*a*), are more elaborate than those in graves at Khafajah.[111] It is the cart burials at Kish, perhaps slightly earlier than the " royal " graves at Ur, though found devoid of precious metal, that indicate the wider range of metalwork available to those of wealth and social standing: tools (saws, goads and awls), weapons (fine daggers and shaft-hole axeheads), still of copper or arsenical copper, and finely cast zoomorphic rein-rings (not yet analysed). Among the unpublished Early Dynastic III graves at Tell 'Uqair was at least one containing a pair of copper sandals: [112] a rare item in the metal repertory. It has been argued recently that the analyses of copper tools and weapons from a group of Early Dynastic I graves found by the French Expedition at Kheit Qasim in the Hamrin region indicate that they were made with native copper from Talmessi on the Iranian plateau, as were objects analysed from Susa.[113]

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 S.I.S. 4–5 were found four hooves of oxen,[114] 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,

[105] *UE* I, graves C.3, 4, 59, 73.

[106] *UE* I, Pl. XLVI. 2.

[107] P. R. S. Moorey, *Iraq* 28 (1966), 38 ff.; in detail: *Excavations at Kish, 1923–33* (Oxford, 1978), catalogue on microfiches.

[108] P. Delougaz, *Private Houses* . . ., 59 ff.; graves 1, 4, 5, 8, 18.

[109] Ibid., graves 66, 67 and 83.

[110] Ibid., graves 86, 87, 89, 91, 92, 94, 97, 108, 109, 110, 113, 114, 119A.

[111] L. Ch. Watelin, *Excavations at Kish* IV, 1.XX 1–2; for Kish analyses: P. R. S. Moorey and F. Schweizer, *Archaeometry* 14 (1972) 180 ff.; the stands have not been analysed.

[112] Baghdad, National Museum of Antiquities, public display, 1977.

[113] Th. Berthoud, *Lettre d'Information Européenne, Archéologie Orientale* I (May, 1980) 14; see p. 38 here.

[114] C. L. Woolley, *UE* IV, 38, Pl. 29.77.

certainly indicates an Early Dynastic I–II dating; but Frankfort did not accept it.[115] 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 III in the Temple Oval at Khafajah; but Frankfort suggested they might have been made earlier.[116] In the Shara Temple at Tell Agrab, in an Early Dynastic II context, was a badly corroded anthropomorphic stand, just like those from Khafajah.[117] Here also were three solid cast copper statuettes, two male, one female, of worshippers; [118] technically more outstanding is the three-dimensional cast copper model of a one-man chariot, drawn by four equids.[119] 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.[120] 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.[121]

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. The legs are more intricate pieces of hammered sheet copper, again over cores. Detail was worked on the surface with metal tracers. Some heads were of hammered copper, some of cast. The few cast heads which have been properly examined are said to show traces of the multiple piece-moulds in which they were cast after an original wax model. " On some of them, between the horns, down the front of the head, and under the lower jaw there remain traces of casting webs ".[122] A small copper bull's head, from the Sin Temple at Khafajah, " was certainly cast *à perdue*; the horns and most of the muzzle were solid ".[123] In some cases the horns were made separately and fitted on; [124] the joints between the main antlers and the tines on the stag's head from Tell al-'Ubaid were soft

[115] *Archaeology and the Sumerian Problem* (1932), 16, note.

[116] H. Frankfort, *Sculpture of the Third Millennium B.C.* ... (Chicago, 1939), 38 ff., Pl. 98–103.

[117] Ibid., 11, Pl. 55.

[118] Ibid., 11–12, Pl. 56.

[119] Ibid., 12–13, Pl. 58.

[120] Ibid., 12, Pl. 54.

[121] H. Frankfort, *More Sculpture* ... (Chicago, 1943), 11, Pl. 61, 311–12; Baghdad, National Museum of Antiquities, public display, 1977.

[122] H. R. Hall and C. L. Woolley, *UE* I, passim; on technique H. Maryon *AJA* 53 (1949), 99; and in C. Singer, *A History of Technology* I (Oxford, 1954), 626.

[123] H. Frankfort, *Sculpture of the Third Millennium B.C.* ..., 42, Pl. 104.

[124] Berlin VA 3142: A. Moortgat, *The Art of Ancient Mesopotamia* (London, 1969), Pl. 53 (22·9 cm H); Telloh: de Sarzec, *Découvertes en Chaldée* (Paris, 1884–1912) Pl. 5 ter: 2a, b (*c.* 18·75 cm H; now in the Louvre); City Art Museum, St. Louis, A. Parrot, *Sumer* (London, 1960), 186 (22·5 cm H); cf. from Bahrein, P. V. Glob, *Kuml* (1955), 191, Fig. 1; other animal heads: H. V. Hilprecht, *Explorations in Bible Lands* (Edinburgh, 1903), 539, Fig. on 540; H. Frankfort, *Art and Architecture of the Ancient Orient*, 29B (incorrectly as Nippur),.

soldered. This is the oldest published example of this technique.[125] Hard soldering (or brazing) with a low melting point silver-copper-tin alloy has been observed on an Early Dynastic III bronze axehead from Ur.[126] Smaller animal heads in gold found at Ur were made from thin sheets of the metal, probably hammered into a bowl shape first and then finished with hammer and chasing tools. The difference of technique is reflected in the difference of style, as Woolley noted in recognizing the hammered gold ones as being generally more conventional than those cast in silver or copper, where the freedom of modelling in wax was more apparent.

For obvious, if nonetheless regrettable, reasons more detailed information is often available on fine or unusual metal objects without archaeological context than on their excavated relatives. Such objects must be cited with circumspection in surveys of this kind, but to ignore them arbitrarily conceals the range of the evidence. The Metropolitan Museum, New York, has a vessel-stand of Early Dynastic III type, made up of three separate units: a foot comparable to those on the Kish and Diyala stands previously mentioned; a central standing animal; and an upper bracket set on its back (Plate I*b*). The animal is of arsenical copper (Cu: 94·0%; As: 2·6%; Zn: 0·9%; Sn: 0·2%; Pb: 0·3%) 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 a core. The solid animal head was cast separately and fitted by a " tongue in groove " device to the neck, which is tapered and reached 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 pouring 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.[127]

The base metal equivalents of the well-known Early Dynastic II/III votive stone human statuettes have also still to be studied primarily through a few examples from unknown sources. Three are particularly important examples of this aspect of the sculptor's art in metal; all are lost-wax castings. The Louvre has a " bronze " bearded male figure in a kilt standing on a small base plate; in the Metropolitan Museum, New York, is a copper statuette of a man wearing only a girdle, who carries on his head a box or pile of bricks; and the Schimmel collection contains a copper male worshipper, best paralleled by a stone statue from Mari, set on an openwork base, inscribed by a scribe with a dedication to the goddess Ninegal.[128] Closely related to these figures is a whole group of cast copper foundation figurines, plain,

[125] H. Maryon, *AJA* 53 (1949), 114.

[126] P. M. Roberts, *Welding and Metal Fabrication* 42 (1974), 415–6, Fig. 12–13 (BM 121574); also a hard solder for soldering gold lugs to a silver bowl: J. Lang in W. A. Oddy (ed.), *Aspects of Early Metallurgy* (British Museum, 1977), 169.

[127] 1974. 190; about 40 cm high; *The Metropolitan Museum of Art: Notable Acquisitions, 1965–75* (New York, 1975), Fig. on p. 40. The technical report was prepared by Lynda Aussenberg and Pieter Meyers for Dr. Vaughn Crawford; I am much indebted to them for permission to cite it here.

[128] Louvre: G. Contenau, *Mon.Piot.* 37 (1940), 37 ff., Pl. IV; *Manuel* IV, 2031, Fig. 1124: AO 19523; Metropolitan: V. E. Crawford, *BMMFA* April, 1960, 246 ff., Fig. 6; Schimmel: O. Muscarella (ed.), *Ancient Art: The Norbert Schimmel Collection* (Mainz, 1974), no. 106.

anthropomorphic and zoomorphic, many of known source and date.[129] One text of this period relevant to the history of metal statuary speaks of a silver statue of the deity Šag-šag 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.[130] 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.

In the interests of brevity the full range of metallurgical techniques evidenced for Early Dynastic IIIA by the outstanding finds in the " Royal Cemetery " at Ur cannot be detailed here. Indeed it would be superfluous, since they are fully described in the excavation report and a number of easily accessible subsequent studies.[131] It need only be said that the range of metals (gold, silver, electrum, copper, tin-bronze and lead) not to mention the quality, the variety of techniques, and the standards of craftsmanship provide a constant reminder of how inadequate our conclusions are likely to be when drawn from the exiguous range of metalwork usually available for study from most excavations and the persisting absence of evidence for workshops and industrial debris in this period. This crucial point is constantly emphasized in subsequent periods by accumulating textual references to large quantities of metals, and very varied repertories of metal objects, otherwise wholly unattested. It is clear that by the middle of the third millennium B.C., if not substantially earlier, Sumerian craftsmen in major urban centres were masters of all the basic techniques of casting and working precious and base metals. Nor would it seem, to judge from the large-scale fragments found at Khafajah and Tell Agrab, that they were daunted by scale. The only other technique, a decorative one, not appropriately represented at Ur, is the art of the engraver on metal. The surviving Sumerian masterpiece of this craft is the silver vase inscribed for Entemena, on a copper base, found in tell " K " at Telloh and now in the Louvre.[132]

The precocious appearance of iron in Mesopotamia has not yet been fully considered. Some of the fragments of iron in early contexts have in the past been too easily dismissed as intruders from later levels. This need not be so. The context of each find has to be individually assessed. Such small pieces of terrestrial iron might result from copper smelting where iron fluxes have been used, leaving ductile iron in the bottom of the furnace, as perhaps at Samarra.[133] Worked meteoric iron, with its distinctively high percentage of nickel (about 10%), has always been accepted in early contexts when identified by metallurgists, as in grave PG/580 of the " Royal Cemetery " at Ur, and reportedly at Tell al-'Ubaid, also in an Early

[129] R. Ellis, *Foundation Deposits in Ancient Mesopotamia* (Yale, 1968), 46 ff.; an Ur-Nanshe example in the British Museum (116685) is cast copper.

[130] Berlin VAT 4853: A. Spycket, *Les statues de culte dans les textes mésopotamiens* ... (Paris, 1968), 34–5.

[131] C. L. Woolley, *UE* II, chp. XIV; H. Maryon, *AJA* 53 (1949), 93 ff.; P. M. Roberts, *Gold Bulletin*, 6 (4), Oct. 1973, 112 ff.; K. R. Maxwell-Hyslop, *Western Asiatic Jewellery c. 3000–612 B.C.* (London, 1971), 1 ff.

[132] de Sarzec, *Découvertes en Chaldée* I (Paris, 1884–1912), 261–4, Pl. 43, 43b.

[133] R. F. Tylecote, *A History of Metallurgy* (London, 1976), 2–3, 40. Now fully discussed by Jane C. Waldbaum in T. A. Wertime and J. D. Muhly (ed.), *The Coming of the Age of Iron* (Yale, 1980), 69 ff.; for Samarra see E. Herzfeld, *Die Ausgrabungen von Samarra* II (Berlin, 1930), 5, Fig. f, Pl. 47.

Dynastic context.[134] Terrestrial iron has been identified by metallurgists in third millennium samples from Chagar Bazar and as the blade of a knife or dagger with a bronze hilt, from Tell Asmar late in Early Dynastic III.[135] Other reported occurrences have not been metallurgically studied: an iron find in levels " D " and " E " of the Anu ziggurat at Uruk in the fourth millennium has been noted already (p. 22); pieces of iron from palace " A " at Kish (Ingharra) [136] and lumps of iron from courtyards in the so-called " Northern Palace " at Tell Asmar in the mid- to later third millennium B.C.[137] The iron finds cited in some books from pre-Sargonid levels at Mari appear to be those from the Ishtar Temple dated much later in the final report.[138] The first textual references to iron, despite problems in translating metal terminology, are sufficient to sustain the evidence provided by these isolated surviving fragments.[139]

Simple beads, amulets, globular pinheads and " handles " were made of green, blue, and occasionally black (manganese), glazed faience during the Early Dynastic period and have been found throughout the area, although the industry may have been most active in the north. Vessels remain extremely rare. None was reported from the " Royal Cemetery " at Ur, but there was a miniature bowl from an Early Dynastic II context at Khafajah and others from Tell Agrab, as well as a " mace-head " from Tell Chuera.[140] An outstanding find is the green glazed spouted bowl, decorated with a bearded bull *couchant* in low relief, found in grave 317 on Tell Ingharra (Kish), of the late Early Dynastic or early Akkadian period.[141] It is in this chronological horizon that the earliest well documented examples of the material known as " Egyptian blue " (Woolley's " glass paste ") occurred at Ur [142] in the form of beads. This substance is a blend of silica, natron (sodium carbonate), copper carbonate and lime akin to frit, in which the percentage of lime is the distinguishing feature.[143] Its appearance at a time when the earliest production of objects in glass may also be attested (see p. 35) is not likely to be mere coincidence. As metalsmiths experimented with alloys, and more varied ore sources were exploited, pyro-technology in general benefited from the stimulus of new techniques. Whether the stimulus for its production came from Egypt through Syria is an important, open question.

The role of metals and metallurgy within early Sumerian society has yet to be

[134] C. L. Woolley, *UE* II, 49, 433 (U.9139); the reference to the fragment from 'Ubaid on p. 293 is not clear and might be a confusion with the PG/580 piece, as it is not mentioned in *UE* I; J. K. Bjorkman, *Meteors and Meteorites in the Ancient Near East* (Arizona State University, 1973).

[135] M. E. L. Mallowan, *Iraq* 3 (1936), 26; *Iraq* 4 (1937), 98; H. Frankfort, *OIC* 17 (1933), 56, 61–2; *Man* (1950), no. 160.

[136] E. Mackay, *A Sumerian Palace* ... (AM I.2, Chicago, 1929), 123–4; an iron ring was reported from a grave in the slightly later cemetery A, but not kept by the excavators.

[137] P. Delougaz, *Private Houses* ..., 198, 244.

[138] A. Parrot, *Le Temple d'Ishtar* (Paris, 1956), 180–1; see the earlier oblique reference, *Afo* 12 (1937–9), 151–2.

[139] H. Limet, *Le Travail du Métal*, 29 with comments of E. Sollberger, *AfO* 20 (1963), 175 ff.; B. Landsberger, *JNES* 24 (1965), 290–1, n. 25.

[140] P. Delougaz, *Private Houses* ..., 28; P. Delougaz and S. Lloyd, *Pre-Sargonid Temples* ..., 268, 281; A. Moortgat, *Tell Chuera in Nordost Syrien* ... *1964* (Berlin, 1967), 34–5, Pl. 23.

[141] L. Ch. Watelin, *Excavations at Kish* IV (Paris, 1934), Pl. XXXI. 7; P. R. S. Moorey, *Iraq* 32 (1970), 127–8, in Baghdad.

[142] C. L. Woolley, *UE* II (London, 1934), U.13531, 13598, from graves PG/1517, 1601; for the cosmetic pigments in use at Ur see M. Bimson, *Iraq* 42 (1980), 75 ff.

[143] A. P. Laurie *et al.*, *Proc. Royal Society* 89 (1914), 418–29; A. Lucas, op. cit., 340 ff.

fully explored through the textual sources,[144] so it is not yet possible to correlate the information they yield in any meaningful way with the archaeological data assembled here. What confidence may be placed in certain recurrent generalizations about the significance of bronze and innovative weapon technology among the factors involved in the emergence of a complex society in Sumer is by no means yet clear. In this connection emphasis has recently been placed upon the conflict of city-states in the early Dynastic period: " Warfare leads to the intensification of weapon production and to its technological development—instrumental, perhaps, in the very evolution of bronze technology (bronze is harder and clearly superior to copper as a material for weapons). The growth of weapon production implies a further division of labour entailing a double demand for increasing subsistence goods; to support specialized labour power, and to increase exports to obtain copper and tin ".[145] The same authors speak of " early and explosive development of bronze, advanced weaponry . . .".[146] Allowing for the fact that undue emphasis may have been placed on a contrast in war intensity between the fourth and earlier third millennia B.C., there is no metallurgical force in the argument that tin-bronzes are necessarily superior to arsenical coppers, which, on the present meagre body of analytical data, appear to have been the predominant " alloy " in the third millennium B.C. in Sumer, as elsewhere. The rest of the argument is plausible enough in general to merit closer examination in this particular case.

Adams has offered some preliminary comments on the place of metals as a guide to the growth of wealth and social differentiation in graves of the Early Dynastic period.[147] The later fourth and early third millennia B.C. provide a range of archaeological and textual indicators of the emergence of a social status, wealth differentiated society of complex structure in which full-time specialists manufactured metalwork under close controls, whether of temple, palace, or possibly kin and family groups. Although an emerging range of developed craft techniques in metal accompanied these socio-political changes, there are no grounds for believing that innovative metal technology had any seminal role in them. Rather they created the patronage and industrial structure under which such skills evolved and flourished. Precious metals do not feature conspicuously in the early economic and administrative texts so far available, though new information from Ebla indicates how large the concentrations of gold and silver might be at places like Mari, under both palace and community control, and how considerable was the level of craft activity in such metals in the court workshops at Ebla in the third quarter of the third millennium B.C.[148] This had previously been inferred largely from finds in the few " royal " graves of the Early Dynastic IIIA period at Ur. But if in any archaeological context the relative value, both in economic and social terms, of precious metals is

[144] In general see M. Lambert, *Sumer* 9 (1952), 198 ff.; *Sumer* 10 (1954), 150 ff.; S. N. Kramer, *The Sumerians* (Chicago, 1963), 73 ff.; A. I. Tyumenev, *Ancient Mesopotamia* (ed. I. M. Diakonoff; Moscow, 1969), 70 ff. (in English).

[145] K. Ekholm and J. Friedman, in M. T. Larsen (ed.), *Power and Propaganda* (*Mesopotamia* 7, Copenhagen, 1979), 47.

[146] Ibid., 47; see references in note 75 here on arsenical coppers.

[147] R. McC. Adams. *The Evolution of Urban Society* (Chicago, 1966), 98 ff.

[148] P. Matthiae, *Ebla: an Empire Rediscovered* (London, 1980), 172–3, 181–2.

to a degree self-evident, the same may not be said of copper and its alloys. Although copper was the most common metal—the basic register of exchange values until the Akkadian period—it was still so highly valued in Sumer, into which it had to be imported, as to be subject to rigorous bureaucratic control, constant recycling, and use only for essential artefacts.

Agricultural tools, notably sickles,[149] are always a crude guide to the availability of copper within Mesopotamia. Until at least the Akkadian period sickles with a flint edge were still the predominant type.[150] When the available archaeological evidence is almost exclusively from shrines or graves it is more than unusually dangerous to press a negative about tools, but the extreme rarity of metal picks, hoes, spades, ploughshares etc. in the period covered here serves at least as a reminder of the still restricted use and accessibility of base metals in the region. Where baked clay, ground stone, chipped flint, bone or wood sufficed for agricultural tools, then they continued in use, as in the prehistoric craft traditions. This qualification serves, moreover, to highlight clearly the place of tin-bronzes in the middle and later third millennium B.C. in Mesopotamia. Once it is appreciated that unalloyed copper (including arsenical copper) was itself in restricted supply, then the probable rarity of tin-bronzes is the more easily understood. Their presence in any particular context may be as significant a mark of wealth and status, relatively speaking, as the conventionally precious metals. That there was a major tin-bronze industry in Sumer before the Ur III period remains a very open question.

To what extent metal objects, particularly weapons, may be seen as defining special status or function, even in copper or arsenical copper, is less easily resolved and requires more detailed study in a wider range of mortuary contexts than are presently available.[151] The contrast between say the "Jamdat Nasr graves" at Ur and the Early Dynastic III cemetery "A" at Kish in terms of metal deposited is very marked; but what does it signify? Is it symptomatic of a massive expansion in metal supply and manufacture, of major innovations in weapon technology, of major social changes, or is it partly that and partly a contrast in the social status of those buried in the respective cemeteries? Certainly weapons, or rather daggers and axeheads, were much more commonly placed in graves in Early Dynastic III than at the beginning of the historic period; and when it can be checked (all too rarely) weapons of these types are more various, and technically improved, by the final phase of the Early Dynastic period. What their presence signifies in graves may be a more pertinent question. The relative absence of spearheads and arrowheads from graves, even in Early Dynastic III, might indicate that daggers and axeheads were significant badges of rank, of "officer" or "warrior" status, and were the personal possessions of the privileged few. By way of contrast arrowheads and spearheads, and where necessary daggers and axeheads, were issued by a central

[149] Compare, for the Old Babylonian period, P. R. S. Moorey, *Iraq* 33 (1971), 61 ff.

[150] J. C. Payne, *Iraq* 42 (1980), 105 ff.

[151] An even more broadly based inquiry would be required to see how archaeological contrasts in weapon typology and grave furnishings support Diakonoff's distinction between a Late Prehistoric "military democracy" and the emergence in the Early Dynastic period of ranked troops of charioteers and heavy infantry controlled by the ruler or temple authorities, argued in *Ancient Mesopotamia* (Moscow, 1969), 184 ff. Professional armies were not characteristic of Mesopotamian society in antiquity.

authority in periods of conflict to the main body of troops, and then withdrawn into the city, temple or palace armoury. Significantly, when such arms appear with men of markedly lower status, they are the guards in the " Royal Tombs " at Ur; presumably the standing royal guard and part of the household. The concentration of arrowheads in grave 80 at Abu Salabikh is particularly striking in this respect.[152]

In view of the primary role it was once given in the early history of Near Eastern metallurgy, the wider cultural significance of Sumerian metalworking requires assessment in the light of recent research in those neighbouring regions whence came the materials. It is also timely when increasing attention is paid in studies of trade to the cultural interactions between societies associated commercially.[153] With metalwork at least two distinct factors are involved in this problem: the extent to which travelling finished goods were available to stimulate local craftsmen to imitate them and thereby extend their own repertory of forms, and the possibility of contact between craftsmen, direct or indirect, that would have enabled specialist craft techniques to migrate. As such contacts are more to be expected in workshops patronized or controlled by wealthy customers, whether institutional or private, the absence of contemporary foreign artefacts comparable in range and quality to those in the Ur " royal " graves, which have long dominated the subject, precludes any but the most tentative suggestions. To the east, Elam fell within the Mesopotamian orbit for much of the third millennium B.C., but very little fine metalwork is yet available from Elamite sites of this period. Even if certain finished luxury metal objects were traded, or in any other ways moved, out of Mesopotamia into regions whence the metals came, there is no clear evidence that base metal weapons and tools of lowland manufacture were widely distributed outside the plain. Local production for local needs appears to have been the pattern both in Mesopotamia and in Iran, at least by the third millennium B.C.

An enormous increase in information about eastern and central Iran, and contiguous regions of Asia, in the third millennium has indicated that traditional recognition of " Sumerian influence " in the metalwork of Tepe Hissar, in the " Treasure of Asterabad ", and at other sites, over-simplified a complex pattern of commercial and cultural interactions across the Iranian plateau.[154] If gold and silver Sumerian handiwork had any local impact, it was as models to be imitated in a manner acceptable in more localized markets. Direct craft innovation through the agency of Sumerian craftsmen beyond the boundaries of Elam, even if there, no longer seems so likely. Indeed a few typological indicators suggest that northern Mesopotamia may have been as much influenced metallurgically from Iran as from

[152] J. N. Postgate, *Iraq* 39 (1977), 286–7, Pl. XXXIIc; note how rare spearheads and arrowheads are in Kish " A ": E. Mackay, *A Sumerian Palace and the " A " Cemetery at Kish, Mesopotamia* (Chicago, 1929), 164–6; the count at Ur is relatively small too when it is appreciated that javelin and harpoon heads are classified in Woolley's " arrowhead " category.

[153] R. McC. Adams, in J. A. Sabloff and C. C. Lamberg-Karlovsky (eds.), *Ancient Civilization and Trade* (Albuquerque, 1975), 451 ff. P. L. Kohl, *South Asian Archaeology*, 1977 (ed. M. Taddei, Naples 1979), I, 55 ff.

[154] See essays by D. Potts, C. C. Lamberg-Karlovsky, M. Tosi and J. Deshayes in J. Deshayes (ed.), *Le Plateau Iranien et l'Asie Centrale des Origines à la Conquête Islamique* (CNRS, Paris, 1977).

Sumer.[155] North-westwards from Sumer, into Syria and Anatolia, where Mesopotamian penetration had a long history, the dissemination of craft information has been more specifically charted, notably in jewellery, where, for example, granulation may provide a test case.[156] But the existence of unresolved, radically divergent views of the relevant relative chronologies, across North Mesopotamia, Syria and the Anatolian plateau, still obscure the direction of stimulus.

*(c) The Akkadian Period*

Limet has provided a useful study of the textual evidence for metals and metalworking in the Akkadian period,[157] emphasizing its limitations. Generally speaking the archaeological record for the routine repertory of metalsmiths is equally meagre outside the Ur graves, since there is still so little published excavated material from occupation levels securely 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 has been suggested on the basis of restricted evidence from Ur. 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 (see p. 27). This is the unequivocal evidence for large scale copper castings of the very highest quality.

The first of these, the well-known cast copper male head from Nineveh,[158] has long been known though never published in full metallurgical detail. The casting core has largely gone, though chaplets survive, leaving the head 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 a 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 has been intentionally damaged at some point in its history. Diakonoff argued from its hair and beard styling that the life-size cast copper head of a bearded man, now in the Metropolitan Museum, New York, once in the Brummer Collection and said to be from western Iran, should also be dated to the Akkadian period.[159] It was cast solid with a cavity in the neck to take a rectangular

[155] J. Deshayes, *Les outils de bronze de l'Indus au Danube (IV^e au II^e millénaire)* (Paris, 1960), II, 178, 411. The history of metalworking in Iran shows many strong local traditions not yet comprehensively surveyed, except in the relatively narrow range of this book; see, in general, P. R. S. Moorey, *Iran* 20 (1982), in press.

[156] K. R. Maxwell-Hyslop, *Western Asiatic Jewellery c. 3000–612 B.C.*, 36–7.

[157] H. Limet, *JESHO* 15 (1972), 3–24; for the Ur Sargonid graves see H. J. Nissen, *Zur Datierung des Königsfriedhofes von Ur* (Bonn, 1966).

[158] R. C. Thompson, *LAAA* 19 (1932), 72: original discovery in what seems to be a late seventh century B.C. context. I am most grateful to Professor Carl Nylander for discussing this head with me, showing me detailed photographs taken during a recent exhibition of it in Europe and telling me of a recent analysis; see C. Nylander, *AJA* 84 (1980), 329 ff.

[159] *Musée de l'Ermitage, trav. du département oriental* IV (Leningrad, 1947), 117–8 (English summary); see also E. Porada, *Ancient Iran* (London, 1965), 62, Fig. 38, n. 34 for later dating. A. U. Pope, *A Survey of Persian Art* (Oxford, 1939), IV, Pl. 105, 106: Metropolitan Museum, New York 47.100.80. I am grateful to Dr. Pieter Meyers for information on an analysis done by a commercial laboratory in 1951; the head is 34·3 cm high. The original source is unknown: O. Muscarella in D. Schmandt-Besserat (ed.), *Ancient Persia: The Art of an Empire* (Undena Publications 1979), 34–5.

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.[160] It is smaller, has eyes modelled in one with the face, a short beard, and the casting extends down onto the shoulders in a way neither of the other two heads do. Its date is a much more open question and the original association of the heads on the art market may mean no more than a common geographical source in modern times.

The achievement of Akkadian craftsmen in casting large-scale human statuary was confirmed in 1975 when, at Bossetki near Dohak in northeast Iraq, a bulldozer turned up the lower part of a cast copper crouching nude man, clasping the base of a standard or a 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.[161] It is a massive hollow copper casting which still retains some of its clay core; the chaplets are 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.

There is a growing body of evidence for a varied glaze and faience industry in the Akkadian period. Finds from Tell Taya include vessels, one matched at Mari, as well as smaller objects.[162] The evidence from Taya also indicates that the majority of faience beads in the " bead layer " at Nineveh were of the Akkadian period.[163] Of particular technical interest are those beads glazed in different colours: " although, in most cases the glaze has entirely disappeared, there are sufficient remains to show that whilst some were red others were yellow and blue ". Red (?iron or copper in a reduced atmosphere) and yellow (?lead/antimonate) are new colours in the glaze repertory,[164] reflecting the wider range of metal oxides available at this time. Small moulded statuettes of animals *couchant* in glazed faience reported from excavations at Assur and Kish come from graves of the Akkadian through into the Ur III periods.[165] The possible appearance of glass about this time remains one of the most pressing unresolved questions in the history of applied chemistry during the later third millennium B.C. in Mesopotamia. Tiny glass beads

[160] A. U. Pope, op. cit., Pl. 107 (14·7 cm high).

[161] A. H. Al-Fouadi, *Sumer* 32 (1976), 63 ff.; T. Madhloom, *Sumer* 32 (1976), 41 ff. (Arabic); F. Raschid, *Sumer* 32 (1976), 49 ff. (Arabic); J. Oates, *Babylon* (London, 1979), Pl. 17.

[162] J. Reade, *Iraq* 30 (1968), 244–5, 249; *Iraq* 33 (1971), 98, Pl. XXVd; *Iraq* 35 (1973), 165, Pl. LXXVd, LXVIIIb, 167, Pl. LXVIIb, LXVIId, left, centre; see A. Parrot, *Le Temple d'Ishtar* (*MAM* I, Paris, 1956), Pl. LII.1047, p. 121.

[163] R. C. Thompson, *LAAA* 38 (1931), 82; H. C. Beck, *Antiquity* 5 (1931), 427–37; *Ancient Egypt* (1934–5), 69–83; (1935), 19–37; cf. J. Reade, *Iraq* 35 (1973), Pl. LXVIIb.

[164] The yellow is particularly interesting; cf. a frog amulet of the Ur III to Isin-Larsa period from Telloh glazed yellow: de Genouillac, *Fouilles de Telloh* I (1930), 182, 185; II (1936), 107, Fig. 4b; both yellow and red pigments are recorded at Tell Asmar, P. Delougaz, *The Private Houses* ..., 235, 244, 247–8.

[165] L. Ch. Watelin, *Excavations at Kish* IV (Paris, 1934), Pl. XXXI. 4–5; A. Haller, *Gräber und Grüfte von Assur* (Berlin, 1954), 6 ff, Pl. 7 f.

might well be produced by " accidents " in producing a glaze; but larger objects are more problematical.[166] A glass pinhead from grave 5A of pit 14, attributed to level 4 at Nuzi, might be as early as the Akkadian period.[167] A small cylinder of glass was found at Tell Asmar " definitely beneath walls of a ruined building which had contained tablets of the 28th year of Shulgi ".[168] This appears to be a piece of a glass tube of a type regularly used in manufacture; but its supposed early date, as with the apparently near contemporary fragment of blue glass from Eridu, coloured with cobalt,[169] still raises more questions than it answers. The Eridu fragment may be raw material for glazing rather than evidence for true glass production.

### (iv) *Summary and Prospects*

Throughout the time considered here Mesopotamia received her metals through intermediaries. If at any time, like the Egyptians in Sinai and the Wadi Arabah, her rulers directly exploited foreign source areas through carefully organized expeditions, clear proof of it is still awaited. The highland zones whence the metals ultimately came were all at a considerable distance from Mesopotamian manufacturing centres. When typologies are sufficiently clear there is no certain evidence yet of a regular trade in finished objects, at least those of base metal, outside the immediate area of the river valley. As later, when documentary evidence is available, metals travelled into Mesopotamia as ingots or carefully selected and broken down ore samples. Primary smelting was probably confined to the mining areas, or as close to them as fuel sources allowed. Lying outside the zone of primary exploitation of metal it is unlikely that the earliest smiths of Mesopotamia were innovators in the basic techniques of working either native or smelted metals. Basic craft skills were more likely to have come whence the metals came. The same may also have applied later to techniques of manufacturing, first arsenical coppers then tin bronzes; but not necessarily to more sophisticated techniques of working, such as the use of multiple moulds or lost-wax casting. These and the skills required to work fine jewellery or large-scale metal sculpture could have evolved locally in response to the demand of wealthy patrons. At present evidence is too sparse, inside and outside Mesopotamia, for a sound assessment.

The importance of much more metallographic research on early Mesopotamian copper and bronze work is evident in order to establish accurately the basic methods of manufacture. Chemical analyses are significant for charting the emergence of alloys, perhaps also in time for pinpointing the earliest exploitation of the sulfide zone of copper ores, but they are largely discredited in the present state of knowledge as a guide to ore sources. More promising in this respect are determinations of isotope ratios of lead contained in ancient metal objects. Even if such ratios cannot be matched with ratios for lead ores from known ancient mining zones, they do serve the secondary purpose of grouping those objects which contain isotopically

[166] As possibly H. C. Beck, *LAAA* 20 (1933), 179–183, from Nineveh IV; R. J. Braidwood, *Mounds in the Plain of Antioch* (*OIP* 60, 1960), 341, Fig. 258 (Amuq G); generally H. C. Beck, *Ancient Egypt* (1934–5), 7 ff.

[167] R. F. S. Starr, *Nuzi* (Camb., Mass, 1939), 380, 515.

[168] P. Delougaz, *Private Houses* . . . (Chicago, 1967), 246: As. 31: 671.

[169] H. Garner, *Iraq* 18 (1956), 147 ff.

similar leads. Valuable research in this direction has already been done on early Mesopotamian glass.[170] Such researches may also assist with locating the sources of silver and tin used in ancient Mesopotamia, whilst work in is progress to narrow down the probable sources of gold through other trace elements.[171] All such work will be important not only for the history of technology, but also for the direction of trade into Mesopotamia : always a matter of crucial importance in understanding, not only local cultural developments, but also those of distant communities with which such trade was conducted.[172]

Any understanding of the role of metallurgy in early Sumerian society and its place in the socio-economic development of the city-states of late fourth and third millennium Mesopotamia will only be set on a sound footing by close correlation of the sparse textual and archaeological data. This brief bird's eye-view of the latter has sought to provide the broad perspectives, indicating the kind of information at present available and the hazards of trying to generalize from it without due attention to the particular contexts of the finds and the prevailing inadequacy of metallurgical information about them. Laboratory research is steadily improving knowledge; but the recovery through fieldwork of metal artefacts and industrial debris remains unpredictable and necessarily restricted in a region, unlike ancient Iran, where finished metalwork was not lavishly deposited in graves.[173]

## APPENDIX

*Notes on the analytical data used in this paper*

1. Apart from the technical difficulties of comparing analyses done at different times in different laboratories, often by different methods, there is the fundamental question of an analysed object's archaeological context and date. This is often impossible to follow up from published information. For instance, the table in *UE*, II, p. 290, must be re-assembled chronologically in the light of the following information on numbered objects (Woolley's absolute chronology, of course, also has to be adjusted downwards to fit present opinion). The identity and date of the numbered objects may no longer be independently established. " Ist. grave " has not been identified. It may well have been Neo-Sumerian rather than Early Dynastic IIIA as given.

U.11436 (PG 970): Late Akkadian/Neo-Sumerian; U.11475 (PG 1035): Late Akkadian; U.11886 (PG 1054D: " Royal Grave "): E.D.IIIA; U.12098 (PG/s): date uncertain; U.12229 (PG 1301): E.D. IIIB; U.12239 (PG 1305): E.D. IIIA; U.12483 (PG 1422): Neo-Sumerian; U. 12672 (PG 1382): E.D.IIIB

2. The following select bibliography lists the unspecified metal analyses used in

[170] R. H. Brill, *Iraq* 40 (1978), 23 ff.

[171] See references in note 15 here.

[172] Systematic laboratory study of Mesopotamian faience, frit etc. has only just begun and few results have yet been published.

[173] For a general review of the Iranian evidence see P. R. S. Moorey, *Iran* 20 (1982), in press.

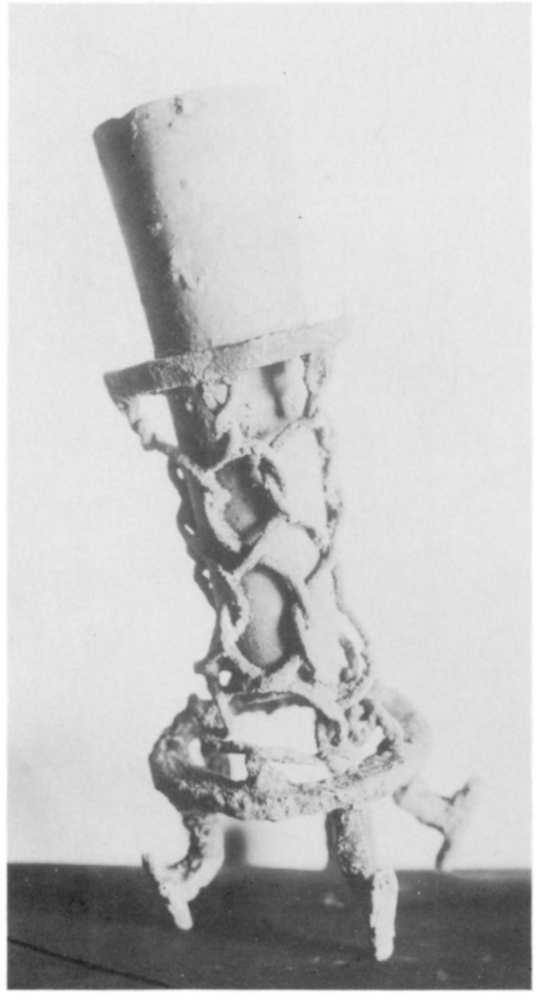
this paper; individual analyses cited in the text have footnote references.
P. Delougaz, *The Temple Oval at Khafajah* (Chicago, 1940), 151 ff.
H. Frankfort, *Iraq Excavations of the Oriental Institute* 1932/3 (Chicago, 1934), 57 ff.
M. Levey, *Chemistry and Chemical Technology in Ancient Mesopotamia* (Amsterdam, 1959) 201 ff.
P. R. S. Moorey and F. Schweizer, " Copper and Copper Alloys in Ancient Iraq, Syria and Palestine: some new analyses ", *Archaeometry* 14 (1972), 177 ff.
J. R. Partington, *The Origins and Development of Applied Chemistry* (London, 1935), 211 ff. (as a source for the pioneering analyses).
H. Peake, " The Copper Mountain of Magan ", *Antiquity* 2 (1928), 452 ff.
E. A. Speiser, *Excavations at Tepe Gawra* I (Philadelphia, 1935), 101–2.
C. L. Woolley, *Ur Excavations II: The Royal Cemetery* (London, 1934), 284 ff.
—, *Ur Excavations IV: The Early Periods* (London, 1955), 164 ff.

3. I am grateful to Dr. David Adams, formerly of Edinburgh University, and Dr. John Curtis of the British Museum, for an opportunity to see the detailed lists of Dr. Hugh McKerrell's analyses of Mesopotamian objects in the British Museum. This information is the basis of certain parts of the following papers, where specific details are not given:
E. R. Eaton and H. McKerrell, " Near Eastern Alloying ", *World Archaeology* 8 (1976), 169 ff.
H. McKerrell, " The Use of Tin-Bronze in Britain and the Comparative Relationship with the Near East " in *The Search for Tin* (A. D. Franklin *et al.* (ed.), Washington, D.C., 1978), 7 ff.
—, " Non-dispersive XRF applied to ancient metalworking in copper and tin bronze ", *PACT* I (1977), pp. 138 ff.

This pioneering work has to be used with care if inappropriate interpretations are to be avoided. The samples were relatively small and varied considerably from region to region; no information is given from which the reader may check the type, source and date of each object sampled (all factors basic in any valid interpretation); and the relevance of the results to the translation of *annakum* is by no means as direct as the authors argued (cf. the comments of R. McC. Adams, *JNES* 37 (1978), 267–9). Their main contribution was the demonstration that the transition from copper-arsenic " alloys " to tin-bronzes was far lengthier, more irregular, and more complex than had previously been supposed.

*Addendum to note 113*

The important research of Th. Berthoud is now increasingly available, see *Scientific Studies in Early Mining and Extractive Metallurgy* (ed. P. T. Craddock, British Museum, 1980), 87 ff.; *Dossiers de l'Archéologie* 42 (1980), 24 ff. Its implications for the history of Sumerian metallurgy have yet to be critically assessed.



*a*. Copper vessel stand and stone vase from grave 494 (male) in the "Y" sounding at Kish (No. V.642); Early Dynastic I/II; 35 cm high.

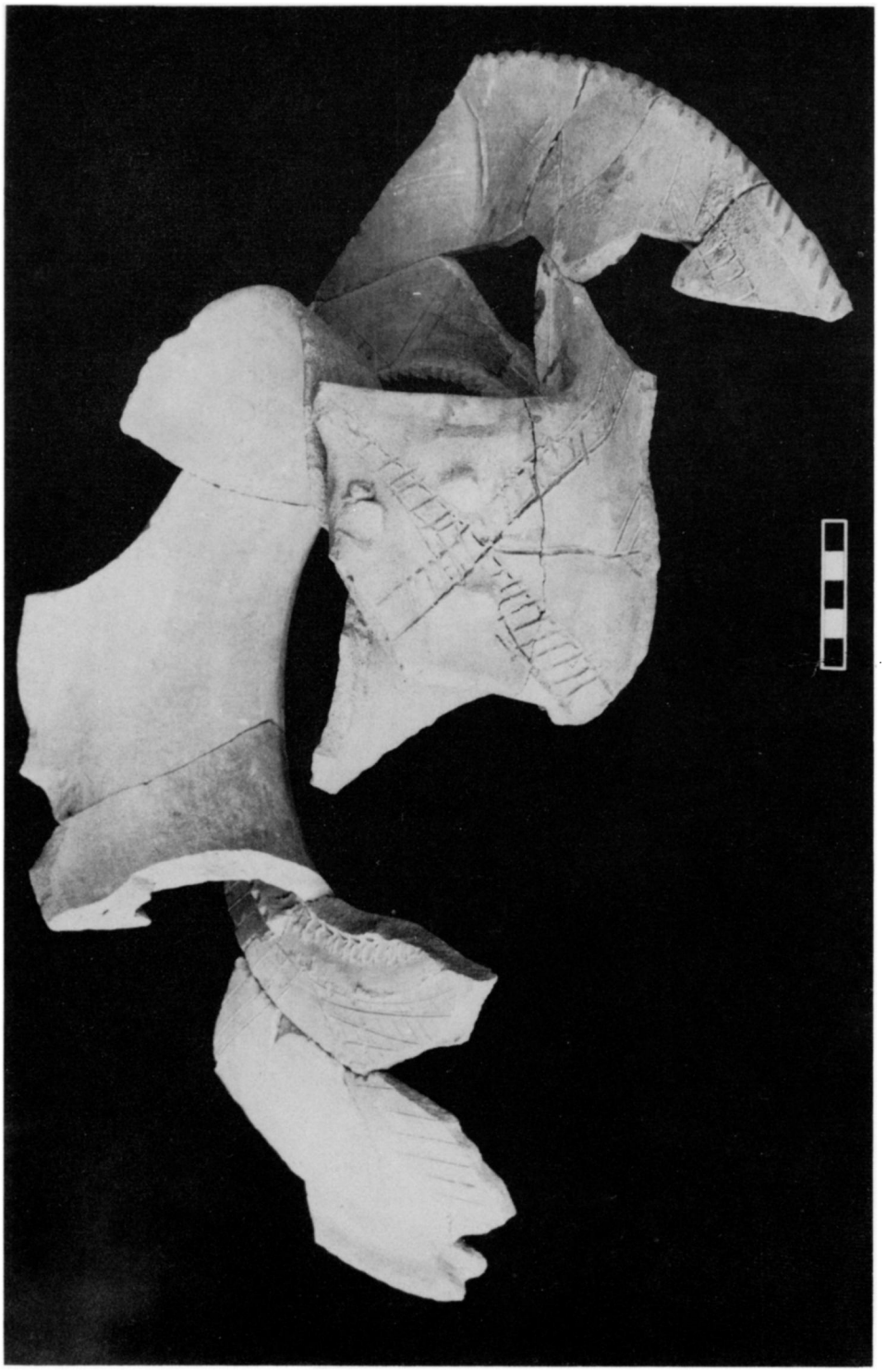
*Expedition Photograph.*

*b*. Arsenical copper vessel stand in the form of an ibex; Early Dynastic III; Metropolitan Museum, New York, 1974. 190; 40 cm high.

*Courtesy, The Metropolitan Museum of Art, Rogers Fund*, 1974.

PLATE I

**PLATE II**



Upright-handled jar from Adab.