COLLOQUIA ANTIQUA
2

INSIGHTS INTO HITTITE HISTORY AND ARCHAEOLOGY

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CHAPTER 11

METALS AND METALLURGY IN HITTITE ANATOLIA

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Abstract

The present chapter attempts to give an overview of Hittite metallurgy from a philological as well as from an archaeological point of view. While both disciplines provide interesting information, it still is difficult to gain a coherent picture of Hittite metallurgy, as the two types of evidence elucidate totally different aspects and only sometimes complement each other. Some differences exist between the two images of Hittite metals and metallurgy, based on these independent studies, especially on the quantity of metals in circulation and the pioneering use of iron.

Metals and metallurgy had a high socio-economic and cultural importance in Hittite culture. Studies of Hittite written documents from temples or palaces have amply demonstrated the importance of metals for the Hittite economy, through texts on the circulation of metals or the organisation of craftsmen. On the other hand, archaeological studies of actual finds have concentrated on the archaeometallurgical, technological and cultural-historical aspects and illustrate mainly the daily use of metal. The following article is an attempt to give an overview of the use of metals in the Hittite world on the basis of various disciplines such as philology, archaeology and archaeometallurgy.

A. METAL IN THE LIGHT OF HITTITE TEXTS (Jana Siegelová)

The oldest written records indicating the use of metals in Anatolia are accounting documents and letters of Old Assyrian merchants, who over several generations at the beginning of the 2nd millennium BC maintained an active trade between Aššur and Anatolia. They carried tin and textiles from the metropolis and bought copper in Anatolia, and possibly also traded with textiles there. A much wanted article was iron. In the documents silver is also attested, used primarily as a medium of payment. Gold also played an important role, even if it otherwise served as a capital deposit in the Assyrian

commercial settlements. Only a small proportion of the extensive written records of the Assyrian *emporia* has so far been published; nonetheless it becomes sufficiently clear that the Assyrians concentrated on trade, while the production and processing of metals were in the hands of native craftsmen.

The rulers of the Old Hittite kingdom, which united the independent city states in Central Anatolia until the middle of the 17th century BC, thus inherited a relatively developed metallurgy. In contrast to the period of the Old Assyrian commercial settlements, among Hittite written records (from the 17th to the beginning of the 12th century BC) no commercial documents are preserved – they seem to have been recorded on perishable wooden tablets, thus the information on metallurgy and the metal trade is more limited. Clay tablets, written in Hittite cuneiform script, predominantly focused on cultic affairs and administrative practices. Information about metalworking is meagre and must be gleaned from the scattered and incidental references in descriptions of celebrations, ritual regulations, vows and documents for magic actions or royal regulations. The rare administrative records, such as tax lists, stocktaking minutes or inventory lists contain valuable information on metal objects.

In the course of the five centuries of Hittite history, metallurgy underwent certain technological developments (according to the written sources which we outline in this short overview).

The oldest written records already mention gold, silver, iron, copper, tin and bronze. Black iron, often interpreted as meteoric iron, and lead are attested only from the 15th century onwards. However, as iron as well as lead finds are already attested from Early Bronze Age contexts, their late appearance in Hittite texts seems rather to be accidental.

The metals mentioned were listed together with stones and they were probably regarded by Hittite scribes as such. These were the primary elements of which the universe was composed.[1] Naturally the material value of the metals and their ability to be stored was also estimated. 'Silver and gold' was the synonym for wealth. Gold alone was considered to be durable, pure and firm. Silver was considered as symbol of purity and it seems that its bactericidal effects had been recognised. Lead was also used as cure. Iron was considered as a symbol of stability and a term for strength.[2]

Such is the nature of the preserved texts that the most commonly mentioned metals are gold and silver, specified as either war booty or tribute: gold from

[1] Lists of goods for ritual or magic ceremonies contain – in varying order – 'silver, gold, lapis lazuli, carnelian, Babylon stone, rock crystal, marcasite, iron, copper, bronze, tin, lead'; often also only 'silver, gold, all precious stones'. See Siegelová 1984, 91-100.

[2] Siegelová 1993, 112-13.

Amurru, Ugarit and Alašiya; silver from Ugarit.[3] Of course the locations mentioned do not necessarily correspond to the actual sources of the raw material. Silver (in the form of ingots)[4] and sometimes gold[5] were also levied as tax. Four different qualities of gold were distinguished: a standard product (the metal name without any specification), 'excellent' quality (GUŠKIN SIG_5) and two different alloys with copper (GUŠKIN *QADU* URUDU and GUŠKIN SIG_5 *QADU* URUDU). Likewise for silver a standard product, an 'excellent' quality and a further quality KU_3.BABBAR *mi(n)tešnaš* were known for the raw material as well as for finished products. The precious metals were controlled by the administration offices and hoarded as an accumulation of capital, but were also spent: for temples (regular maintenance or for votives),[6] for furnishing palaces (insignia, emblems, prestige weapons and jewellery),[7] or

[3] War booty: silver, gold, KUB 24.3 + II 47; go]ld, copper from Alašiya, KBo 12.38 I 5'; silv]er, gold, tin and copper probably too in KUB 36.98 b rev. 14'. Tribute: gold from Amurru, KBo 10.12 I 9'; KBo 5.9 I 30; gold and silver from Ugarit, RS 17. 227, 20-21; silver, gold, copper from Ugarit, RS 17. 340, 23; gold and copper from Alašiya, KBo 12.38 I 13', 15'. See Siegelová 1993, 113.

[4] KBo 18.155; KBo 18.156. See Siegelová 1986, 188, 192.

[5] KBo 18.153 (+) 153 a obv. 2', 3'. See Siegelová 1986, 100. For 20 bars of gold in a magazine, see also Columbia University Library (HFAC 8) + KUB 42.81 r. col. 1'.

[6] Regular maintenance for temples: KBo 20.75 rev. 6, KUB 56.24 I 9'- 10', 14', IV 4, 9-10, KUB 40.2 rev. 19-24. Deliveries for cultic ceremonies – cult statues: KUB 7.49, 9', KUB 56.3, 6'; cult symbols: KUB 42.78 II *passim*; equipment for cultic ceremonies, rituals or magic procedures – rhyta or other vessels: KBo 17.75 IV 8'- 9', KBo 17.88 + II 1, KUB 1.17 I 5, KUB 20.81 II 11', KBo 4.13 V 11; drinking straws: KBo 26 + I 4', KBo 16.80 obv. (?) 3'; *peran pedumaš* '(object) to-bring-in-front-of' (according to D.P. Mielke this can hardly be a libation arm, as is considered in Siegelová 1998, 65 n. 3. Perhaps it is some kind of cutlery[?]): KUB 42.69 II(?) 18', KUB 42.46, 1', KUB 42.64 rev. 16'; measuring vessels: KBo 11.44 rev. 11'; washing bowl: KUB 10.21 II 32, KBo 30.56 IV 25, KUB 2.15 I 11'; table: IBoT 2.98 V 2', 4'. 100 Shekels of silver for the celebration of the AN.TAḪ.ŠUM Festival in Arinna, provided by his majesty, KBo 9.91 rev. 9'-10'. Votives – statues or busts of gods: KUB 15.1 I 7, III 36', KUB 48.123 I 18', of the king: KUB 15.17 + I 8, KUB 31.53 obv. 2; cult symbols: KUB 15.17+ I 6-7, KUB 31.53 obv. 2 – 3, KUB 15.5 IV 5; rhyta and other vessels: KUB 15.17 + I 7, KUB 31.53 obv. 1, KUB 31.54 IV 16'; flasks for perfumes or ointments: KUB 15.3 I 20, KUB 15.11 III 16; amounts of silver: KUB 15.5 II 23', IV 15', 36', 37'; bars of gold: KUB 15.5 IV 14'.

[7] Palace equipment – insignia: lituus with silver inlays, Bo 3769 lk. col. 6'; lituus of gold, KUB 10.21 I 3; emblems: KUB 42.84 obv. 5; seal of gold, KUB 13.34 + I 28. Prestige weapons – scabbard (plated with gold): KUB 12.1 III 7', KBo 18.178 obv. 2': spears: KBo 10.28 V 6, KBo 11.73 rev. 21', IBoT 3.59, 6'; silver helmets: KUB 26.66 III 6. Jewellery – golden diadems and wreaths: KUB 22.70 obv. 12, 17, 19, 71, KUB 15.23 obv. 14, KUB 42.38, 22'; hairpins: KUB 42.75 obv. 8, IBoT 1.31 rev. 1; earrings: KUB 42.38, 15', 16', KBo 30.77 obv. 4'; earrings with pendants: KUB 42.69 II(?) 16'; colliers: KUB 58.59 I(?) 9', KUB 42.43 obv. 7'; torques: KBo 18.161 obv. 8', KUB 42.64 rev. 4'; necklace: KBo 9.92, 2', 3', 4', KUB 42.64 rev. 8', KUB 42.78 II 23', KUB 42.69 II(?) 6', KUB 12.1 IV 18'; pendants: KUB 12.1 III 15'; elements of necklaces: KUB 12.1. IV 4', 18'; beads: KUB 42.64 rev. 4', KUB 42.69 II(?) 15'; collier: KUB 12.1 III 14'; pins: KUB 42. 78 II 6', KUB 42. 84 obv. 6; brooches: KUB 42. 43 obv. 4'; pectoral: KUB 15.1 I 10; rings: KUB 42.64 rev. 12'; armrings: KUB 42.38 obv. 11', KUB 42.38 8'

as remuneration or reward (all metals, but predominantly silver). These rewards mostly took the form of finished objects (belts of bronze or gold, silver or gold jewellery, daggers with gold inlays, knives or textiles). Silver, on the other hand, was referred to mainly by weight, thus it may have been a kind of currency, but a standardised form has not yet been detected. Precious metals were used likewise as material for the most important written documents such as international treaties.[8]

The most common raw material for many centuries was copper.[9] It came as booty or tribute from Ugarit and Alašiya.[10] Hittite economic texts also point to origins in Kizzuwatna and in further regions in Anatolia not yet securely located, levied as taxes.[11] Considerable quantities are mentioned, always indicated in *mina* values, which were delivered in the form of artefacts such as axes, hatchets, sickles, arrowheads, different types of knives or daggers, vessels or household utensils. The first three types (i.e. axes, hatchets, sickles) were standardised on a weight of 2 *minas* (about 1 kg) and thus represented a standardised currency. In addition to copper, taxes were delivered in tin, silver (in the form of ingots) or iron (blades, clubs, ingots or simply indicated by weight), but to a more modest extent. Tin was always noted by weight and obviously

made of twisted gold. Similar silver jewellery is mentioned, but in lesser quantities. Stylus of silver, KUB 17.20 II 25; vessels: IBoT 1.31 rev. 2, KBo I 3 obv. 33, beakers of silver: KUB 31.76 obv. 7', rhyta of silver: KUB 31.76 rev. 14', 18'; perfume flasks: KUB 12.1 IV 28'; spoon: KUB 12.1 IV 28'; holder (?): KBo 11.25 V(?) 10', KBo 18.176 I 7'; spindle: KUB 12.1 IV 33'; nails: KUB 42.57, 3'; table: KUB 42.69 III(?) 8'; chair: KUB 42.69 III(?) 9'; footstool (with gold plating): KUB 42.21 obv. 9; stands: KUB 42.81 +, 2'; feet of a bed: KBo 18.175 (+) V 14; chariot, decorated with gold: KBo 11.43 I 21, KBo I 3 obv. 32. Bars of gold stolen from palace: KUB 31.76 I 11'. Gold for embroideries: KUB 42.64 rev. 15', KUB 34.45 + obv. 10' (shirts), KUB 12.1 III 26' (sash), 27' (tapestries); silver for embroideries KUB 42.11 II 7 (dress); decorations for dresses: KUB 12.1 III 19', KBo 10.23 (+) I 15'; for sashes: KUB 12.1 III 26' or belts: KUB 12.1 III 32', KUB 42.59 obv. *passim*; for shoes: KUB 42.64 rev. 13' (two pairs decorated with gold, one pair decorated with silver), KUB 12.1 IV 34', KUB 13.34 + 40.84 I 10 (golden shoes of the queen); head-wear decorated with gold: KUB 12.1 IV 44'; (saddle-)cloth decorated with gold: KUB 12.1 III 4'.

[8] Gold tablet: treaty with Karkamiš between Šuppiluliuma I and Šarri-Kušuḫ, KUB 19.27 left edge 6; silver tablet: treaty between Ḫattušili III and Ramesses II, KBo 1.7 obv. 14. See Siegelová 1993, 117.

[9] Siegelová 1994, 119-21 with references from Hittite cuneiform texts.

[10] *Cf.* n. 3.

[11] Tax-payers located in Asia Minor: Hen[-, -]hira, Arpuzziia, Šawatta, Kurkuriša, KUB 42.29 II 4', 12', 15'-16' V 18'; Kuenma/zuliia, Mizamizana, Huwar[-, Šar[-, Tuššimna, Šapla, KUB 42.28 + III 4', 8', IV 6', 7', 14', 19'; Zišk[uliia(?), Bo 6419, 5'; Awan[a-, KBo 18.164, right col. 5'; Tetum[-, Kapittat[-, KUB 26.67, right col. 3', 13'; Munna[-, Šahhu[-, KBo 18.162 I 6', 13'; Ar[x]huz[i-, Luli[- KBo 7.24 II 14', IV 1'; Ank[uwa(?), Anzilatašši, Parnašši, Zarar[a-, KBo 18.161 rev. 8, 13, 16. Tax-payers located in Kizzuwatna: KUB 42.28 + IV 17', KUB 26.67, right col. 6'. The highest amount delivered by a tax collection office is 496 *minas*; the highest amount paid by one tax-payer amounts to 200 *minas*. See Siegelová 1986, 141-85.

more strictly controlled. The largest testified quantity is 1 (or 2) talents (roughly 30 kg). No specific relationship of the proportions of copper and tin within respective deliveries can be observed. Where they were supplied together and both entries are preserved, the proportions varied significantly: 1: 14.5, 1: 10.33, 1: 8.4 and 1: 8. The tin came from specific locations, of which alas Kizzuwatna alone can be securely located.[12] The administration offices and depots to which the deliveries were sent, stored and regularly controlled the material, but they must also have further processed the raw materials. This would explain why copper, which never appears to have been delivered in the shape of ingots, nevertheless existed as ingots in the depots. Bronze, which is mentioned as one of the materials held in the depots, might have been produced there, although copper and tin were always delivered separately.

Considerable quantities of copper were handed out from the depots to craftsmen, who converted it to adzes, saws, pliers, grip arms, heels, spades, sickles, and also to spears or parts of horse-bits. In Middle Hittite times door bolts, forks, needles and different vessels are mentioned as well. In the manufacture of jewellery copper was used but rarely, for instance for hair clips. In cultic contexts copper was used particularly for the manufacture of paraphernalia or vessels. Copper statues or cultic symbols were more rarely mentioned; if they occur, they are often covered with gold. Finally, copper was used, together with lead, as raw material for glass production.

Bronze[13] occurs in Hittite texts more rarely than copper and also originated – according to a temple building ritual – from Alašiya. Reliable data concerning its provenance and manufacture are completely absent; according to tax and expenditure lists, it seems that bronze was cast in workshops controlled by the central administration. As to the composition of the alloys, however, nothing more is known than the relation between copper and tin in the deliveries mentioned above. Bronze was apparently considered a high quality material for specific requirements. It was used for the production of lance-heads of the guard, whereas arrowheads were always fabricated of copper. Occasionally, elaborate libation vessels were made of bronze; normally they were of precious metal. Bronze was also used to produce lamps and medical instruments. Bronze tools, such as axes, sickles, knives, daggers and needles (these last usually made of copper), seem to have had a symbolic value rather than a practical purpose. Occasionally, statues and other cultic paraphernalia were made of

[12] The locations mentioned are: Awan[a-, KBo 18.164, right col. 5'; Tetum[-, Kapittat[-, KUB 26.67, right col. 3', 13'; Munna[-, Šahhu[-, KBo 18.162 I 6', 13'; Ar[x]huz[i-, Luli[- KBo 7.24 II 14', IV 1'; Kizzuwatna, KUB 26.67 right col. 6'. See Siegelová 1986, 162-66.

[13] Siegelová 1994, 121-22 with references.

bronze, while during the 13th century iron statues seem to become more popular. In comparison with silver and gold, bronze played a subordinated role: it was seldom used for jewellery or ornaments; only belts and buckles, which were given in larger numbers to reward functionaries, generally consisted of bronze.

Hittite metallurgy has always captured the imagination of researchers due to the early attested use of iron.[14] Iron is mentioned in limited quantities already in Cappadocian documents. In Hittite sources of the 17th-16th centuries (Old Hittite period) iron still appears as an extraordinary material, restricted to the production of royal insignia and weapons such as lances and sceptres, which were at the same time used in ritual and magical contexts. In texts of the Middle Hittite period (15th-beginning of the 14th century BC), the repertoire of iron objects grew and now included ceremonial objects such as various axes and the *lituus* as well as jewellery, which was distributed to cult functionaries. Under the Hittite empire (14th-13th centuries BC), the attestations for iron objects rise considerably. Again, the repertoire broadens: in addition to royal insignia, it was used for cultic objects, such as idols in anthropomorphic or zoomorphic shape, which testifies to the high appreciation of iron. Simultaneously, however, larger numbers of knives, daggers, and/or swords or spearheads appear in Hittite texts of this time. On the other hand, iron jewellery becomes rarer. That iron was more widely used during the Empire period is also corroborated by the fact that communities delivered their taxes in iron and that it was now weighed in *minas*.

The 'black iron', which was thought to come from the sky, and thus was interpreted as meteoric iron, is attested more rarely. It was used for the same objects as ordinary iron, however, and there is no evidence of its being reserved for special purposes.

On the basis of tax lists and other Hittite economic records, A. Müller-Karpe[15] computed the relative frequency of particular metals and was able thereby to gain insights into the circulation of the metals in the Hittite empire in 13th century. According to him, approximately 25% of taxes were paid with raw metals, of which about 60% was copper, 8% tin and 13% silver; whereas there was just one attestation each for gold and iron (Fig. 1.1). On the other hand, in the inventory lists, which reflect the contents of the stores of the administrative centres and temples, only 6% of the metals mentioned in the documents is found in the form of unprocessed metals (predominantly silver)

[14] Siegelová 1984 with references; Košak 1986.
[15] A. Müller-Karpe 1994, 74-78.

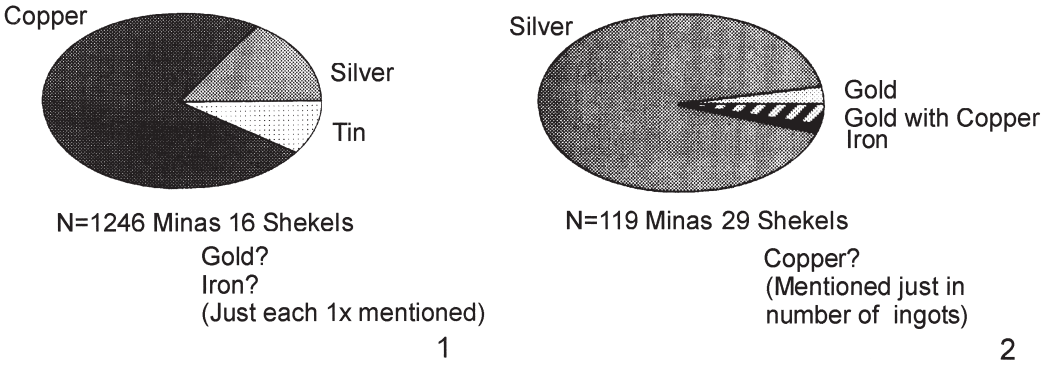

Fig. 1. Quantitative ratios of various kinds of raw metal according to A. Müller-Karpe: (1) in Hittite tax lists; (2) in Hittite inventory lists of palaces and temples (after A. Müller-Karpe 1994, Abb. 50a-b).

(Fig. 1.2). According to A. Müller-Karpe, this difference testifies to the importance of the state sector in metalworking.[16] Accordingly, finished metal products formed only 13% of the tax deliveries, whereas in the inventory texts the percentage of finished metal products rises to 40%. As A. Müller-Karpe himself notes,[17] he counted axes and sickles as finished products in making his calculations, although these might have been a kind of standardised currency rather than actual tools. It is significant that in the tax lists precious metals in the form of finished products are missing; this seems to provide evidence that these raw materials were only processed in state workshops.[18]

The processing of the metals lay in the hand of smiths (^{LÚ}SIMUG). In connection with metalworking, ^{LÚ}TIBIRA is mentioned as well. Except for these general designations, specialised branches of these occupations, whose members already appear as corporate groups during ceremonies, are documented from the Middle Hittite period onwards. Thus we know of gold-, silver-, iron- and coppersmiths, whereas for lead, tin or bronze no special job designations have been attested so far. The gold- and silversmiths can also be subsumed under the term $^{LÚ}KU_3$.DÍM, which should be translated as 'jeweller'. This occupation coincided repeatedly with the function of a treasurer or administrator, who belonged to most influential officials of the state administration.[19]

[16] A. Müller-Karpe 1994, 76.
[17] A. Müller-Karpe 1994, 77.
[18] A. Müller-Karpe 1994, 78.
[19] Siegelová 1986, 118-21.

In contrast, the metalworker, ^{LÚ}TIBIRA, who may have worked with copper judging from the ideogram, was obliged to participate in *corvée* labour such as the building of roads and of fortresses according to Hittite laws.[20] A trained smith (^{LÚ}SIMUG) might even be found among the serfs, and he could be bought like a potter, carpenter, leatherworker or weaver for 10 Shekels (*ca*. 120 g) of silver.[21]

Hittite scribes paid little attention to the metallurgical procedures itself. From isolated notes it can be concluded that the raw material was first sorted. Melting was described with the verb *zanu-* (to cook); for gold *lapanu-* ('to make glow') was used as well. The application of purification processes might be inferred from the fact that different qualities of metals are mentioned. The skill of alloying is attested by texts describing the production of gold – copper alloys and, of course, bronze. The metal was cast (*lahuwai-*) into ingots or finished products. From an ingot or talent the necessary quantity was broken off (*arha duwarnai-*), in order to recast (*appa lahuwai-*) it into final products. In the case of iron, according to the terms used, three production stages can be observed: 'the iron directly (taken) from the furnace' (AN.BAR *ŠA* KI.NE), the standard product 'iron' (AN.BAR), and the higher quality, probably more highly valued 'excellent/first-class iron' (AN.BAR SIG_5).[22] The final product might have been iron ingots, bars or blades. State-owned iron smithies are attested by the famous letter KBo 1.14 of Ḫattušili III to an Assyrian king.[23] On the other hand, 56 iron blades and 16 clubs of black iron mentioned in a tax list[24] show that iron was also produced by provincial communities.

Some objects made of less precious metals were improved by covering with silver, gold or tin. The exact techniques – plating or fire-gilding[25] – cannot be specified as the process is only described with the term GAR.RA, *halissiia-*. According to the finds the jewellers mastered several difficult techniques, but in the Hittite language only 'engraving' (*guls-*) can be translated with any degree of security. Torsion or filigree work might be designated as *tarupp-*

[20] Hittite laws §56: 'None of the coppersmiths is exempt from "making" ice, a fortification, and royal roads, or from harvesting vineyards. The gardeners render the *luzzi*-services in all the same (kind of work)' (Hoffner 1997, 68).

[21] Hittite laws §176 b: 'If anyone buys a trained artisan – either a potter, a smith, a carpenter, a leather-worker, a fuller, a weaver, or a maker of leggings, he shall pay 10 shekels of silver' (Hoffner 1997, 140-41).

[22] KUB 42.21 obv. 6; see Siegelová 1986, 137-39.

[23] Siegelová 1984, 155-56.

[24] KBo 18.158, 3' and 5'; see Siegelová 1986, 194.

[25] It has to be pointed out, however, that fire-gilding in the ancient Near East is hitherto only attested from the Sasanid period, i.e. from the 3rd century AD onwards (see Anheuser 1999, 15).

'twisting (with wire)'. Important parts of artefacts were often accentuated by being made of precious metal. For artefacts composed of several parts and materials different techniques of combining were known, such as riveting, soldering or mounting.[26]

B. HITTITE METALLURGY FROM AN ARCHAEOLOGICAL POINT OF VIEW (Hidetoshi Tsumoto)

As we have seen above, documentary evidence provides a number of insights into topics such as metallurgical procedures, the organisation of craftsmen and the circulation of metals. However, it refers to just a part of Hittite metallurgical activities, mainly those concerning official institutions. Archaeological finds can elucidate further aspects of Hittite metallurgy that are not represented in the texts.

Compared with other categories of artefact, metal objects are less frequently encountered. Archaeological finds can be assigned to three different basic categories: settlement finds, grave finds and hoards. While in graves and hoards objects have been deposited intentionally, finds in settlements represent unintentional deposits: the finds preserved are things that were lost, overlooked or could not be retrieved for other reasons. As metals were always a relatively precious commodity, it is rare for metal objects simply to be lost; if this happened, mainly small objects or scrap metal are concerned. Only in a few cases of destruction through warfare or natural catastrophe are complete inventories of metal objects found *in situ*, for example at Kaman Kalehöyük in the later Karum period[27] or in Ortaköy-Šapinuwa from the Hittite period.[28] The normal fate of a metal object, however, was the crucible to be recycled.

Tombs often contain metal objects as funeral gifts. Compared with the rich assemblages of metal objects from Mycenae or Egypt, Central Anatolia provides little evidence for tombs with metal assemblages, mainly because no Hittite royal graves have been discovered so far. Textual evidence informs us that objects of precious metal were part of the funeral gifts.[29] The few Hittite graves excavated so far seem to be those of members of the lower class, and only rarely contain metal objects,[30] just as few hoards that contain metal objects

[26] KUB 42.38 obv. 17'-18': two pairs of silver earrings, one pair mounted with tin, the other with lead; see Siegelová 1986, 498-99.

[27] Omura 1994.

[28] Süel 1998.

[29] Otten 1959.

[30] For a summary of Hittite burials, see Emre 1991.

are known from the Hittite world. So far only Kastamonu,[31] Şarkışla[32] and Bolu[33] may be named.

Although it is not explicitly mentioned in Hittite written records, we can assume that most metal artefacts were recycled, that is collected and re-melted. The hoard from Tell Sifr in Iraq, which includes axes, adzes, sickle-blades, spades and copper scraps wrapped in palm mats, very probably represents metal collected for re-melting.[34] Furthermore, contemporary Old Babylonian written evidence shows the administrative collection of agricultural metal implements from peasants after the season's use, for checking and, if necessary, reworking the implements.[35] Metal was never wasted, especially precious metal such as gold and silver. The relatively low frequency of appearance of precious metal in archaeological contexts is explained by such conditions of circulation.

Regrettably, there are no finds which show real evidence of metal circulation in Hittite Anatolia. The metal hoard with 77 bronze objects – partly unfinished swords, and standardised flat and shaft hole axes – found at 'the house of the great priest' of Ras Šamra-Ugarit in northern Syria,[36] contemporary to the late Hittite Imperial period, might show us the metal circulation combined with temple- and palace economies which are also known from Hittite written sources.

METAL PRODUCTION

Sources of Metal

The Pontic and Taurus Mountains, which surround the Central Anatolian plateau, offer rich mineral resources, such as copper, iron and silver (Fig. 2). Gold is found in western Anatolia. Naturally, the Hittites tried to bring these mineral-rich areas under their control to exploit these resources. As a result, complex relationships developed between the Hittite empire and these regions, which included the Kaška lands in the north, Kizzuwatna in the south and Arzawa in the west. Unfortunately, no actual evidence for Hittite mining and smelting activities has been discovered so far. However, analysis of lead isotopes shows that some metal finds from Anatolia and northern Syria indeed

[31] Emre and Çınaroğlu 1993.
[32] Bittel 1975; H. Müller-Karpe 1980, 767, no. 87, Taf. 159, C.
[33] Yıldırım 2001.
[34] Moorey 1971.
[35] Postgate 1992, 226-29.
[36] Schaeffer 1956, 251-52.

Fig. 2. Distribution of metal ores in Anatolia (after A. Müller-Karpe 1994, Abb. 1).

originated from ores in the Taurus Mountains.[37] Also metal of non-Anatolian origin was used by the Hittites, as indicated by the find of an ox-hide ingot, possibly originating from Cyprus, in Boğazköy.[38] This find indicates that the Hittite empire was involved in the (metal-)trade network of the eastern Mediterranean in the Late Bronze Age, which is well illustrated by the spectacular finds from the excavations of shipwrecks at Ulu Burun and Cape Gelidonya.[39] Copper from the rich mines on Cyprus surely was imported and used by Hittite smiths besides local Anatolian copper.

Tin is an indispensable commodity for alloying with copper to produce bronze. The existence of tin deposits in Anatolia is highly controversial.[40] Recently, A. Yener suggested the Kestel mine in the Taurus Mountains as a source of tin in the Early Bronze Age.[41] However, there is absolutely no evidence for tin mining in the Middle and Late Bronze Age. Judging from the written records from Kültepe-Kaneš, it is clear that in the early 2nd millennium BC tin reached Anatolia from outside via Aššur. The Late Bronze Age

[37] Yener 2002, 39-40.
[38] A. Müller-Karpe 2000, 116 and Abb. 5.2.
[39] See Pulak 2002; Yalçın *et al*. 2005.
[40] Weisgerber and Cierny 2002, 179-80.
[41] Yener 2000.

shipwreck at Ulu Burun yielded approximately one ton of tin ingots and shows the amount of tin that circulated in long-distance trade in the eastern Mediterranean.[42] Tin ore deposits in Afghanistan and Central Asia are up to now the most likely sources of tin for the Near East in the Bronze Age.[43] Without doubt the origin of the tin used in the Bronze Age of the Near East will continue to be controversially discussed.

As only a few metal objects have actually been analysed for their exact composition, it has to be borne in mind that it might be wrong to assume that all copper-based artefacts consist actually of bronze. As we have seen above, Hittite texts clearly show that besides bronze, copper was worked into tools and weapons.

Metalworking

Several Hittite sites in Anatolia, such as Boğazköy, Kuşaklı, Alaca Höyük, Gavurkalesi, Tepecik, Norşuntepe and Tarsus, have yielded metal workshops or at least finds related to metalworking.[44] So far, workshops seem to be located mainly in or near palaces and temples, for instance in the temple quarter of the Upper City and next to the Great Temple in the Lower City in Boğazköy-Ḫattuša. The written evidence clearly show that metallurgy to a great extent was closely related to the temple- and palace economies. But it should be kept in mind that excavations up to now have focused largely on public buildings, while domestic dwellings have seldom been investigated. The large number of private workshops in Karum-Kaneš in Kültepe may caution us against making

[42] Pulak 2000, 150-55. These tin ingots have been isotopically analysed, and demonstrate that the tin does not originate from known ores in England or Central Europe.
[43] Weisgerber and Cierny 2002.
[44] A. Müller-Karpe 1994; 2000.

Fig. 3. Finds related to metallurgical activities (3-9 to same scale):
(1) and (2) Copper 'ox-hide' ingots from Cape Gelidonya, length (1) 74 cm, (2) 66 cm (after H. Müller-Karpe 1980, Taf. 161.34-35);
(3) Pot-bellow from Alaca Höyük, diameter 37.5 cm (after A. Müller-Karpe 1994, Taf. 2.1);
(4) Clay tuyères from Boğazköy, length 9 cm (after A. Müller-Karpe 1994, Taf. 3.14);
(5) Clay crucible from Tarsus, height 10.2 cm (after A. Müller-Karpe 1994, Taf. 13.1);
(6) Stone hammer from Boğazköy, length 5.4 cm (after A. Müller-Karpe 1994, Taf. 62.14);
(7) Stone mould for ornaments of precious metal from Tarsus (after A. Müller-Karpe 1994, Taf. 51.4);
(8) Stone mould for axe from Boğazköy (after A. Müller-Karpe 1994, Taf. 25.5);
(9) Clay mould for bar-shaped ingot from Alişar Höyük; (a) A Syrian bringing 'ox-hide' ingots on Egyptian wall-painting from Tomb 100 (Tomb of Rekhmire) in Thebes; (b) Scene of metalworking on Egyptian wall-painting from Tomb 100 in Thebes (after A. Müller-Karpe 1994, Taf. 15.4; (a) H. Müller-Karpe 1980, Taf. 14; (b) A. Müller-Karpe 1994, Abb. 82).


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too rash generalisations. Thus, the concentration of metal workshops in or near public buildings in Hittite sites may be related to our limited state of knowledge rather than to an actual situation in the past.

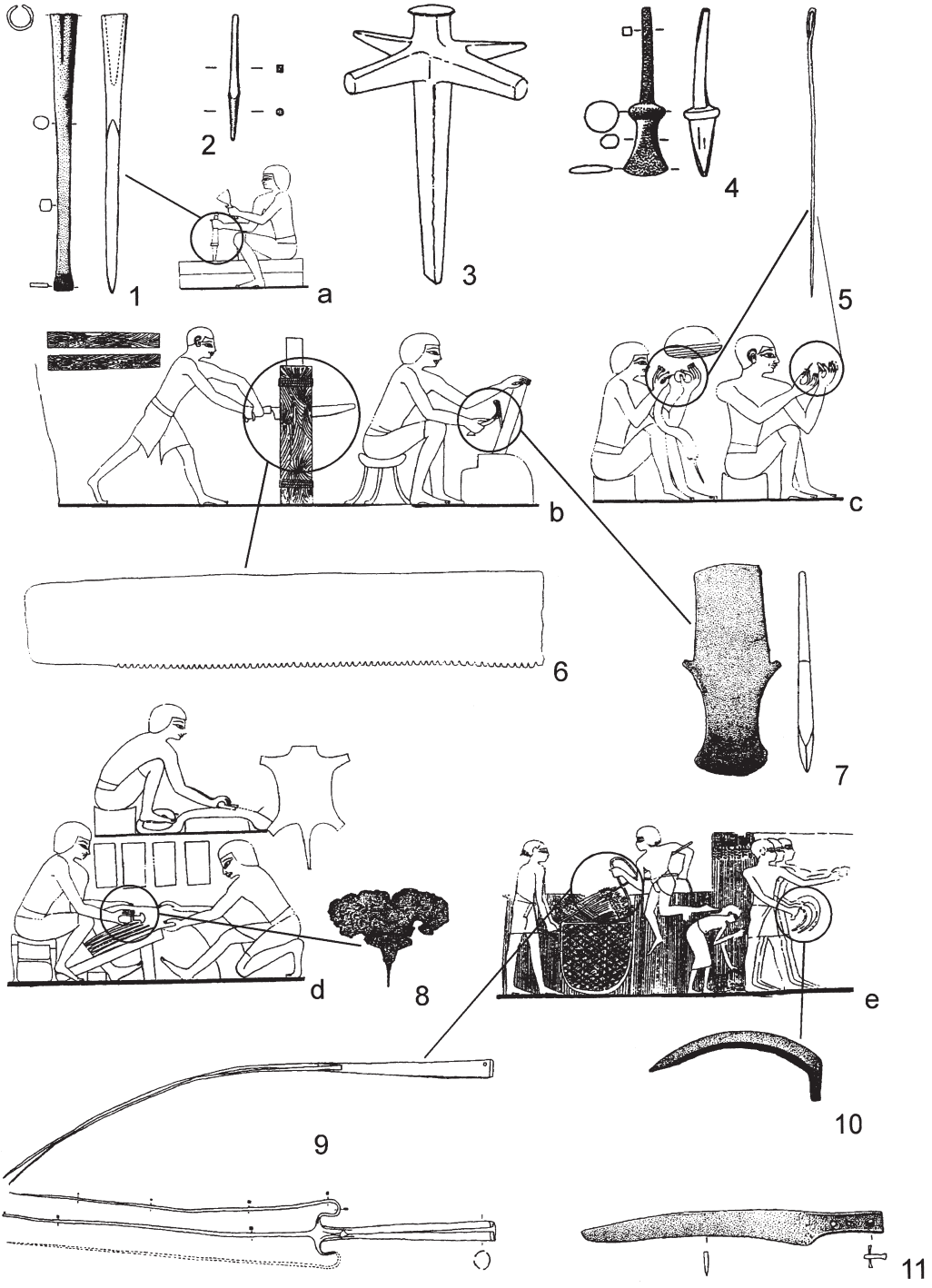
Compared with the vast amount of finds relating to metallurgical activities in Kültepe during the Karum period, those from Hittite sites are relatively sparse. However, we still can reconstruct metallurgical processes for the Hittite period with a high degree of certainty:[45]

Melting and alloying. Raw metal came to the settlements in the form of ingots (Fig. 3.1-2),[46] lumps or finished objects, which might have been produced already at or near the mining sites. These raw materials were melted in furnaces and crucibles (Fig. 3.5). From the beginning of the 2nd millennium BC onwards pot-bellows were used for providing air to the furnaces (Fig. 3.3). *Tuyères* (clay pipes) were used to conduct the air to the furnace or crucible (Fig. 3.4). Alloying (for example, copper with tin to produce bronze) was also carried out at this stage.

Casting. The molten metal was then poured into moulds to form artefacts (Fig. 3.7-9). Three types of mould are attested: open, bivalve and those for lost-wax casting. Most moulds were made of stone, usually sandstone, but moulds of baked clay are attested. Surprisingly, many moulds for casting ingots, not just moulds for artefacts, were revealed from Hittite settlements (Fig. 3.9).[47] Moulds for lost-wax casting, which consisted of clay or sand, do

[45] See A. Müller-Karpe 2000.
[46] For systems of weights, see A. Müller-Karpe 1994; 2005.
[47] A. Müller-Karpe 2000, 119.

Fig. 4. Tools (various scales):
(1) Bronze chisel from Boğazköy, length 19.8 cm (after A. Müller-Karpe 1994, Taf. 74.11);
(2) Bronze awl from Boğazköy (after Boehmer 1972, Taf. XXXVIII.963);
(3) Bronze multiple-chisel from Boğazköy, length 8.8 cm (after A. Müller-Karpe 1994, Taf. 65.10);
(4) Bronze chisel(?) from Boğazköy, length 4.2 cm (after A. Müller-Karpe 1994, Taf. 63.10);
(5) Bronze needle from Boğazköy, length 5.8 cm (after Boehmer 1972, Taf. XXII. 508);
(6) Bronze saw from Bogazköy, length 67.5 cm (after Neve 1989, Abb. 1);
(7) Bronze lugged-adze from Boğazköy, length 15 cm (after Erkanal 1977, Taf. 2,.21);
(8) Bronze leather-knife(?) from Tarsus, length 7.3 cm (after H. Müller-Karpe 1980, Taf. 162, B12);
(9) Bronze fork from Sivas Region. Eskişehir Museum, length 65.6 cm (after Yalçıklı 2000, Abb. 1a);
(10) Bronze sickle-blade from Tarsus, length 12.6 cm (after H. Müller-Karpe 1980, Taf. 162, B13);
(11) Bronze knife from Boğazköy; (a) Working scene with chisel and hammer on contemporary Egyptian wall-painting from Tomb 100 in Thebes; (b) Scene of wood-working on contemporary Egyptian wall-painting from Tomb 100 in Thebes; (c) Working scene with needle on contemporary Egyptian wall-painting from Tomb 100 in Thebes; (d) Scene of leather-working on contemporary Egyptian wall-painting from Tomb 100 in Thebes; (e) Scene of agricultural activities on contemporary Egyptian wall-painting from Tomb 52 (Tomb of Nakht) in Thebes (after H. Müller-Karpe 1980, Taf. 171.17; a-c: Taf. 16.3; d: Taf.15.6; e: Taf. 21A).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not usually survive as they had to be destroyed to remove the artefact. Judging from the objects themselves, the technique of lost-wax casting flourished in the age of the Hittite empire, especially for the production of statues or decorative artefacts.[48]

Cold working. The cast objects needed to be processed further after their removal from the moulds. Hammers of various sizes, used for forging, repoussé or sinking, always consisted of stone (Fig. 3.6), while chisels (Fig. 4.1, 3-4) and awls (Fig. 4.2), used for fine work such as engraving or cutting, were made of bronze.

No metallurgical scenes are depicted in Hittite art, but contemporary evidence is well illustrated on the wall paintings of graves from Thebes in Egypt (Fig. 3b).[49]

METAL ARTEFACTS

Tools

What role did metal artefacts play in the daily life of the Hittites? When visiting Hittite sites, we are always impressed by the monumental architecture. With what tools did the Hittites build these enormous structures? The most distinct character of Hittite monumental architecture is the exquisite combination of various building materials such as stone, brick and wood. Metal implements clearly played an important role in processing stone and wood during the building process.

P. Neve has tried to reconstruct this building process and the role of the tools.[50] The foundations of buildings always consisted of stone. The foundation stones were shaped mainly with relative simple stone hammers made of gabbro or basalt. Various tool marks on the stones also testify to the use of metal implements such as chisels (Fig. 4.1), picks, drills and saws, while the actual tools themselves have only rarely survived. For example, the dowel holes on the foundation stones or stone cores demonstrate the use of tubular drills, which consisted of metal tubes with a diameter between 4 and 6 cm. They were mechanically operated in combination with water and fine sand as an abrasive. Modern experiments demonstrated that a hole about 3 cm in diameter could be drilled at a rate of 6-9 cm per hour.[51] Also cut marks made

[48] A. Müller-Karpe 1994, Abb. 88.
[49] Davies 1943.
[50] Neve 1989; 2002.
[51] Seeher 2005, 23

by a pendulum saw can be observed on the foundation stones of temple buildings at Boğazköy.[52]

Tools for woodworking are more numerous. Several tool types are found, such as axes, adzes, chisels (Fig. 4.1) and saws. A fragmentary bronze saw from Boğazköy still measures about 67.5 cm in length (Fig. 4.6).[53] Axes and adzes must have been used to process wood. Typical Hittite axes and adzes were lugged (Fig. 4.7).[54]

Neve pointed out that these tools are comparable to finds from the other areas in the eastern Mediterranean. Similar drill holes, the use of pendulum saws, or finds of bronze saws are also known from Crete and in the Mycenaean palace of Tiryns in mainland Greece.[55] Also, an Egyptian type of axe has been found at Bogazköy.[56] He presumed that these finds indicate the presence of foreign specialists in the Hittite capital and that Hittite architecture was influenced by North Syria or the Late Minoan culture.[57] With these specialists travelled their specific tools and, of course, their knowledge and expertise.

Apart from building tools, agricultural tools should have had a large importance in Hittite society, as the economy without doubt was based on agriculture. In spite of this, relatively little is known about agricultural tools. Sickle-blades (Fig. 4.10),[58] axes,[59] adzes[60] and tridents (forks, Fig. 4.9)[61] can be identified clearly as agricultural implements in metal. Some knives could also have been used for agricultural and pastoral purposes (Fig. 4.11). In Hittite sites, no chert or flint sickle-blades have been found and we have to assume that sickle-blades generally consisted of metal. In contrast, no metal tools can be securely identified as digging tools, such as spades or ploughshares, even if sometimes adzes have been considered as hoe-like tools for working the soil.[62] Judging from earlier and contemporary evidence from the Near East, the cattle-drawn

[52] Neve 2002, 93. A bronze tool, the purpose of which is not clear (Neve 1992, 336, Abb. 34, also represented hypothetically as leather-knife on our Fig. 4.8), could have been used as blade of a pendulum saw (see Schwandner 1991, Abb. 6).

[53] Neve 1989.

[54] See Erkanal 1977; A. Müller-Karpe 1993.

[55] Neve 1989, 402; 2002, 94

[56] Neve 1993, 29 and Abb. 70.

[57] Neve 1989, 405.

[58] Boehmer 1972, 126-27.

[59] Boehmer 1972, 35-36, Taf. II.

[60] Boehmer 1972, 37-38, Taf. II.

[61] Yalçıklı 2000. Ordinary forks for daily work were certainly made of wood, not metal. The inscription on one of the bronze tridents clearly relates this object to harvest work, but possibly in a more ritual context.

[62] Brentjes 1952-53, 461. See also A. Müller-Karpe 1993.

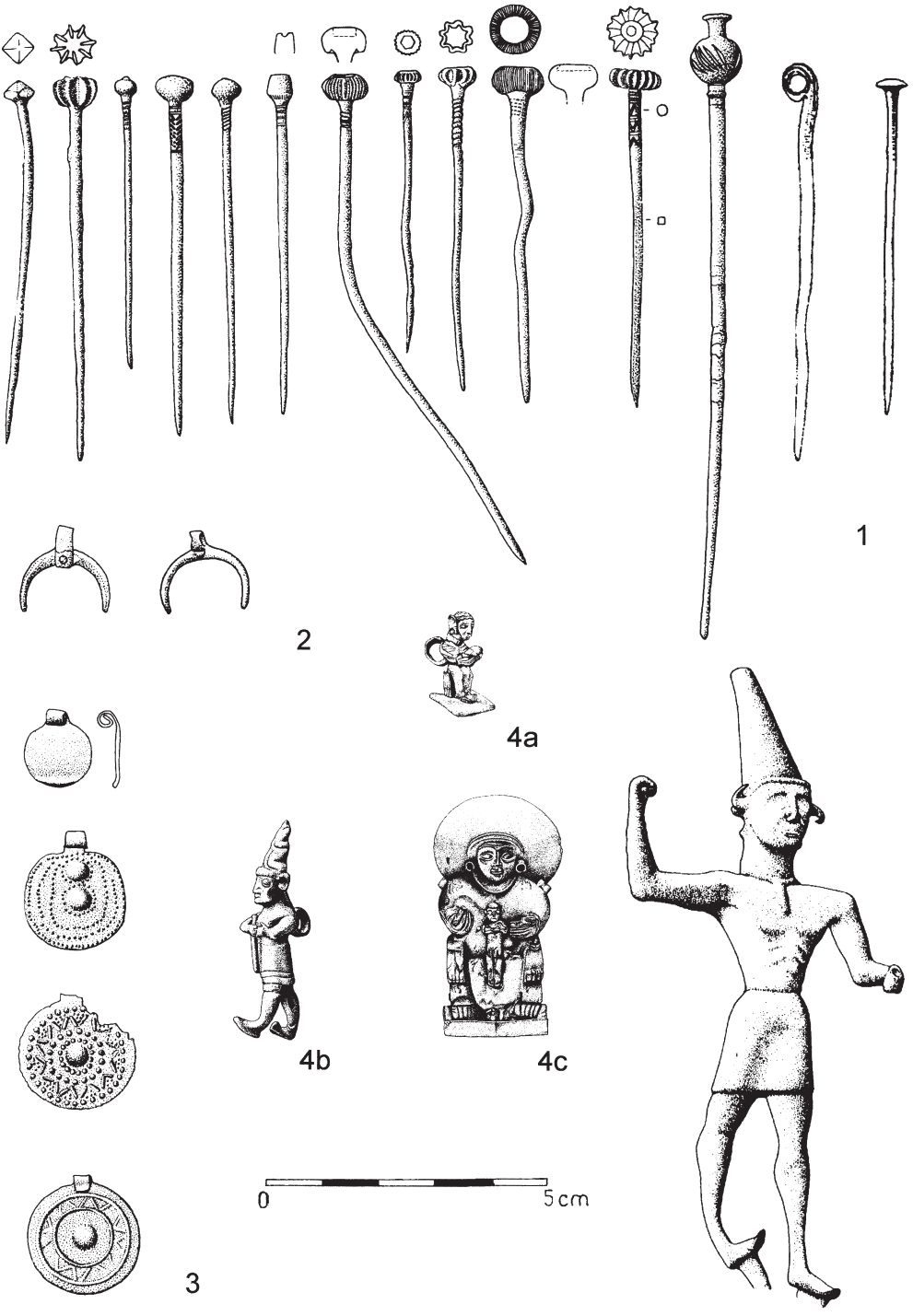
plough surely must have existed in Hittite Anatolia,[63] but obviously it was made entirely of wood.

Weapons

Metal played an important role in the manufacture of weapons in the warfare of the Bronze Age.[64] The most frequently found offensive weapon in Hittite sites are arrowheads.[65] Spearheads had a long tradition in Anatolia. While spearheads from the first half of the 2nd millennium BC were hafted by means of a tang, with two slots in the blade providing additional support,[66] most of the Late Bronze Age spearheads were socketed.[67] Daggers and knives show a similar development. In the first half of the 2nd millennium BC the handles (normally of organic material) of daggers and knives were attached with simple rivets to the blade, but later the blade and hilt were cast in one piece, with inlays of wood or bone in the hilt.[68] In the 13th century BC more sophisticated short swords with a tang and crescent-shaped hand guard became popular throughout the whole eastern Mediterranean, except for the Aegean.[69] The more complicated weapons with flanges and sockets required bivalve moulds and additional cold hammering for their production. Battle-axes are characteristic weapons of the Hittites in the 2nd millennium BC. They are shaft-hole axes with a comb-like projection on the back.[70] Two-piece moulds were used

[63] Brentjes 1952-53.
[64] See the contribution by Lorenz and Schrakamp in this volume, pp. 136-38.
[65] Boehmer 1972, 104-05, Taf. XXVI-XXX; A. Müller-Karpe 1999, 66.
[66] See, for instance, the so-called Anitta dagger from Kültepe (Erkanal 1977, Taf. 14.2), which in fact is a spearhead.
[67] For example Boehmer 1972, Taf. XIII, no. 207.
[68] Boehmer 1972, 41-45 and Abb. 22.
[69] Niemeier (2002, 298) assumed that this type is Hittite, while Geiger (1993, 217) supposed these swords to originate from northern Syria, based on the distribution of this type.
[70] Erkanal 1977; Yıldırım 2001, 132-34.

Fig. 5. Ornaments and figurines (same scale):
(1) Various types of pins from Boğazköy (after H. Müller-Karpe 1980, Taf. 171.21-32; Boehmer 1972, Taf. XXI.469; Taf. XXII.519);
(2) Crescent-shaped pendants from Boğazköy (after H. Müller-Karpe 1980, Taf. 171.34-35);
(3) Round pendants from Boğazköy (after H. Müller-Karpe 1980, Taf. 171.38-40, 42);
(4) Amulet figurines; (4a) Gold pendant depicting sitting goddess from Kayalıboğaz/Boğazköy;
(4b) Bronze pendant depicting standing god. Anadolu Medeniyetleri Müzesi, Ankara;
(4c) Gold ornament depicting sitting goddess with a child. Metropolitan Museum of Art, New York (after H. Müller-Karpe 1980, Taf. 173.1-2, 4);
(5) Bronze statue of standing god from Dövelek. Anadolu Medeniyetleri Müzesi, Ankara (after H. Müller-Karpe 1980, Taf. 176, A5).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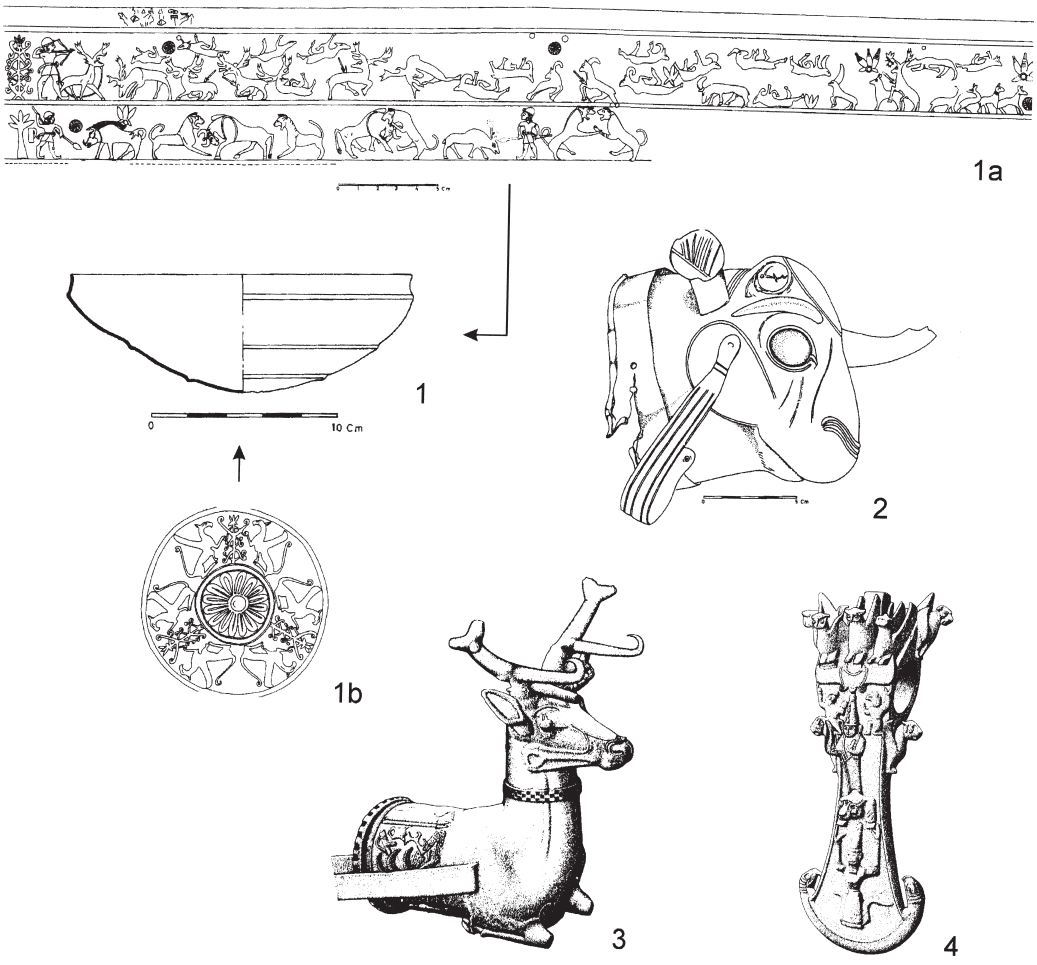

Fig. 6. Cultic vessels and weapon (to same scale): (1) Bowl from Kınık. Kastamonu Museum (after Emre and Çınaroğlu 1993, figs. 22-23); (2) Ox-head shaped rhyton from Kınık. Kastamonu Museum (after Emre and Çınaroğlu 1993, fig. 3a); (3) Silver rhyton from 'Anatolia'. Metropolitan Museum of Art, New York (after H. Müller-Karpe 1980, Taf. 176, A2); (4) Ceremonial axe from Şarkışla(?). Vorderasiatisches Museum, Berlin (after Erkanal 1977, Taf. 20).

to produce these weapons. Of the defensive weapons illustrated in the iconographic record or referred to in texts, just bronze armour-scales have been found at Boğazköy and Korucutepe.[71]

Further Evidence for the Use of Metal

Other objects of daily use also were produced in metal, such as vessels,[72] styli for writing[73] and straw-tip beer-strainers.[74] The latter consisted of perforated and rolled sheet-metal, which were set on the tip of a drinking tube made of organic material, in order to filter impurities and foam from the beer.

Ornaments and jewellery frequently consisted of metal. Pendants are mainly round (Fig. 5.3) or crescent-shaped (Fig. 5.2), possibly representing the sun, stars and the crescent moon.[75] These types of ornaments have a long tradition in the ancient Near East and in addition to their decorative function might also have served as amulets. Pins are capped with various forms of heads, such as conical, spherical, pyramidal, lentil, mushroom, disc, dice or rolled (Fig. 5.1).[76] Earrings and finger rings also belonged to the personal ornaments.[77] Few gold ornaments were found at Hittite sites. Some splendid examples of gold objects are several finger rings[78] and several small gold figurines from Boğazköy (Fig. 5.4a)[79] and Karkamiš.[80] Compared with the frequent references to precious metals in written documents, the actual finds are very few.

Cultic objects, such as depictions of deities and various objects used in ceremonies were also frequently made of metal. Figurines in metal representing deities either show standing gods with a raised arm or sitting goddesses (Fig. 5.4-5).[81] Vessels used for cultic purposes such as rhyta (Fig. 6.2-3)[82] and cultic bowls (Fig. 6.1),[83] sometimes made of precious metals, show the high achievement of Hittite metalworking technology, namely lost-wax casting,

[71] Boehmer 1972, 102-03, Taf. XXV. See Lorenz and Schrakamp in this volume for an extensive discussion, p. 140.

[72] For example, see Emre and Çınaroğlu 1993.

[73] For example *Die Hethiter und ihr Reich* 2002, no. 146.

[74] A. Müller-Karpe 1999-2000, 109, Abb. 21.

[75] Detailed overview in Boehmer 1972, 19-20, Taf. I.

[76] Boehmer 1972, 79-80, Taf. XVII-XXII with typological table (Abb. 33).

[77] For example Boehmer 1972, 119-20, Taf. XXXV, nos. 1041-1042.

[78] Bittel 1976, 236-37; *Die Hethiter und ihr Reich* 2002, nos. 137-138.

[79] Bittel 1976, Abb. 171; *Die Hethiter und ihr Reich* 2002, no. 117.

[80] Bittel 1976, 211, Abb. 242-245.

[81] Bittel 1976, 161-62, Abb. 170-171, 173.

[82] For instance the silver rhyton in the Museum of Fine Arts in Boston (Bittel 1976, 160 [Abb.169]).

[83] Emre and Çınaroğlu 1993.

cold-hammering, repoussé, gilding, chasing and brazing. Shaft-hole axes with plastic decorations, certainly used in ritual or ceremonial contexts, such as the example from Şarkışla (Fig. 6.4),[84] also serve to illustrate the high technological achievements of lost-wax casting.

Important treaties normally were recorded on tablets made of bronze, silver or even gold. The only example that has been preserved is a bronze tablet from Boğazköy, recording the treaty between the Great King Tutḫaliya IV and Kurunta, king of Tarḫuntašša.[85]

THE HITTITES AND EARLY IRON METALLURGY

According to the textual evidence (above), the Hittites seemed to have had a highly developed iron industry. It is often assumed that they may have played a pioneering role in the development of iron metallurgy.

J.C. Waldbaum[86] and recently Ü. Yalçın[87] have collected the evidence for iron artefacts before the beginning of the Iron Age (*ca.* 1200 BC) in Anatolia. Up to now some two dozen Anatolian iron finds from the latter half of the 2nd millennium BC have been published, originating mainly from Alaca Höyük, Boğazköy and Korucutepe, but we should be aware of the fact that most of these objects originated from stratigraphically insecure contexts and that their dating should be taken with a pinch of salt. Compared with earlier periods, the number of iron objects clearly increased in the Late Bronze Age. Interestingly, many of these iron artefacts were tools and weapons, such as chisels, axes, nails, spear- and arrowheads, daggers and knives, while in earlier periods iron was mainly used for prestige objects and ornaments. This archaeological evidence could support the evidence from the written sources. Thus some development in iron metallurgy seems to have taken place during Hittite Empire period. However, it has to be emphasised that iron objects still were relatively rare in the Hittite period, when compared with the enormous quantity of bronze artefacts, and we might conclude that iron was still exceptional even in the Empire period.

'Black iron', which is mentioned in written documents, has sometimes been interpreted as meteoric iron. The archaeological finds do not allow any conclusions to be drawn about the nature or origin of this material.[88] However,

[84] Bittel 1976, 299, Abb. 341; *Die Hethiter und ihr Reich* 2002, no. 147.
[85] Otten 1988.
[86] Waldbaum 1980.
[87] Yalçın 1999; 2005 (more extensive).
[88] Yalçın 1999; 2005, 499.

judging from its quantities mentioned in written texts, it is hard to conclude that it was indeed of meteoric origin.

Little archaeometallurgical analysis of Hittite iron artefacts has been undertaken.[89] Some metallographical analyses of speiss and artefacts from Boğazköy[90] indicate that Hittite metallurgists lacked a good knowledge of or control over the smelting process, and did not understand the process of carburisation, which is indispensable for producing steel. There is no clear evidence for the deliberate production of steel until the 1st millennium BC, even if steel has been reported from Level III (dated approximately to the whole 2nd millennium BC) at Kaman Kalehöyük in central Anatolia.[91] The Hittite term 'first-class iron' (AN. BAR.SIG$_5$) might refer to steel, which may have been produced occasionally, but we cannot yet prove this assumption.

The nature of the Hittite iron industry still raises many questions. Answering them may also be important for solving the problem of when, where, and how the Age of Iron in ancient Near East began.

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[89] Recently, Ünsal Yalçın analysed a 'Hittite' iron sword at the Ruhr Museum in Essen and concluded that the 'damast' technique (making 'Damascus Steel' with lamination) was already known in the Hittite period (Yalçın 2005, 449, Abb. 7-8). This sword, however, was not excavated but bought from the art market. It seems to originate from north-western Iran (or eastern Anatolia?) and to date a little later (about the turn of 2nd and 1st millennia BC?) based on the shape of its haft (Medvedskaya's Type V: Medvedskaya 1982, 73-74), 'bimetallism' and the 'casting-on' technique (Maxwell-Hyslop and Hodges 1964).

[90] Muhly *et al*. 1985.

[91] Akanuma 1995; 2002.

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