

# 13. Ivory and related materials

OLGA KRZYSZKOWSKA [SCIENTIFIC ANALYSIS] AND ROBERT MORKOT [EGYPTOLOGY]

## Introduction

Ivory is a dense and fine-grained material, suitable for carving in the round or in relief, and is ideal for making inlays and veneers, where its natural white colour contrasts well with wood and other materials. Strictly, usage demands that the term 'ivory' be reserved for the dentine of elephant tusks alone; but a somewhat looser definition, encompassing the dentine of other large mammals – hippopotamus, walrus, sperm whale – is gaining acceptance. This allows greater flexibility in discussing and describing the materials and their uses; and moreover, has become essential given recent attention to the role of hippopotamus tusk as a source of ivory in antiquity (e.g. Caubet and Poplin 1987; Krzyszkowska 1988, 1990). Thus whenever possible the terms elephant ivory and hippopotamus ivory should be adopted; but, unqualified, 'ivory' may serve as a useful generic term when distinctions are neither desirable nor practical (e.g. 'ivory workshops').

By Dynastic times, if not earlier, the elephant had become extinct within Egypt proper. Elephant ivory was therefore an import: but several potential sources existed – in Africa itself and also in western Asia. By contrast the hippopotamus was indigenous to the Nile; extinction in the Delta occurring in the seventeenth century AD. It is unlikely that the ivory of other large mammals (e.g. walrus or indeed mammoth) attested in northern Europe, ever reached Egypt. For the use of 'related materials' the evidence – at present – for boar's tusk is scanty; for antler (the boney outgrowths on the skulls of deer) non-existent. But bone itself – readily available as a by-product of hunting and husbandry – is attested in a range of finds, some utilitarian, others decorative. Horn, too, is known from Egyptian contexts: while also an animal product, it is not 'related' to bone and ivory in the physical sense, being a keratinous substance akin to that of hooves.

Until recently, few attempts had been made to identify the types of ivory used in the ancient world, Egypt included. Even today, no systematic study of Egyptian ivories exists; most published objects are described simply as 'ivory' (and behind this label may well lurk objects that are really bone). This lamentable state of affairs seems all the more

surprising since the hippopotamus is amply attested in Egyptian art and iconography, and the tusks themselves are easily recognised. However, the poor record of interest and publication inevitably hampers any attempt to discuss the development of ivory-working throughout Egyptian history. Changing sources, patterns of exploitation and use are exceedingly hard to verify. Impressions may indeed be formed from museum catalogues or casual study of displays, but these rarely (if ever) constitute an adequate or representative sample. By stark contrast, ivories from the eastern Mediterranean and the Aegean have been well studied in recent years (e.g. Caubet and Poplin 1987, 1992; Caubet *et al.* 1987; Poursat 1977a, 1977b; Krzyszkowska 1988; 1990). Special attention has been devoted to accurate identification of the types of ivory represented in the archaeological record, to changing patterns of use over time, to regional variations, to manufacture methods, and to workshop material (Krzyszkowska 1992). While full documentation remains a distant (and perhaps unrealistic) goal, significant progress has been made. Certainly, the general trends of ivory use are now fairly clear for the Aegean, Cyprus, the Syro-Palestinian coast, and to a lesser extent Anatolia (Caubet 1991; Bourgeois 1992). Moreover, some general developments seem to be mirrored in Egypt itself, such as a marked increase in elephant ivory in the middle of the second millennium. Egypt, as a major importer, user and 'exporter' of elephant ivory, undoubtedly had some effect on the availability of this material in adjacent areas. Egypt also seems the most probable source of hippopotamus ivory used in Minoan Crete during the third and second millennia BC. Thus a detailed and systematic study of Egyptian ivories would be welcome not only to Egyptologists but also to a wider audience. The present account is meant as broad overview of our current knowledge, often patchy and incomplete; it may perhaps encourage specialist studies in future.

## Identification

The accurate identification of ivory and related materials is based on a study of morphology and structure (Krzysz-

kowska 1990). The tusks of elephant and hippopotamus are distinctive, both in size and shape. Their features may be preserved, or reflected, to a greater or lesser extent in finished objects. A circular box (*pyxis*), for instance, may take its shape from the hollow end of an elephant tusk; 'wands' and 'clappers' preserve the natural morphology of hippopotamus lower canines with little modification. The shape of hippopotamus incisors makes these tusks ideal for small cylindrical vessels (e.g. Kohl tubes) and handles. In other cases it is possible to exclude a particular material on morphological grounds: a bone yielding insufficient solid material for making a large plaque or carving in the round. This approach demands little more than a familiarity with the morphological features of the raw materials and a good dose of common sense. Moreover, by studying the interplay between natural morphology and finished shapes, we may gain insight into the selection of raw materials and manufacture methods (see Krzyszkowska 1988, 1990).

A second line of study requires some knowledge of the structures of dentine and bone in their unworked state. The tusks of elephant and hippopotamus are teeth of continuous growth, and thus the dentine is laid down in a series of layers, termed lamellae. The patterns and appearance are quite distinctive, especially in freshly cut sections and under low (e.g.  $\times 2-4$ ) magnification (Penniman 1952; Krzyszkowska 1990). The challenge is to recognise these in finished objects, where the patterns may be obscured or obliterated by decoration or tool marks, and where the appearance may be altered by the effects of deposition. Extremes of humidity and acidity can cause ivory and related materials to decay, although sometimes the effects may aid identifications, e.g. the distinctive cone-in-cone splitting of elephant tusk, and the cracking along the natural fracture line of hippopotamus lower canines. However, it must be recognised that even expert examination will not yield firm identifications in every case. Phrases such as 'ivory, type uncertain', or 'bone/ivory' are entirely acceptable, for they are honest and will not mislead.

As indicated, hippopotamus tusk and bone are both locally available in Egypt, while elephant tusk had to be acquired further afield. For the second millennium BC, the two potential sources were Africa itself and western Asia. Despite the fact that two different species of elephant are involved (*Loxodonta africana* and *Elephas maximus*), there is no reliable means for distinguishing their ivory. Trials have been undertaken with isotopic analysis on modern African specimens in attempts to combat poaching (van der Merwe and Lee-Thorpe 1990; Vogel *et al.* 1990), but the application of these methods to archaeological finds is not feasible. While claims have also been forwarded that *fresh* Asian and African ivory can be distinguished visually (Penniman 1952: 13-20), there are no grounds for hoping this could ever be achieved with archaeological material: quite the

contrary. Tusk size and shape are equally unreliable indicators, yet these have been used as 'criteria' for ascribing tusks and finished objects from archaeological contexts to a particular species or sub-species (Krzyszkowska 1990: 17, 28 n. 11). In modern, well-documented populations, considerable variations have been recorded within relatively small distances: ecological pressures play a role, as do more predictable factors such as age and sex. Weights and dimensions given in certain ancient sources are almost worthless, since no indications are given as to where the tusks had been cut or how the measurements were taken (e.g. across, from end to tip; or along the outer curve). Nonetheless it is fair to say that the largest tusks of the Bush elephant (*L. africana africana*) will exceed those of the Forest variety (*L. africana cyclotis*) and those of the Asian species (*E. maximus*). Some ivories from archaeological contexts (e.g. Nimrud) are so large in diameter that the tusks of the Bush elephant do seem to be the most probable source. The section of tusk from the Ulu Burun wreck of the fourteenth century BC (Bass 1986: 282-3, ill. 18) measures fifteen centimetres in diameter and has been cut beyond the pulp cavity. A block from Mycenae comes from a tusk of comparable size, with an estimated diameter of about 18 cm at the pulp cavity (Krzyszkowska 1990: pl. 7, 1992: 26, pls. 1a-b). On *modern* criteria, the Bush elephant would be more likely to yield tusks of this size; whether we may safely say the same for the later second millennium BC is far from clear. Our inability to be more precise is irritating, since key issues are at stake here: patterns of acquisition and long-distance trade to Egypt and beyond its shores.

### Evidence

Our evidence for the use of ivory and related materials in ancient Egypt is derived from various sources, none wholly satisfactory. Finished objects are central to any inquiry; but, as already indicated, information is limited by the paucity of accurate identifications. For the origins of the ivory itself, we are dependent on a jigsaw of vague and sometimes conflicting data. Documentary and pictorial evidence exists from Egypt itself, western Asia and from the later Classical world; but rarely do the concerns of the ancient sources coincide with our own questions. Rigorous and critical analysis is always required. Another approach is to consider the known ecological requirements of the species in question and set these against our undeniably patchy knowledge of ancient environments. The resulting picture may be broadly correct, but blurred around the edges. Firm osteological evidence is, not surprisingly, rather rare – except in the case of the domesticates. Finally, the following *caveat* must be borne in mind: the patterns of acquisition and exploitation certainly varied over time. Local and regional variations are also to be expected.

## Elephant ivory: sources

### *The Asian elephant (Elephas maximus)*

The role of the Indian subcontinent as a supplier of ivory to the west is poorly documented. Some Indian ivory probably reached Assyria through Babylonia in the first millennium and was used in Achaemenid Persia. The foundation texts of Darius I, from Susa, name India, Arachosia and Kush as sources of ivory used in the palace (see Morkot 1991: 325). The Biblical Ophir, where the fleets of Solomon and Hiram obtained exotica, including ivory, has also been identified with the Indian subcontinent (see Barnett 1982: 9, esp. n. 4; Groom 1981: 48–54). This, however, is unlikely, as are identifications with Oman (Groom 1981: 49–51) or Malaysia (Groom 1981: 49). Ophir was probably situated along the African coast of the Red Sea and perhaps corresponds to the same area as the land described by the Egyptians as Punt (so Groom 1981: 231). Following Alexander's campaigns, actual elephants were brought overland to Seleucid Syria for use in war (Barnett 1982: 5, 65); ivory may well have followed the same route. Falling ivory prices in the Hellenistic period suggest increasing supplies from this quarter, although the activities of the Ptolemies along the Red Sea coast (see p. 326) perhaps also opened up the African trade (Barnett 1982: 65). By the time of the Roman empire, the Indian subcontinent was a major – though not exclusive – source of ivory used in Roman workshops (Barnett 1982: 68–9). Rome also imported east African ivory, although the trade was now dominated by the kingdom of Axum, with ports on the Red Sea. This change from the Nile to the Red Sea routes may have coincided with greater exploitation of the Forest elephant than the Bush elephant.

In ancient times elephants also existed in western Asia, although the nature and distribution of the animal are much debated (Krzyszkowska 1990: 15–16 with earlier references). The so-called 'Syrian elephant' has been seen by some as a distinct subspecies of the Asian elephant (i.e. *E. maximus assurus*). However, this identification rests on dubious grounds, namely tusk shape and representations of the animal, e.g. in the Theban tomb of Rekhmira, the vizier of Thutmose III (TT100, see below). Osteological work has been limited, but molars found at Ugarit suggest that the elephant of western Asia was identical to the living species (*E. maximus*). The distribution and size of populations are hard to gauge; estimates are based on the known environmental needs of modern elephants and presumed ancient conditions. These suggest a possible range from north and west Syria, including the Amuq plain, stretching into the foothills of the Zagros range and down onto the Assyrian plain to southern Mesopotamia. However, overall population density is hard to gauge, and it is equally problematic to estimate how much ivory was available from this source. In the middle to late second millennium BC, local centres of ivory working developed along the Syro-Palestinian

coast (e.g. Ugarit), and Cyprus and the Aegean were also potential users.

In the Asian species tusks are borne by males alone; and in some modern populations (e.g. those under pressure) scarcely 50 per cent carry tusks. While it is extremely dangerous to generalise about tusk size, those of the Asian species tend to be small (at least compared to those of the Bush elephant; see p. 321). Nonetheless ivory from western Asia undoubtedly reached Egypt in the Late Bronze Age. On the reliefs of Hatshepsut at Deir el-Bahari, tusks are listed among the tribute received by Thutmose I from the land of Niy, and an inscription from the reign of Thutmose III boasts that 120 elephants were killed for their ivory, also in Niy (Gardiner 1947: I, 158–9). Although the exact location of Niy is debated, the Orontes Valley seems most likely. Syrians and, somewhat more surprisingly, Keftiu (Minoans?), were shown bearing tusks as tribute in the tomb-chapel of Rekhmira. While the small elephant accompanying the Syrians does reflect some artistic confusion (i.e. it may be a juvenile, rendered incorrectly with tusks, or an adult shown at well under life size), its domed head and small ears are clearly those of the Asian species (Krzyszkowska 1990: 14, fig. 2; 27 n. 5). Ivory was also depicted as part of the 'tribute' received from the rulers of western Asia, but is impossible to quantify. The Amarna letters refer to very few ivory objects (e.g. EA25; see Moran 1992: 78 *rhyta*) being sent by Asiatic rulers to Egypt. One letter (EA40; see Moran 1992: 113) records three pieces of ivory sent by a high official from Alashia (Cyprus?) as a greeting-gift to the Egyptian vizier, but this is not evidence for substantial exchange of ivory between the countries. It is impossible to know whether these pieces were elephant or hippopotamus ivory, although its source was probably western Asia.

The elephant of western Asia seems to have become extinct in the early first millennium BC; whether this happened, through overkill or increasing environmental pressures cannot be said (Barnett 1982: 164–6; Miller 1986; Krzyszkowska 1990: 28 nns. 8–9). One of the latest pieces of evidence – though by no means unequivocal – is the elephant from Musri, depicted on the Black Obelisk of Shalmaneser (853–824 BC) in the British Museum (WA 118885). Whether the toponym Musri is in this case referring to Egypt or to an Asiatic country has been a subject of constant debate, and the other tribute of Musri depicted on the obelisk confuses rather than aids the identification. Tadmor (1961) argued that in all later Assyrian sources Musri is understood as Egypt, and in relation to the Black Obelisk and its elephant he has generally been followed (e.g. Collon 1977: 220, n.16, cautiously; Caubet and Poplin 1987: 298; Morkot 1998). However, others (e.g. Barnett 1982: 7, pl. 1b) still regard a location to the northwest of Assyria as more probable, since the beast clearly belongs to the Asian species, with a domed head and back, and small high-set ears (Krzyszkowska 1990: 18, fig. 3).

By contrast, the al-Mina 'tusks', on which many com-

mentators built a case for the Syrian ivory trade of the eighth century BC, are in reality far less exotic, since they are actually the horn cores of water buffalo and domesticated cattle (Francis and Vickers 1983 with earlier references; cf. esp. Barnett 1982: 11, pl. 1c). There are strong indications that the prosperous centres of Syria–Palestine and Assyria had long since turned to other sources – notably Africa – for their supplies of ivory.

### **The African elephant (*Loxodonta africana*)**

There are two types of African elephant; the Forest elephant (*L. africana cyclotis*) and the Bush elephant (*L. africana africana*), but there is considerable confusion in the literature as to their distribution and exploitation in ancient times. Ancient accounts of the Battle of Raphia in 217 BC describe the Ptolemaic elephants as smaller than the Asian elephants of the Seleucids. Since the Bush elephant is undoubtedly larger than the Asian species, the Ptolemaic fighting elephants were evidently of the Forest variety, as Scullard rightly argued (1974: 24–6, 61–2, 143–4; cf. Krzyszkowska 1990: 16–17, 28 n. 10). These seem to have been obtained from the hinterland of Ptolemais Theron and shipped down the Red Sea. However, it is quite wrong to suppose that the Forest variety alone was known to, and exploited by, the people of the ancient world. In Pharaonic times, some ivory probably followed much the same route as later, i.e. via the Red Sea from Punt. Thus, some tusks may have been of the Forest variety; but Punt probably also exploited eastern parts of the Sudanese savanna and the Butana, which would have been likely habitats of the Bush elephant. However, the bulk of Egyptian ivory was imported via Nile routes from the gathering places in Upper Nubia. These were, in the earlier periods, Yam and Kerma, and in the vice-regal period Napata and the towns of the Abri–Delgo Reach. There can be little doubt that the major sources of this ivory must have been located in the savanna lands of the central Sudan, and perhaps regions farther afield such as Darfur and Kordofan. These would have been the habitats of the Bush elephants. It is, however, worth noting that changes in source can be dictated by the over-exploitation of regions, their abandonment as hunting grounds and the consequent renewal of stocks (Burstein 1996).

Further confusion as to the sources and exploitation of ivory in the Pharaonic period has been introduced by Hayward (1990). Hayward's article, aimed primarily at an Aegean audience, states that there is no documentary evidence to indicate that Egypt was exporting raw ivory (i.e. unworked tusks) during the Late Bronze Age, but this ignores the limits and nature of the sources. She argues, on rather tenuous grounds, that the people of the Aegean may have obtained ivory from North Africa. In this connection she discusses an obelisk inscription of Hatshepsut, which records the capture of 700 tusks from the Tjehenu-Libyans

(Hayward 1990: 107). She suggests that this was either Libyan ivory coming from further west (i.e. Tripolitania) or alternatively that it came from further south, and was en route to the Mediterranean. Certainly from the Roman period there is evidence for the Forest elephant much further west along the Mediterranean littoral, from Tripolitania to the Atlantic coast, as far inland as the Atlas foothills (Krzyszkowska 1990: 18; Gill 1992: 233). The Hatshepsut obelisk inscription must be referring to activities much closer to the Nile valley and the most likely explanation is that the ivory was being brought along the desert road through the Kharga Oasis from the south (for this route see Morkot 1996). Although 700 tusks does seem a sizeable shipment, we lack contemporary sources which similarly quantify the trade, and the vast quantities of ivory objects attested in the Amarna Letters must have required regular consignments on a considerable scale. Evidence for the ivory trade in the nineteenth century AD indicates that significantly larger quantities were being collected regularly (e.g. Petherick 1861). Egypt certainly imported large quantities of ivory from the south, and received some from western Asia. It seems very likely that unworked tusks were exported, although the documentary evidence is lacking. The major documentary source is the Amarna archive (Moran 1992), which reflects only one aspect of international commodity exchange in the Late Bronze Age (royal gift exchange, often in relation to marriage). In these letters, with the exception of gold and occasionally ebony, the Egyptian 'exports' are all manufactured goods. It is dangerous to conclude from this that raw materials were not exported.

### **Elephant ivory: procurement and use**

As already indicated above, the most likely source of elephant ivory throughout the Dynastic period was the central Sudanese savanna, but early instances of ivory use (e.g. by the A-Group) may represent exploitation of local supplies, rather than long-distance trade. At least this is the inference to be drawn from the rock-drawings of Lower Nubia and other Predynastic representations of elephants (e.g. on the 'Carnarvon knife-handle', see Bénédite 1918, pls. I–II; Krzyszkowska 1990: 17, fig. 4; 28 n. 12). These point to the survival of the elephant in Upper Egypt and Lower Nubia until increasing aridity early in the Old Kingdom drove them further south. If the Predynastic Upper Egyptian Kingdom stretched only as far south as Gebel el-Silsila, then Abu ('the elephant', i.e. the early settlement of Elephantine at Aswan) would have been an Egyptian trading post within Nubia.

Objects of ivory and bone are rather common in Predynastic and Early Dynastic graves and are among the most important finds from the 'main deposit' at Hierakonpolis. The latter were caked with crystalline mud and consolidated soon after excavation with boiling wax:

their condition long impeded serious study (see Penniman 1952: 16). Happily, those at the Petrie Museum have been cleaned, studied and thoroughly published (Adams 1974: 59–75); and a programme of cleaning and conservation has been undertaken recently for the pieces in the Ashmolean. Payne's catalogue of the Predynastic collection at Oxford (1993) includes identifications of the materials. Other groups of early 'ivories' have also been studied, e.g. those at the Walters Art Gallery in Baltimore (Randall 1985) and those in the British Museum.\*

Thus, documentation for the early period – while still far from adequate – is probably better than for any other era in Egyptian history. While hippopotamus tusk evidently accounts for a substantial proportion (see below), some elephant ivory is attested, especially for carvings in the round. For instance, several female figurines in the British Museum, including a 'dwarf' (Barnett 1982: pl. 5b) are 'probably elephant ivory' (ID-OHK 92). And 'gaming pieces' in the form of lions from Abydos (First Dynasty) also appear to be made of elephant ivory (BM EA52920; Spencer 1980: cat. no. 497, ID-OHK 92; Drenkhahn 1986: cat. nos. 67, 70, Abb. 6–7). But since most of the items are rather small – morphologically feasible in hippopotamus ivory or even bone – only first-hand inspection can yield firm identifications. Certainly other examples of the same types do exist in hippopotamus ivory, e.g. 'dwarfs' (Walters Art Gallery 64093; Randall 1985: cat. nos. 12–14) and lions (BM EA16181; Spencer 1980: cat. no. 498, ID-OHK 92; Petrie Museum UC 27619; Adams 1974: cat. nos. 356–8). Occasional examples of 'cosmetic items' have also been identified as elephant ivory (e.g. Ashmolean 1911.373; Payne 1993: cat. no. 1927, short-toothed comb), but hippopotamus ivory and bone seem the more usual materials. In rare cases, the use of elephant ivory permitted fairly sizeable objects to be made, e.g. a relief plaque, measuring 17.5 × 12.5 cm (Petrie Museum UC 14868; Adams 1974: cat. no. 359). But at this stage it is difficult to ascertain the factor(s) which influenced selection and use. Thus, the aim of future studies must be to explore further the interplay between elephant and hippopotamus ivory (and bone) during the fourth and third millennia; noting in particular any chronological or regional variations in the range of end-products from each material.

Climatic changes which occurred during Early Dynastic times affected not only Egypt proper but also Nubia. Increasing desiccation of the regions flanking the river would have forced elephant populations southwards, though they may still have been present in Dongola at the time of the

Early Kerma kingdom. The commodities brought by Harkhuf from Yam included incense, ebony and elephant tusks. If we follow the theory put forward by David O'Connor (1986), locating Yam in the Berber-Shendi Reach, then Harkhuf's journey would have taken him close to the source of the commodities. If, however, we adopt the more traditional view that Yam was in the Kerma region, if not Kerma itself, then we must assume that the rulers were already engaged in long-distance trade with the regions further south. Certainly by the Middle and Classic Kerma periods, the rulers of Kerma were effectively acting as middle-men, procuring ivory from source and supplying it to Egypt to the north. It seems likely that by this time (i.e. Middle Kingdom – Second Intermediate Period), if not earlier, no elephants were to be found in the Nile Valley north of the Nile–Atbara triangle. Eventually, the Kerma rulers came to dominate long-distance traffic in ivory, cutting out the principality of Thebes and communicating directly with the rulers of Avaris, perhaps using a combination of desert and Nile routes, but the extent to which these presumed patterns of acquisition are reflected in the surviving products of the ivory industry is impossible to say, since documentation for this period is rather poor.

By the Eighteenth Dynasty at the latest, all elephant ivory reached Egypt by long-distance 'trade'. However, Egyptian domination of large parts of Nubia in the New Kingdom meant changes in the way this 'trade' operated: some ivory was now paid as part of the 'tribute', and some was received as 'gift'. Texts of this period record ivory coming from a variety of southern countries: the Nehesy lands, Kush, the South Countries, God's land and Punt. These are imprecise locations, but, in any case, indicate the immediate, rather than the ultimate source. From collecting points in Nubia it was usually shipped northwards, although there are some indications of the use of desert routes. Unfortunately we have little indication of the quantities involved on any occasion (see p. 323 for the Hatshepsut obelisk recording 700 tusks seized from the Tjehenu-Libyans). However, elephant ivory was certainly one of the most valuable of the Kushite exports and may well have been the most important. Moreover our documentary evidence for the acquisition of ivory in western Asia also dates to the Eighteenth Dynasty: the great hunt of Thutmose III, and as 'tribute' or 'princely gift' (see p. 322). The overwhelming impression given by our documentary sources is of a marked increase in supplies of elephant ivory during the Eighteenth Dynasty. This is amply reflected in the archaeological record, both within Egypt and beyond. For instance, in the Aegean, elephant ivory is first securely attested in LBA I (c. 1600–1450 BC), with quantities increasing in LBA II–III (1450–1200 BC; see Krzyszkowska 1988: 228–33). Likewise in Egypt the greatest exploitation in the New Kingdom seems to belong to the reign of Amenhotep III and immediately after. Although the Amarna Letters and finds from the tomb of Tutankhamun

\* Objects of ivory and bone in the reserve collection of the British Museum Department of Egyptian Antiquities were inspected by O.H. Krzyszkowska in July 1992 at the kind invitation of the Keeper, Mr W.V. Davies. In the present account, the reference ID-OHK 92 indicates identifications made at that time. A complete list is lodged with the Department.

constitute unusually rich sources and may therefore skew our picture somewhat, the broad trends seem clear enough.

By the New Kingdom, ivory was used for substantial objects, such as the headrest of Tutankhamun and a variety of cosmetic items. Some were carved from solid pieces of elephant tusk and sizeable ones at that, such as the red-stained ivory 'water dish' from Tutankhamun's scribal equipment (diameter: 16.3 cm; see Reeves 1990: 166). Other large items are composite, but still using sizeable pieces of tusk, such as the ivory headrest representing Shu which is made from two pieces joined with a wooden dowel and four gold nails, the hieroglyphs and details being inlaid with blue pigment (total height: 17.5 cm, length: 29.1, width 9.0; British Museum 1972: no. 37; Reeves 1990: 183). Two game boards from Tutankhamun's tomb (KV62) were also carved from solid blocks of ivory, hollowed and fitted with small drawers to contain the gaming pieces. The dividers for the squares are integral, the squares having been chiselled out (Cairo JE62061, object no. 585; length: 13.5 cm, width: 4.2 cm, height: 2.8 cm; Tait 1982: 17-18, pls. VIII-IX; and Tait 1982: 1-17 pl. VIII object no. 393 this is slightly larger than 585).

There are examples of solid ivory furniture made from small elements, such as the 'folding stool' headrest of four cylindrical ivory duck-headed legs fitted into Bes-head terminals of stained ivory, the flexible neck support being made of three rows of stained ivory pieces (height: 19.2, length: 26, thickness: 10.5; Desroches-Noblecourt 1963: pl. XLIIb; Reeves 1990: 183). A small jewel box was made from a solid frame of blocks of ivory with ivory panels for the sides and lid (Desroches-Noblecourt 1963: pl. XXIIIb). More typical is the use of ivory as veneer and inlay in combination with ebony and cedar, as in the case of the portable chest (British Museum 1972: no. 14; Reeves 1990: 189), as well as the chair and footstool (British Museum 1972: no. 16). Thin veneer was glued, while thicker panels were held with ivory pins. The most elaborate use of small pieces of ivory is the veneered box from the tomb of Tutankhamun, with veneers of plain ivory making a frame for a panel of herringbone marquetry of over 45,000 ivory and ebony slivers (Reeves 1990: 191). Examples of small cosmetic objects, many of stained ivory, are closely similar to those described in the Amarna Letters, such as the one in the form of a trussed duck, with a swivel lid from the tomb of Tutankhamun (length: 8.5 cm; Reeves 1990: 158). Goose- or duck-shaped cosmetic boxes can be made in a variety of materials, with parts in ivory, but they also occur in western Asia either as imports or as locally made Egyptianising objects (see Bryan 1996: 50-4). Other similar objects, particularly those in the form of a 'swimming' girl with a duck, made of ivory, wood and ivory and wood alone, have generally been termed 'cosmetic spoons', but are now considered to be ritual implements (see now Kozloff and Bryan 1992: 331-64). Some items of jewellery were also

made of ivory, notably bracelets (see, for instance, Reeves 1990: 152).

From Ugarit, a series of bed-panels carved in low relief has been recovered (Caubet and Poplin 1987: 287, figs. 16-17). In the Aegean too, evidence from texts and finds alike point to the use of ivory (often in combination with other materials) to decorate fine furniture (Krzyszowska 1996: 99-102). There were undoubtedly marked regional differences in the styles of furniture and the way in which it was decorated. For instance, low-relief carving seems to be relatively uncommon in Egypt, a notable exception being a casket from the tomb of Tutankhamun (for body of box see British Museum 1972: no. 21; for lid see Desroches-Noblecourt 1963: pl. V). By complete contrast, in the Aegean, low-relief carving is commonly used to decorate furniture plaques and cosmetic articles alike. In this connection it is worth citing a wooden box lid decorated in low relief from Saqqara, either an Aegean import or carved locally under Aegean influence c. 1450 BC or later (Kantor 1947: 85, pl. XXIVA; Hood 1978: 115-16, fig. 101). Certainly in the international climate of the early LBA, the possibility of external influences from the Aegean or eastern Mediterranean on Egyptian traditions must be acknowledged. One type of carving not generally found in Egypt, but common in western Asiatic ivories is open-work in which the design is drilled and fully cut-through (*ajouré*). The only example of this period from Egypt seems to be the arm-band showing Thutmose IV smiting enemies in front of the god Monthu (Berlin ÄM 21685: length: 11.2 cm). The earliest western Asiatic examples appear to be those from Megiddo (discussed by Bryan 1996: 69-72, fig. 14) although most other western Asiatic Egyptianising ivories, like Egyptian ivories, carry incised decorations (Bryan 1996: 60-76, figs. 6-10).

Ivory continued to be depicted in the 'tribute' scenes of the Nineteenth and Twentieth Dynasties, but it has generally been assumed that with the end of the viceregal system in Nubia, ivory along with other exotica ceased to be exported to Egypt or arrived less regularly (*per contra* Morkot 1995: 184-6). There is a scarcity of ivories from the Third Intermediate Period, but aside from a presumed shortage of the raw material, other factors may also be at work, most significantly a change in burial customs. A decline in the craft has also been noted for western Asia during the Early Iron Age (Caubet and Poplin 1992: 94); here, however, the revival began much earlier, with the tenth to eighth centuries BC a veritable heyday (Herrmann 1986: 47-53). It has been generally accepted that the elephant was extinct in western Asia by this time (Barnett 1982: 164-6; Collon 1977). Both documentary and archaeological evidence, although far from unequivocal, points to Africa as the source of the ivory (Morkot 1998). Thus, the impact of 'availability' on the ivory industry of any given area is immensely hard to gauge. Great centres of carving very often arise in areas which lack local supplies; conversely, areas with adequate

supplies do not always make use of them. In Egypt, the hippopotamus always provided an alternative – if less versatile – source of ivory, but the extent to which this was exploited during the first millennium BC remains uncertain (see p. 327). The Late Assyrian emperors received ivory and elephant-hides as part of the tribute of the rulers of Phoenicia, and, although the supplies may not have been as regular (or as large) as they were in the New Kingdom (i.e. Late Bronze Age), there is no reason to assume that there was a total cessation of ivory coming from Sudan via Egypt (Morkot 1995: 185–6). There is ample evidence for the continued export of ivory from Sudan during the Egyptian Late Period and Ptolemaic period, but much of this was destined for use in Persia (Morkot 1991: 324–5) or Greece (Gill 1992; Oliver 1992; Burstein 1996; Morkot 1998). Despite the evidence for the export of ivory to the Mediterranean (presumably through Egypt), Barnett (1982: 22, pls. 8b, 10f. 11a) drew attention to the relative paucity of Late Period ivory work from Egypt itself: fine items are few and far between. A minor craft, then, not a major art; for originality and inventiveness – hallmarks of Egyptian ivories in the Pharaonic period – were by then increasingly rare.

### Hippopotamus ivory: sources and use

Swampy and riverine locations are the natural habitat of the hippopotamus (*Hippopotamus amphibius*). Now confined to sub-Saharan Africa, they survived in the Nile Delta until the seventeenth century AD and were last sighted in Upper Egypt within the past 100 years. Thus, it is reasonable to suppose that they were present throughout much of the Nile Valley, in both Egypt and Nubia, in ancient times (but cf. below). This is borne out by numerous representations of the animals from the Predynastic period onwards. Noteworthy are the Egyptian tomb paintings and reliefs depicting the harpooning of the hippopotamus (Säve-Söderbergh 1953; Krzyszkowska 1990: 21, fig. 6). Since hippopotami can cause considerable damage to crops, hunting them was effectively a form of ‘pest control’. Obviously this activity yields a useful by-product – ivory. But questions remain. Were tusks always collected after the kill? Were the animals sometimes killed expressly for their tusks? And were tusks ever traded from one part of the Nile Valley to another?

Aside from Egypt, small areas of Syria–Palestine also seem to have supported hippopotamus populations in antiquity. Of these, one was apparently located in the Amuq basin and Orontes Valley, providing a ready source of hippopotamus ivory for Ugarit (Caubet and Poplin 1987: 292–7) and thence to Cyprus. Extinction perhaps occurred early in the first millennium BC. Osteological remains found at Tel Qasile (near modern Tel Aviv) suggest the presence of a second (rather small?) population which evidently survived as late as the fourth century BC (Haas 1953). It is, however, unclear whether Syria–Palestine (and Cyprus) relied solely

on local supplies of hippopotamus ivory, or whether they ever had cause to obtain it from the Delta. The Ulu Burun shipwreck of the late fourteenth century BC has yielded a number of hippopotamus tusks (both lower canines and incisors), along with a cut section of elephant tusk (Bass 1986: 282–5, ill. 18–19; Bass and Pulak 1989: 11, fig. 20). The nationality of this ship and its destination are both unknown: but the cargo is very mixed and includes raw materials and products from numerous centres around the eastern Mediterranean and further afield (Bass 1987).

For the export of hippopotamus tusk from Egypt we have some slender evidence, admittedly circumstantial in nature. In Minoan Crete, hippopotamus ivory was used from the pre-palatial period (mid third millennium) onwards; Egypt, rather than Syria–Palestine, seems by far the most likely source for this era (Krzyszkowska 1988: 226–9). The same may well be true for early-mid second millennium, given the strong evidence for Minoan contacts with Egypt during the Middle Kingdom and early Eighteenth Dynasty, e.g. the ‘Minoanising’ frescoes at Avaris (Bietak 1996: 73–9, pls. III–VIII; and see Warren 1995 for general background on Minoan–Egyptian relations). Although Aegean workshops increasingly depended on elephant ivory during the fourteenth and thirteenth centuries BC (see p. 320), hippopotamus ivory was never wholly abandoned. However, whether the tusks, such as that found in Mycenae, originated in Egypt or Syria–Palestine is quite impossible to say (Krzyszkowska 1984: 124, pl. 13a; *pace* Cline 1995: p. 106 no. 88, pl. 20.6 ‘probably Syria–Palestine’).

In Egypt and Nubia the use of hippopotamus ivory goes back to Predynastic times. The recent Sudan Archaeological Research Society survey in the Dongola Reach recorded one unexcavated tomb of perhaps Neolithic or Kerma date which was covered with hippopotamus teeth. These are also known at Kerma itself. Reisner’s excavations yielded the well-known ivory inlays among other items, some of which have recently been identified as hippopotamus (Bonnet 1990: cat. nos. 213–14; 265–6; 276–7. 283, 285, 287–91; see Wenig 1978: cat. nos. 45–51). The Petrie Museum possesses two unworked hippopotamus tusks from the Garstang excavations at Meroe (unpublished).

In Egypt there are ample signs that hippopotamus ivory was used from Predynastic times onwards. Combs, bracelets, pendants, certain vessels and handles are all morphologically feasible in hippopotamus tusk (see Payne 1993 for specific cases). So too are some figurines and other carvings in the round, e.g. gaming pieces (see p. 324). Several bulls’ legs (belonging to furniture?) in the British Museum are made from hippopotamus ivory (Spencer 1980: cat. nos. 479–81, ID-OHK 92). This material could also be used for inlays and relief carvings, e.g. a fine ceremonial knife-handle from Hierakonpolis (Petrie Museum UC14864; Adams 1974: cat. no. 324; Drenkhahn 1986 cat. no. 79, Abb. 8). Most of these objects are also feasible in elephant ivory, and smaller ones in bone, therefore it is

extremely dangerous (and premature) to generalise about the association of particular end-products with certain raw materials. One must always be alert to cases of 'substitution', whatever the period. Thus Predynastic 'labels' are attested both in hippopotamus ivory (especially incisors) and in bone. Poplin has identified a bull's leg from Abydos as elephant ivory (Louvre E11019A; Desroches-Noblecourt and Vercoutter 1981: 22–3 no. 24). While the wands and clappers of the Middle and New Kingdom were almost always made from lower canines (requiring little modification beyond removal of the enamel), elephant tusk could be used, albeit producing a much straighter shape (Drenkhahn 1986: cat. no. 92). Clearly only systematic study, beginning at site level (e.g. Adams 1974), can reveal local and chronological variations in the selection of raw materials. Of particular concern, too, is the role that hippopotamus tusk came to play in the middle to late second millennium BC, when elephant ivory was acquired in considerable quantities. Since our documentary evidence suggests the latter may well have been under direct pharaonic control, it is reasonable to ask whether hippopotamus tusk – a locally available material – became the 'poor man's ivory'. Or, did practical concerns alone dictate how and when it was used? Hippopotamus incisors are ideal for making cylindrical mirror-handles, kohl-tubes and the like; to use elephant ivory for these is not only wasteful, but also more labour-intensive. Whether the collapse of long-distance 'trade' in elephant ivory in the Third Intermediate Period (see p. 325) produced a resurgence in the use of hippopotamus ivory is unknown. As indicated above, our information about ivory working during the first millennium BC is generally rather sketchy. One may note, however, that a few figurines of Ptolemaic date have been published as hippopotamus ivory (Randall 1985: 9–10; see also an inscribed inlay of Saite (?) date in the Walters Art Gallery, cat. no. 40). Furthermore it is also worth bearing in mind that we have next to no evidence for the density of hippopotamus populations for any given period or locale. The mere fact that the animal was attested as late as the seventeenth century AD in the Delta tells us nothing about its prevalence during earlier periods. That is, hippopotamus ivory may – at times – have been available only sporadically, as a by-product of occasional hunting. Moreover availability *per se* does not necessarily translate into selection and use. The interplay between the two (availability and use) is complex: even in the Aegean where documentation is fairly good, considerable difficulties have been encountered in providing explanations for the patterns observed (Krzyszowska 1988: 228–33, esp. 233).

### Bone and other materials

As a by-product of hunting and husbandry, bone is one of the most readily-available raw materials known to man. Although the shape and size of bones do place limits on the

range of end-products, a surprising variety of objects – both utilitarian and decorative – can be made. Nor should bone necessarily be regarded as inferior to ivory. It is easily worked and can take a fine polish. Unfortunately bone has suffered greatly from prejudices and preconceptions in the archaeological literature. Finely worked and decorative objects are all too often misidentified as 'ivory'; sometimes this even extends to more utilitarian objects, such as a First-Dynasty 'arrowhead' in the British Museum (Spencer 1980: cat. no. 487) which is actually bone (OHK-ID 92). However, on the whole, our documentation for the Predynastic and Early Dynastic periods is reasonable (see pp. 324, 326–7 for ivory; and Adams 1974; Payne 1993); later periods have been less well treated.

It is worth stressing that bone – the raw material – is derived from a variety of anatomical parts. Not all of these were suitable or indeed available for use (Krzyszowska 1990: 52–8). Only fresh, uncooked, bone can be worked and thus initial selection is determined by dietary needs and further influenced by butchery practices. Metapodials of the ruminants have little flesh and limited amounts of marrow and are thus natural discards. Moreover, their shafts are straight, thick-walled and immensely strong, thus making them ideal for a wide range of utilitarian and decorative objects. These include tools, pins, inlays, pendants, rings, amulets and small carvings in the round. By contrast, the bones of the upper limbs are covered with more flesh, are less straight, and have thinner walls: altogether less suitable for working. Of the flattened bones, scapulae are probably the most versatile, providing relatively large flat blanks for combs, inlays and plaques; while ribs are more commonly used for tools. Usually the identification of precise bones and species involved will require the attention of a faunal expert, although in the case of heavily worked specimens the designation 'bone' often has to suffice. On a site-level it is also worth attempting to integrate the faunal and archaeological evidence for bone in order to explore the patterns of exploitation and selection.

Horn is attested from Egyptian contexts, although hitherto it has received little systematic study. The material is a keratinous substance akin to that in hooves and forms a sheath over horn-cores, bony outgrowths from the skulls of ruminants, e.g. sheep/goats, cattle and antelope etc. The cores are of no value whatsoever, but sometimes occur archaeologically, with knife marks revealing that the outer sheath had been removed for use. In general, horn survives less well than bone or ivory, yet extremes of dampness and dryness may, in fact, favour its preservation. The most common use of horn seems to have been for vessels (e.g. Ashmolean no. 1895.931; Payne 1993: cat. no. 1214) or handles (Ashmolean no. E.3142; Payne 1993: cat. no. 1234; species identified as oryx). Although presumably most horn used in Egypt was derived from native – or at any rate African – species, circumstantial evidence exists to suggest



that the horns of the Cretan wild goat (*agrimi*) might have been imported for making Egyptian composite bows (Warren 1995: 7 with references).

There is no evidence at present for the use of antler or boar's tusk in Egypt. However, a recently re-discovered papyrus from Amarna depicts a battle between Libyans and warriors who *appear* to be wearing Mycenaean boar's tusk helmets (Schofield and Parkinson 1994). A small fragment, said to be from a helmet plaque, has been reported from Qantir in a context dating to the reign of Ramses II (Schofield and Parkinson 1994: 166, n. 64). At best, however, these pieces of evidence point merely to the possibility of ready-made imports, rather than to local manufacture of an imported material.

### Manufacture methods

Availability aside, the physical properties of the raw materials have a bearing on their selection and use for particular end-products. Broadly speaking, elephant ivory is the most versatile, placing the fewest constraints on the carver in terms of size and shape of finished product. Hippopotamus lower canines and incisors are considerably smaller and present several obstacles to carving. Bone offers the least amount of solid material. However, in every case, there are benefits to outweigh potential disadvantages. Hippopotamus ivory is denser than that of the elephant and has long been prized by carvers for its gleaming white appearance. Also, for some end-products the actual shape of tusks – large curving lower canines, small straight incisors – have positive advantages. The shapes of bones and their tensile strength make these the 'material of choice' for a wide range of items, especially those subjected to frequent use.

Selection is thus determined by both suitability and by the amount of labour required to transform the raw material into particular end-products. But needless to say, for us to understand the precise mechanisms demands a good grasp of the characteristics of the materials in the unworried state and careful scrutiny of finished products. These observations must go well beyond basic identifications of the materials used. Attention must be given to how items were carved from the tusks or bones. For instance, in the Aegean, circular *pyxides* are almost invariably made from the proximal (root) end of elephant tusks. The natural pulp cavity provides the hollow shape and bases are made separately (the reconstruction in Bass 1987: 726–7 is wrong). In the Aegean, elephant tusks are sectioned longitudinally (never transversely) to produce the flat blanks from which relief plaques and inlays were made; carving ordinarily occurs on the 'inner' face (Poursat 1977b: 253; Krzyszkowska 1992: 26 n. 5). In Syria–Palestine and Cyprus, duck *pyxides* are generally made from lower canines, utilising the angle above the 'commissure' (Caubet and Poplin 1987: 279–81, figs. 8–10; and see below). But exceptions to

all these 'rules' do occur: circular *pyxides* with drilled-out centres, and duck *pyxides* cut 'the wrong way' from lower canines or sometimes from elephant ivory. While observations such as these can be made from finished objects alone, many technical aspects can only be understood by studying workshop debris. The Aegean is fortunate in possessing several groups of 'workshop material', notably from Knossos and Mycenae (Krzyszkowska 1992, 1997). However, interpreting material of this kind – offcuts, roughouts, *débitage* – is no easy matter. And even the most basic step in working an elephant tusk – removal of the natural outer surface, or 'bark' – was evidently effected in several ways, even on the same site (Krzyszkowska 1992: 26). Once again, generalisations are dangerous, and certainly practices attested in the Aegean or eastern Mediterranean are unlikely to be matched precisely in Egypt itself. While much may be learnt by observing how modern 'traditional' craftsmen approach and handle their materials, only systematic study of the archaeological evidence can reveal the specific solutions adopted by Egyptian craftsmen.

In this context it is worth stressing that we have scant evidence for the organisation of ivory workshops and their craftsmen in the ancient world, Egypt included. Ivory-working would have been carried out under centralised control, whether in temple or palace workshops. Although many tomb-paintings, particularly in the Theban region, show artisans at work, only one, the Theban tomb of Menkheperaseneb, appears to depict ivory-working (TT86; Davies and Davies 1933: pl. XI; see Fig. 13.1 here). The scene lacks a caption, but seems to show a tusk being sawn into panels. Many of the tools – saws, chisels, knives, points and drills – employed in ivory-working were those used in woodworking (Barnett 1982: figs. 4b–c; cf. Evely

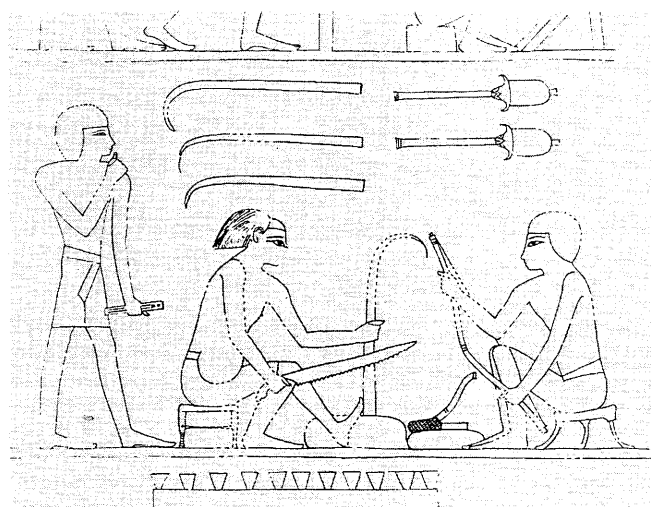


Figure 13.1 Scene possibly depicting an ivory workshop in the Eighteenth-Dynasty Theban tomb-chapel of Menkheperaseneb (TT86).

1992), and the craft may have been practised by the same workers.

Ivory and its relatives are all comparatively soft materials, registering about 2 on the Mohs hardness scale (see Table 2.4). The initial stages of processing could, however, present some obstacles. At the proximal (root) end, an elephant tusk is covered with a somewhat harder (Mohs 4) and slightly ridged outer surface sometimes known as 'bark' or cementum. The distal end or tip lacks any protective outer surface, but the ivory itself is marred with a series of fine black lines or cracks, which may penetrate one to two millimetres within (Krzyszowska 1990: pl. 1). Thus removal of the 'natural outer surface' is a preliminary step in the carving process, although there are several ways in which this could be effected (Krzyszowska 1992: 26). Similarly there are various methods for sectioning the tusk and preparing smaller blocks or blanks to form the basis for carving proper: these are closely linked to the end-products intended (see p. 328). A need for economy would persuade carvers to base much of their work on blocks and blanks cut lengthwise from the tusk. There may also have been some practical advantages, i.e. carving 'with the grain', rather than across it, though this suggestion demands further experimental work. In any case, one may observe that even relatively small items, such as Early Dynastic gaming pieces (e.g. Drenkhahn 1986: cat. nos. 67, 70; length: 7 cm) have been cut longitudinally from the tusk. That is, the lamellae indicate that their long axis follows that of the tusk. This approach was essential for larger items, e.g. the ivory 'Shu headrest' from the tomb of Tutankhamun (described on p. 325) and the ivory palette from the same tomb (length: 30.3 cm, width: 4.5 cm, depth: 2.5 cm; Desroches-Noblecourt 1963: pl. IVb).

Compared to elephant tusks, hippopotamus lower canines present the carver with more serious obstacles. In shape they have a marked curve, while in section they are trihedral (Krzyszowska 1990: 42-7, figs. 17-18, pls. 12-13). Exceptionally hard enamel (Mohs 7) protects two faces of the tusk; the third is covered by 'cementum' (Mohs 4). Cutting through and removing the enamel is thus one of the principal drawbacks of using hippopotamus lower canines. Nonetheless, as Poplin (1974: 85-92, esp. 85-9, figs. 1-6) has demonstrated, the enamel can be cut using string and an abrasive, thus placing this operation within the capability of Predynastic carvers dependent on stone or copper tools. Under natural conditions desiccation causes the enamel to crack and split, and controlled exposure to heat might have been adopted, although proof is lacking (Krzyszowska 1988: 214). For abrasion there is, however, some evidence, e.g. a segment of lower canine from Knossos, dating to EM IIA, shows clear signs of abrasion across the enamel, though removal by this process alone would have been extremely laborious (Krzyszowska 1984, pl. XIIIb; Krzyszowska 1988: 214). A second serious obstacle is the 'commissure', which represents the junction be-

tween the surface of the pulp cavity and the newly formed dentine. The slightly 'resinous' appearance of the commissure mars the otherwise dense and gleaming dentine; though it is an immensely useful feature for us in identifying the material (Krzyszowska 1990: 42-7, figs. 17-19, pls. 14-16). Moreover the commissure represents a line of weakness, along which whole tusks or smaller objects may crack. In the Aegean there is some evidence that carvers sought to avoid 'crossing' the commissure; but if they did impinge on it, the unsightly feature was concealed on the underside of the finished object (Krzyszowska 1988: 224-6, fig. 5, pl. 30). Finally, tusk size could restrict the range of end-products feasible from lower canines (although of a modern specimen with a length of fifty-eight cm along the outer curve, and a maximum width of 6.5 cm: Krzyszowska 1990: 38, pl. 12). Yet for all their natural drawbacks, lower canines could yield objects of considerable size and quality: the key lay in skilful sectioning and carving. Regarding incisors, size is the chief obstacle: lengths of about fifty centimetres (of which some forty centimetres is useable) are recorded, but diameters rarely exceed 5.5 cm.

Bone also requires a certain amount of preliminary processing before it can be used. As noted above, only fresh, uncooked, bone can be worked and thus availability is directly linked to diet and butchery techniques. Removal of sinews, marrow and other unwanted elements can be messy but is not especially difficult, and procedure thereafter is dictated by the end-product. Thus in order to manufacture a straight pin or needle from a metapodial, first the epiphyses (joints) would be removed, then the bone would be sectioned lengthwise to provide four blanks of roughly quadrangular section (as demonstrated by unpublished 'workshop debris' from the Aegean). Flat bones, such as ribs and scapulae, are generally split lengthwise, through their cancellous interior, thus providing relatively thin, flat blanks (Krzyszowska 1990: 53, pl. 20). Unfortunately direct archaeological evidence for bone working – in the form of workshop debris – is even more rare than for ivory-carving. All too often we must fall back on a combination of logic, practical experiment, and ethnographic parallels to reconstruct general approaches.

### Finishing techniques

Direct observation of finished objects can yield a limited amount of information on the final stages of ivory (and bone) working. These would involve polishing to remove unsightly tool marks and, in the case of composite items, assembly by means of dowels and mortises (Barnett 1982: 13, fig. 5). Simple inlays or veneers might be provided with a rough scoring on their undersides to assist adhesion. Staining and colouring of ivories is well-attested in the New Kingdom, especially from the tomb of Tutankhamun (e.g. the water-bowl and casket panels). However, the exact substances used and techniques involved require further inves-

tigation. Although examples of delicate low-relief carving are known, and one example of open-work, most veneered ivory was left plain or simply incised, sometimes with figures, most frequently with texts. These were often filled with coloured pigment (usually blue).

## Conclusions

The wealth of evidence for the use of ivory and related materials in Egypt is great and spans all phases in its history. Systematic study can shed light on a wide range of issues, from sources and procurement of the raw materials to the ways in which they were exploited for particular end-products. There is also huge potential for a detailed investigation into all aspects of working techniques. Last but not least there is undoubtedly scope for further analysis of the changing role that products of ivory and related materials played in Egyptian society and in those of north-east Africa which supplied the raw material. Apart from the economic aspects of ivory, and, from the earliest times, ivory must have been one of the most important items in the Kushite economy, there are also ecological considerations. Both Hellenistic, Roman and early modern sources (such as Petherick 1861) indicate that ivory has often been a by-product of elephants being hunted for food (Morkot 1998: 152). The Assyrian texts refer to elephant-hide, a material which seems not to be noticed yet in Egyptian texts or archaeology. Burstein (1996) has highlighted the effects which over-hunting would have had on elephant populations and migrations; it is also worth considering the relationship with the herders and agriculturalists of the Sudanese savanna. There is still much to be learnt, not only about the details of the ivory trade and ivory-working but also about the wider context, the interaction of people and animals in ancient times. The challenge to future scholars is immense; but the rewards will be felt far beyond the bounds of Egyptology itself.

## References

- Adams, B. 1974. *Ancient Hierakonpolis*. Warminster: Aris and Phillips.
- Barnett, R.D. 1982. *Ancient Ivories in the Middle East*. Jerusalem: Institute of Archaeology, The Hebrew University of Jerusalem.
- Bass, G.F. 1986. A Bronze Age shipwreck at Ulu Burun (Kas): 1984 campaign. *American Journal of Archaeology*, 90: 269–96.
1987. Oldest known shipwreck reveals splendors of the Bronze Age. *National Geographic*, 172/6: 693–733.
- Bass, G.F. and Pulak, C. 1989. The Bronze Age shipwreck at Ulu Burun: 1986 campaign. *American Journal of Archaeology*, 93: 1–29.
- Bénédict, G. 1918. The Carnarvon ivory. *JEA*, 5: 1–15.
- Bietak, M. 1996. *Avaris: The Capital of the Hyksos*. London: BMP.
- Bonnet, C. (ed.) 1990. *Kerma, royaume de Nubie*. Geneva: Mission archéologique de l'Université de Genève au Soudan.
- Bourgeois, B. 1992. An approach to Anatolian techniques of ivory carving during the second millennium BC. In *Ivory in Greece and the Eastern Mediterranean from the Bronze Age to the Hellenistic Period* (ed. J.L. Fitton). BM Occasional Paper 85. London: BMP, pp. 61–6.
- British Museum 1972. *Treasures of Tutankhamun*. London: BMP.
- Bryan, B.M. 1996. Art, empire, and the end of the Late Bronze Age. In *The Study of the Ancient Near East in the Twenty-First Century* (eds. J.S. Cooper and G.M. Schwartz). Winona Lake IN: Eisenbrauns, pp. 33–79.
- Burstein, S.M. 1996. Ivory and Ptolemaic exploration of the Red Sea: the missing factor. *SO 6/2*: 799–807.
- Caubet, A. 1991. Ivoires de Cappadoce. In *Marchands, diplomates et empereurs: études sur la civilisation mésopotamienne offertes à Paul Garelli* (eds. D. Charpin and F. Joannès). Paris: Éditions Recherche sur les civilisations, pp. 123–5.
- Caubet, A., Courtois, J.-C. and Karageorghis, V. 1987. Enkomi (Fouilles Schaeffer 1934–1966): inventaire complémentaire. *Report of the Department of Antiquities Cyprus*: 23–48.
- Caubet, A. and Poplin, F. 1987. Les objets de matière dure animale: étude du matériau. In *Ras Shamra Ougarit III: Le centre de la ville* (ed. M. Yon). Paris: Publications de la Mission archéologique française de Ras Shamra-Ougarit, pp. 273–306.
1992. La place des ivoires d'Ougarit dans la production du proche orient ancien. In *Ivory in Greece and the Eastern Mediterranean from the Bronze Age to the Hellenistic Period* (ed. J.L. Fitton). BM Occasional Paper 85. London: BMP, pp. 91–100.
- Cline, E. 1995. Egyptian and Near Eastern imports at Late Bronze Age Mycenae. In *Egypt, the Aegean and the Levant: Interconnections in the Second Millennium BC* (ed. W.V. Davies and L. Schofield). London: BMP, pp. 91–115.
- Collon, D. 1977. Ivory. *Iraq*, 39: 219–22.
- Davies, N.de G. and Davies, N.M. 1933. *The Tombs of Menkheper-rasob, Amenmose and Another*. Nos. 86, 112, 42, 226. New York: MMA.
- Desroches-Noblecourt, C. 1963. *Tutankhamen. Life and Death of a Pharaoh*. London: Michael Joseph.
- Desroches-Noblecourt, C. and Vercoutter, J. 1981. *Un siècle de fouilles françaises en Égypte 1880–1980*. Cairo: IFAO and Louvre.
- Drenkhahn, R. 1986. *Elfenbein im alten Ägypten: Leihgaben aus dem Petrie Museum London*. Erbach: Deutsches Elfenbeinmuseum Erbach.
- Evely, D. 1992. Towards an elucidation of the ivory-worker's tool-kit in neo-palatial Crete. In *Ivory in Greece and the Eastern Mediterranean from the Bronze Age to the Hellenistic Period* (ed. J.L. Fitton). BM Occasional Paper 85. London: BMP, pp. 7–16.
- Francis, E.D. and Vickers, M. 1983. 'Ivory tusks' from Al Mina. *Oxford Journal of Archaeology*, 2: 249–51.
- Gardiner, A.H. 1947. *Ancient Egyptian Onomastica*, 3 vols. Oxford: OUP.
- Gill, D.W.J. 1992. The ivory trade. In *Ivory in Greece and the Eastern Mediterranean from the Bronze Age to the Hellenistic Period* (ed. J.L. Fitton). BM Occasional Paper 85. London: BMP, pp. 233–7.

- Groom, N. 1981. *Frankincense and Myrrh: A Study of the Arabian Incense Trade*. London and New York: Longman; Beirut: Librairie du Liban.
- Haas, G. 1953. On the occurrence of the hippopotamus in the Iron Age of the coastal area of Israel (Tell Qasileh). *BASOR*, 132: 30-4.
- Hayward, L.G. 1990. The origin of the raw elephant ivory used in Greece and the Aegean during the Late Bronze Age. *Antiquity*, 64: 103-9.
- Herrmann, G. 1986. *Ivories from Room SW 37 Fort Shalmaneser (Ivories from Nimrud 1949-1963 Fasc. IV,1)*. London: British School of Archaeology in Iraq.
- Hood, S. 1978. *The Arts in Prehistoric Greece*. Harmondsworth: Penguin.
- Kantor, H.J. 1947. *The Aegean and Orient in the Second Millennium B.C.* Archaeological Institute of America Monograph 1. Bloomington, IN: Indiana University Press.
- Kozloff, A. and Bryan, B. 1992. *Egypt's Dazzling Sun: Amenhotep III and his World*. Cleveland OH and Bloomington IN: Cleveland Museum of Art and Indiana University Press.
- Krzyszowska, O. 1984. Ivory from hippopotamus tusk in the Aegean Bronze Age. *Antiquity*, 58: 123-5.
1988. Ivory in the Aegean Bronze Age: elephant tusk or hippopotamus ivory? *Annual of the British School at Athens*, 83: 209-34.
1990. *Ivory and Related Materials: An Illustrated Guide*. Bulletin of the Institute of Classical Studies Supplement 59. London: Institute of Classical Studies.
1992. Aegean ivory carving: towards an evaluation of Late Bronze Age workshop material. In *Ivory in Greece and the Eastern Mediterranean from the Bronze Age to the Hellenistic Period* (ed. J.L. Fitton). BM Occasional Paper 85. London: BMP, pp. 25-35.
1996. Furniture in the Aegean Bronze Age. In *The Furniture of Western Asia: Ancient and Traditional* (ed. G. Herrmann). Mainz am Rhein: von Zabern, 85-103.
1997. Cult and craft: ivories from the Citadel House Area, Mycenae. In *TEXNH: Craftsmen, Craftswomen and Craftsmanship in the Aegean Bronze Age* (eds. R. Laffineur and P. Betancourt). Aegaeum 16. Liège: Université de Liège, pp. 145-50.
- van der Merwe, N.J. and Lee-Thorp, J.A. 1990. Source-area determination of elephant ivory by isotopic analysis. *Nature*, 346 (23 August 1990): 744-6.
- Miller, R. 1986. Elephants, ivory, and charcoal: an ecological perspective. *BASOR*, 264: 29-43.
- Moran, W.L. 1992. *The Amarna Letters*. Baltimore MD: Johns Hopkins University Press.
- Morkot, R.G. 1991. Nubia and Achaemenid Persia: sources and problems. In *Achaemenid History VI. Asia Minor and Egypt: Old Cultures in a New Empire*. (eds. H. Sancisi-Weerdenburg and A. Kuhrt). Leiden: Nederlands Instituut voor Het Nabije Oosten, pp. 321-36.
1995. The economy of Nubia in the New Kingdom. *CRIPEL 17* [Actes de la VIII<sup>e</sup> conférence internationale des études nubiennes, Lille 11-17 Septembre 1994. I Communications principales]: 175-89.
1996. The Darb el-Arbain, the Kharga Oasis and its forts, and other desert routes. *Journal of Roman Archaeology Supplement*, 19 [Archaeological research in Roman Egypt]: 82-94.
1998. 'There are no elephants in Dongola': notes on Nubian ivory. *CRIPEL 17/3* [Actes de la VIII<sup>e</sup> conférence internationale des études nubiennes, Lille 11-17 Septembre 1994, 147-54.]
- O'Connor, D. 1986. The locations of Yam and Kush and their historical implications. *JARCE*, 23: 27-50.
- Oliver, A. 1992. Ivory temple doors. In *Ivory in Greece and the eastern Mediterranean from the Bronze Age to the Hellenistic Period*. (ed. J.L. Fitton). BM Occasional Paper 85. London: BMP, 227-31.
- Payne, J.C. 1993. *Catalogue of the Predynastic Egyptian Collections in the Ashmolean Museum*. Oxford: Ashmolean Museum.
- Penniman, T.K. 1952. *Pictures of Ivory and other Animal Teeth, Bone and Antler*. Pitt Rivers Occasional Paper on Technology 5. Oxford: Pitt Rivers Museum.
- Petherick, J. 1861. *Egypt, the Soudan and Central Africa with Explorations from Khartoum on the White Nile to the Regions of the Equator being Sketches from Sixteen Years' Travel*. Edinburgh and London: William Blackwood and Sons.
- Poplin, F. 1974. Deux cas particuliers de débitage par usure. In *Premier colloque international sur l'industrie de l'os dans la préhistoire* (ed. H. Camps-Fabrer). Aix-en-Provence: Editions de l'Université de Provence, pp. 85-92.
- Poursat, J.-C. 1977a. *Catalogue des ivoires mycéniens du Musée Nationale d'Athènes*. Paris: Diffusion de Boccard.
- 1977b. *Les ivoires mycéniens*. Paris: Diffusion de Boccard.
- Randall, R.H. 1985. *Masterpieces of Ivory from the Walters Art Gallery*. New York and Baltimore: Hudson Hills Press.
- Reeves, C.N. 1990. *The Complete Tutankhamun*. London: Thames and Hudson.
- Säve-Söderbergh, T. 1953. *On Egyptian Representations of Hippopotamus Hunting as a Religious Motive*. Uppsala: Horae Soderblomianae.
- Schofield, L. and Parkinson, R. 1994. Of helmets and heretics: a possible Egyptian representation of Mycenaean warriors on a papyrus from el-Amarna. *Annual of the British School at Athens*, 89: 157-70.
- Scullard, H.H. 1974. *The Elephant in the Greek and Roman World*. London: Thames and Hudson.
- Spencer, A.J. 1980. *Catalogue of Egyptian Antiquities in the British Museum V: Early Dynastic Objects*. London: BMP.
- Tadmor, H. 1961. Que and Musri. *IEJ*, 11: 143-50.
- Tait, W.J. 1982. *Game-boxes and Accessories from the Tomb of Tutankhamun*. Tutankhamun Tomb Series VII. Oxford: Griffith Institute.
- Vogel, J.C., Eglington, B. and Auret, J.M. 1990. Isotope fingerprints in elephant bone and ivory. *Nature*, 346 (23 August 1990): 747-9.
- Warren, P. 1995. Minoan Crete and Pharaonic Egypt. In *Egypt, the Aegean and the Levant: Interconnections in the Second Millennium BC* (eds. W.V. Davies and L. Schofield). London: BMP, pp. 1-18.
- Wenig, S. 1978. *Africa in Antiquity: The Arts of Ancient Nubia and the Sudan II: The Catalogue*. New York: Brooklyn Museum.