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# Contents

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# *Butchering of Red Deer (Cervus elaphus L.)*

## – A Case Study from the Late Mesolithic Settlement of Tybrind Vig, Denmark

by TINE TROLLE-LASSEN

## INTRODUCTION

Zooarchaeological studies dealing with subsistence practices of hunter-gatherers have, where hunting is concerned, been applied mainly to the procurement of the game. The relative representation and age and sex distribution of the identified species, the hunting season, and perhaps hunting and trapping techniques, to a large degree all reflect hunter decisions. Indirectly, those choices reflect society's needs for food and raw materials. Zooarchaeological studies applied to human decisions concerning game animals *after* the kill have less frequently been studied.

In the present paper, the interim results of a study of the remains of red deer from a Danish Mesolithic settlement, Tybrind Vig, are presented (1). Based on taphonomic analysis, aspects of skinning, butchering, transportation, and food preparation are reconstructed.

## THE ARCHAEOLOGICAL BACKGROUND

Tybrind Vig is situated off the west coast of Denmark's second largest island: Funen (fig. 1). Large tracts of southwestern Denmark, which during the Mesolithic were dry land, are today covered by sea as a result of iso- and eustatic movements (Christensen 1982, Strand Petersen 1985a, 1985b, Smed 1986, 1987). The settlement, which in Mesolithic times lay on a cove, is today 200–300 m from the coast under 2–3 m of water (fig. 2). The major part of the actual dwelling area was washed away during prehistoric transgressions, but the remains of a combined rubbish zone and inshore fishing bank in the shallow area outside the settlement are preserved. Systematic sub-marine excavation has been carried out since 1978, and it is estimated that about 20% of the site has been investigated (Andersen 1980, 1985) (2) The unusually fine conditions for preservation of organic material are manifested in the large amounts of preserved animal bones and in exceptional finds of wood, bast, and plant fibres.

The artefact material belongs to the Ertebølle culture dated to 4500–3200 b.c. (C-14 (uncal.)), which represents the latest phase of the Danish Mesolithic. The largest part of the finds so far recovered derive from the later part of this culture phase and are C-14 dated to about 3700–3200 b.c. (uncal.) (Andersen 1984, 1985). Despite the comprehensive archaeological material available for study, knowledge of Ertebølle society is still limited (Andersen 1985: 52, Price 1985: 359). The information we do have suggests a relatively complex hunter-gatherer society with intensive economic exploitation, high implement and facility specialization, permanent settlement supplemented by special sites, exchange between groups, varied decorative art, and distinct regional

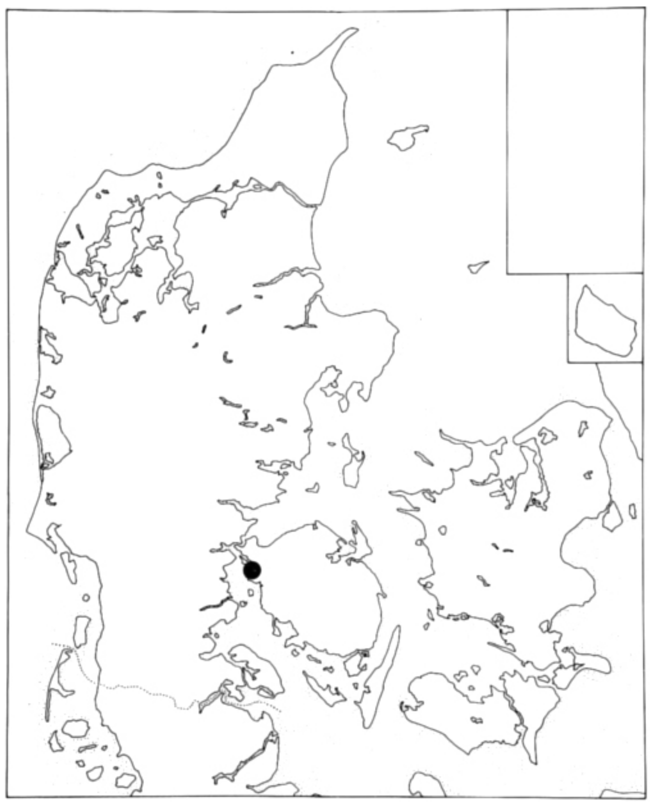


Fig. 1. The geographical location of Tybrind Vig.

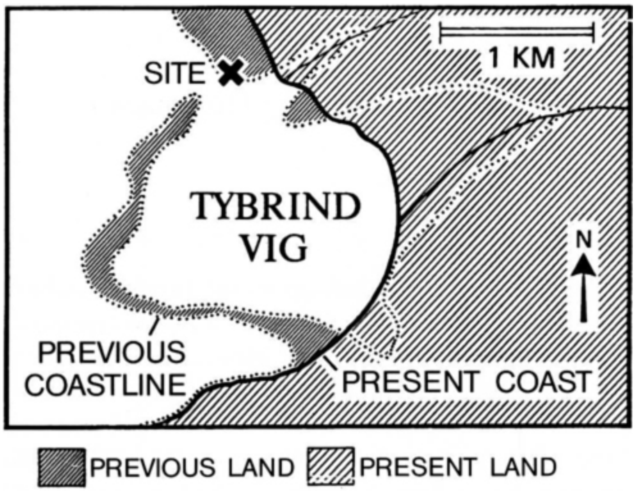



Fig. 2. Map illustrating how the area around the settlement has changed since prehistoric times from a protected cove into the present open bay (after Andersen 1983).

variations (e.g. Albrethsen & Brinch Petersen 1977, Larsson 1980, 1981, 1982, 1983, 1984, Andersen 1981, 1985, Vang Petersen 1982, 1984, Price 1985).

The analyses from Tybrind Vig have revealed occupation during all seasons (Trolle-Lassen 1985). That this was probably of considerable duration – perhaps permanent – is demonstrated in several ways. The abundant artefact and bone material shows that a large number of different activities took place, including a many-faceted economic exploitation. The specific rubbish area, in the form of an off-shore refuse zone, and the presence of a cemetery in connection with the oldest settlement, also suggest prolonged occupation (Binford 1983: 187–190).

The settlement was favourably situated with direct access to the resources of forest, cove, and sea. Amongst extant mammal remains, red deer, roe- deer, and wild pig are best represented in the bone material. Grey seal is slightly less common, while aurochs, wild horse, and various species of whales contribute only a few bones. Bones of fur-bearing animals are present in large quantities: pine- marten, in particular, was exploited (Trolle-Lassen 1986), but remains of polecat, otter, wildcat, and dog are common. There is also one bone from a fox. Bird remains are sparse, whereas there is much to suggest that fishing played a prominent part in the economy (Tauber 1981, Trolle-Lassen 1984, Andersen & Malmros 1985).

Taphonomic effects on skeletal remains of exploited game animals that resulted from prehistoric exploitation of the animals brought to the site have been evaluated. The taphonomic loss has probably been small in the interval between prehistoric deposition and recent times when erosion of the deposits began. The find circumstances suggest that the refuse zone was one of still water and that local vegetation, largely in the form of a reed bed, retained the rubbish (Andersen 1980, 1985, Trolle-Lassen 1984, 1985). The floor of the cove consisted of rapidly accumulating marine gyttja (Andersen 1980, 1985, Smed 1984) into which objects probably sank quickly and were covered by organic material. The marine fauna does not include species that would have affected the composition of the bone assemblage (3), just as the fine state of preservation of the bones shows that diagenesis cannot have caused changes of any consequence.

It was not until the bones were washed free from the find-bearing layers as a result of erosion by the sea that restructuring of the deposits possibly took place. Differential attrition and transport by the current (Gifford 1981) may then have occurred. The effect of these factors on the composition of the Tybrind Vig material is not quite clear but, as a general rule, the chance of a bone being recovered under these circumstances decreases with size and volume.

It is difficult to decide which technique was used to procure red deer for Tybrind Vig. At kill sites, as known from North America, bone assemblages result from a particular hunting and butchering situation. There, both the topography and any observable cultural context often furnish, in themselves, direct evidence of the kind of hunting employed. At a habitation site such as Tybrind Vig, however, the picture is far more complex. The introduced bones were derived from numerous hunting situations that varied with, for instance, terrain, season, and the social structure and needs of the community. Only in rared cases can the settlement context yield direct information about hunting techniques. The many finds of man-size bows in Tybrind Vig, and the many transverse points (Andersen 1985), do suggest, however, that bows and arrows were also used in hunting red deer. This was supported by one coeval and one slightly younger settlement find where the remains of transverse points were found lodged in bones of killed red deer (Noe-Nygaard 1974: 225–229).

Both ethnological sources and present practice show that red deer can be hunted by one or by several hunters (Hahr 1882, Kristoffersen 1974). In Denmark, red deer live in small groups in a relatively confined area and do

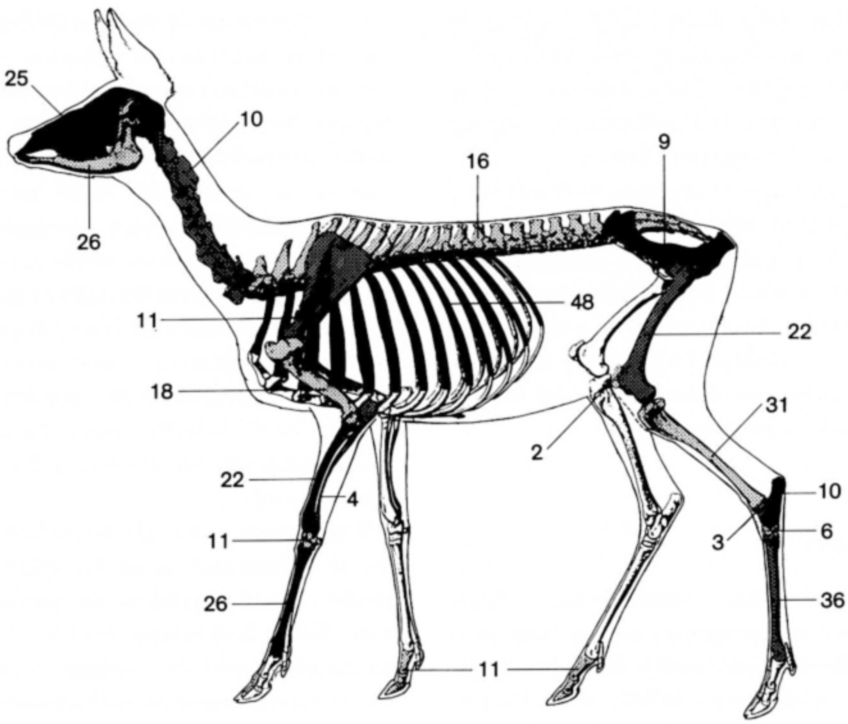



Fig. 3. Red deer skeleton (after Ellenberger *et al.* 1956) showing bones present in the Tybrind Vig material, with the number of fragments indicated.

not undertake major migrations (Valentin-Jensen 1972, Strandgaard 1974). They mainly follow established tracks in the forest and have, at least at the present day, a relatively stable diurnal rhythm. Mesolithic forms of hunting may have involved stalking and covert hunting along the track, or drive, perhaps using ropes to which feathers or other objects were tied (Hahr 1882, Kristoffersen 1974). Pitfalls and snares, as used in trapping elk and reindeer on the Scandinavian peninsula, could also have been used (Selinge 1974, Barth 1981, Ekman 1983). Massive seasonal hunting, which could be interpreted as an expression of communal hunting, was not indicated by analysis of the Tybrind Vig assemblage.

## THE RED DEER MATERIAL

390 bone and tooth finds of red deer (*Cervus elaphus* L.) have been recovered from Tybrind Vig, comprising 22.2% of all identified mammal bones and teeth from the locality. In addition, 99 red deer antlers were recovered.

Just under one-third of the bones have a well-preserved surface (32.6%). Almost half are heavily worn, either locally or overall (49.2%). The remainder have been affected to a lesser degree (17.7%).

About one sixth of the bones are almost or completely whole (14.9%). The majority occur in fragmented form, which in most cases has been attributed to prehistoric human activity (85.1%).

Bones from most of the skeleton are represented (fig. 3); only hyoid, caudal vertebrae, and sternum are absent.

At least 14 individuals are represented, 11 of which are older than three months and three younger. Estimation of the minimum number of individuals has taken into account which side of the skeleton and from which part of the bones investigated fragments were derived.

The age determination of jaws, limb bones, and antler shows that red deer of all ages, from newborn up to 15-year-old individuals, were killed (Trolle-Lassen 1985). Calves (0–1 years) are well represented.

Taphonomic factors must have acted uniformly on the lower jaws of all animals older than 3 years, since development and bone density by that age seem to be relatively complete and stabilized. The age distribution in figure 4 shows, therefore, that red deer in the 3-7-year-old age group were more often killed than older individuals.

Seasonal determination from parts of the red deer is given in figure 5 (after Trolle-Lassen 1985). Each line covers one bone, tooth, or antler. The ontogenetic age of the animal is given for each part of the skeleton in months or years and, for antlers, the number of tines.

It is apparent from the bones that calves were killed at all times of the year, as were older animals.

The presence of unshed antler is not as reliable a seasonal indicator as the skeleton, since antler may have been kept as raw material elsewhere and, at a later time, brought to the site to be worked. Uncertainty also surrounds cast antler, since it cannot be known how long it lay on the ground before collection.

## ANALYSIS AND RESULTS

Methods of identifying skinning, dismemberment, filleting, transportation, and food preparation from bone material involve the analysis of cut marks, bone breakage, and skeletal element representation. While cut marks unambiguously reflect human activity, that is not the case for bone breakage. In addition to breaks caused by geological agencies, dogs may have worked on the Tybrind Vig material. It is, therefore, necessary to include gnawing by dogs in the analysis and to distinguish between the different patterns of breakage and fragment morphology characteristic of dogs and man, respectively.

The relative frequency with which the different skeletal elements occur may form the basis for evaluating haulage strategy, butchering, further transport, and aspects of food preparation such as extraction of bone grease. However, other forms of human and non-human behaviour also affect skeletal representation.

Many practical considerations affected which parts of a red deer brought down in a hunt were transported to a settlement such as Tybrind Vig, for example, the physical state of the animal (e.g. condition and antler configuration) (Speth 1983, Speth & Spielmann 1983), the possibilities of transport, and the needs of consumers all vary with season. Distance from the kill site to the settlement, size of the animal or animals, the number of animals killed, method of butchering, and number of hunters or bearers are all decisive factors affecting what and how much are brought back. What is selected will also be affected to a considerable extent by cultural factors peculiar to a particular society.

Which parts of the whole red deer skeleton were thrown into the water and, as such, could be recorded archaeologically, would depend on the preceding settlement activities. Here, butchering methods, food, and implement preparation, and the possible removal from the site of meaty parts, together with gnawing of bones by dogs, would determine the make-up of the refuse. How the animal was treated in these contexts would again depend on its physical condition, i.e. age, sex, health, and so on (Speth 1983). Which parts of the refuse ended up in the water would be further determined by factors such as the physical effort involved, the possibility of re-utilization, and how much the part was in the way (Hayden & Cannon 1983: 154). The last factor was determined by, among other things, size, occupation density, intensity of activity, and frequency with which the settlement was used (Binford 1983: 187–190).

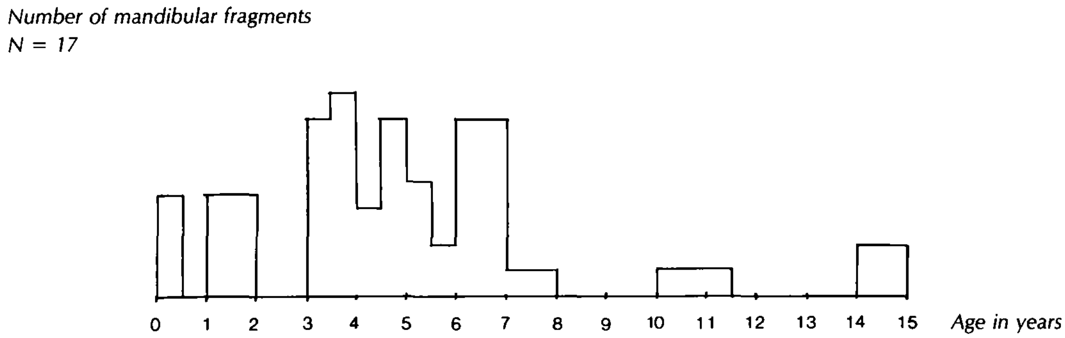



Fig. 4. Age distribution of red deer, based on mandibular fragments.

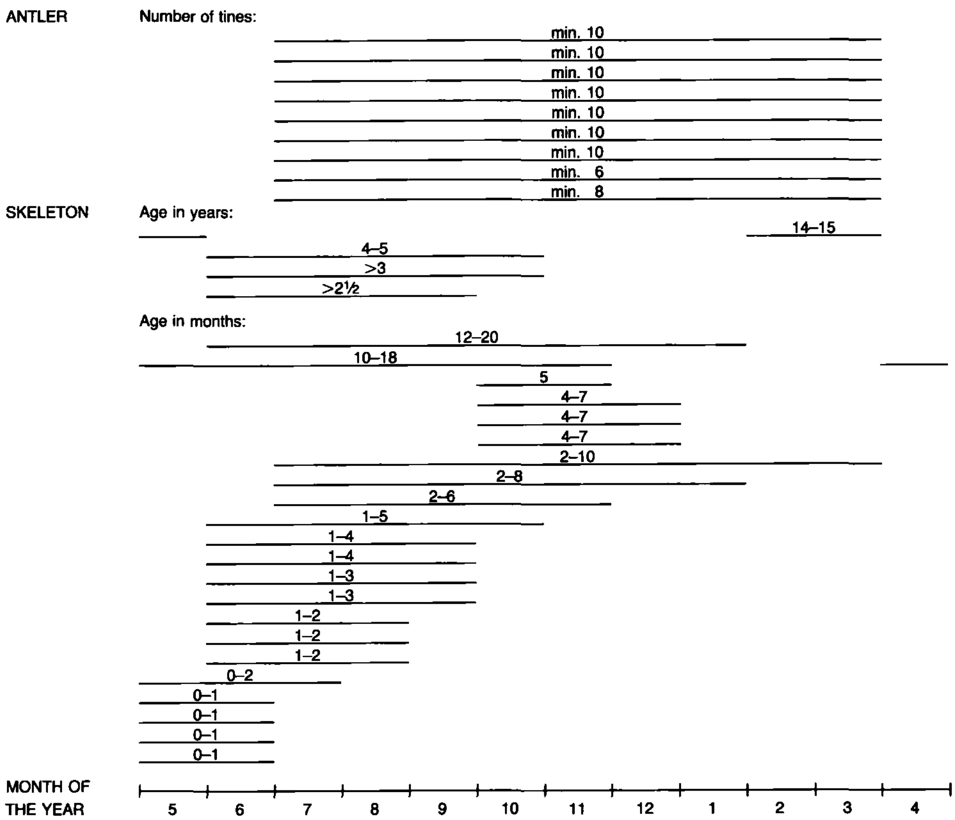



Fig. 5. Season of death determined from skeleton parts.

## Cut marks

All bones were scrutinized for cut marks under the microscope at at least five power magnification, and all cuts were recorded on sketches. Interpretation of cut marks and bone breaks was based on: (a) archaeological literature focusing directly on bones and their potential testimony (Møhl 1972, Sadek-Kooros 1972, Wheat 1972, Frison 1973, 1978, Kehoe 1973, von den Driesch & Boessneck 1975, Noe-Nygaard 1977, Myers *et al.* 1980, Binford 1981, Gifford 1981, Zeimens 1982), (b) ethnographic and ethnoarchaeological literature dealing with the treatment of game (Mathiassen 1928, Birket-Smith 1929, Ingstad 1952, Gould 1967, Fletscher & La Flesche 1972, Rogers 1973, Marks 1976, Yellen 1977, Binford 1978), and (c) the experimental skinning of a pine- marten, skinning and butchering of an otter using flint blades, and skinning and butchering of a red deer using flint axes (Trolle-Lassen 1985) (4).

The cut marks on the skeleton reveal their origin during skinning, dismemberment, filleting, and implement manufacture. This may be seen both by which bones exhibit them and in their position on these bones.

Cuts were observed on bones of animals aged about 5 months and older. The uneven surface of all bones of very young calves prevented identification of any marks there.

Use-wear analysis of flint collected from coeval south Scandinavian settlements shows that mainly unretouched blades were used for skinning and butchering (Juel Jensen & Brinch Petersen 1985, Juel Jensen 1986). Blades with an acute edge angle (c. 20°) have, among other things, cut fresh hide and flesh, while blades in which the edge angle is steep (40–55°) have a polish made by working against flesh and bone (butchering) (*ibid.*).

### *Skinning*

Cuts which with considerable certainty may be ascribed to skinning were observed on the vault and on phalanges (cf. Binford 1981: 101–104, 107, Fletscher & La Flesche 1972: 272, Rogers 1973: 22–24). Slightly more ambiguous were cuts on the upper and lower jaws, radius, tibia, and

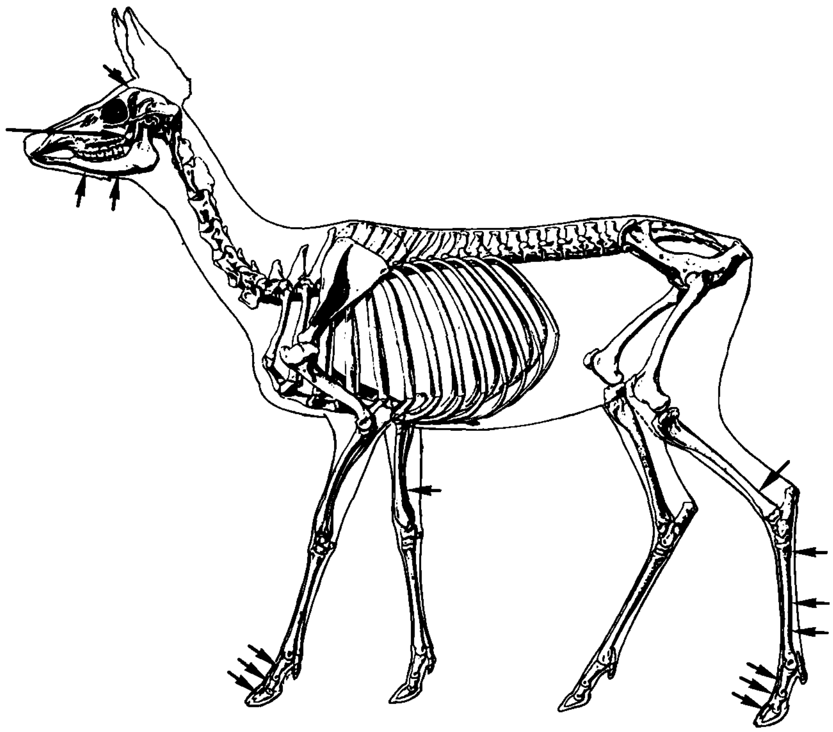


Fig. 6. Red deer skeleton (after Ellenberger *et al.* 1956) showing possible marks of skinning.

metapodials, since these bones acquire cuts during dismemberment or filleting, and the metapodials, because of their use as raw material, also during implement manufacture. The position of possible skinning marks is shown in figure 6.

Half of the eight pieces of *calvaria* with attached antlers exhibited cut marks around the base of the antler, on the burr, and on the vault itself (fig. 7). On the other half, an eroded surface obliterated any such marks.

Three *phalanges* – proximal, medial, and distal – exhibit transverse dorsal cuts (fig. 8). Five other well-preserved phalanges, also representing all types, lacked cuts. Four pieces had an eroded surface.

In both of two fully preserved *maxillae,* oblique and horizontal cut marks were evident on the lateral surface (fig. 9). Some of these may perhaps have been derived from skinning.

Three *mandibles* showed cut marks attributable to skinning (fig. 10). They were all placed latero-basally on the corpus and had an oblique, transverse orientation.

Two distal *radii* exhibited strong and long, respectively, transversal and oblique cuts on the shaft. They were both placed 10–10.5 cm proximal to the most distal point of the bone. Similar transverse marks were seen on two of the six distal *tibiae* with well-preserved surfaces. The cuts are long and cross the shaft 5.5–6 cm proximal to the most distal point on the bone (figs. 11 & 33). They may have been made during skinning (cf. Binford 1981: 107, Højlund 1981: 62, figs. 77–78), but they could have derived from the severing of muscles during filleting.

No metacarpals, but three metatarsals, had annular cut marks possibly due to skinning (fig. 12). In one case, they appeared proximally on the shaft, in another, groups of cuts were found at several places down the distal part of the shaft, and, in a third specimen, there were merely single cuts on the lateral surface of the distal part of the shaft. However, it cannot be ruled out that these marks resulted from preparation for tool-making or, in the proximal case, that they are butchering marks (see below).

On five of the *long bones* of the extremities (radius, metacarpus, femur, tibia, and metatarsus), long, medial longitudinal cut marks were seen. Cuts such as these were also seen on other bone surfaces, and it could not be decided whether they were skinning marks acquired when the hide was cut from the inner side of the limb or whether they were derived from later filleting.

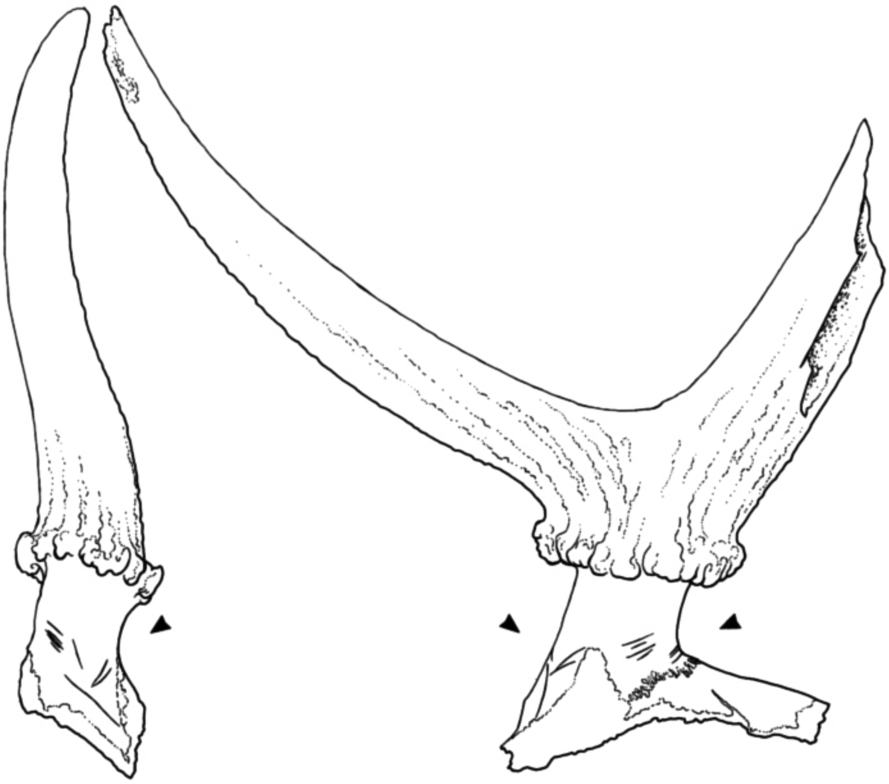



Fig. 7. Skinning marks on the vault around the base of the right antler. 2:5.

*Disarticulation*

Marks that should presumably be ascribed to cutting through articulations while the carcass was butchered were observed on occiput, atlas, axis, mandible, scapula, humerus, ulna, radius, carpal, metacarpus, pelvis, femur, tibia, malleolus, tarsal, and metatarsus (cf. Binford 1981: 107–126, Rogers 1973: 18–25).

The position of these disarticulation marks is shown in figure 13.

Two oblique cut marks dorso-aboral to the third molar on the *maxilla* may be due not to skinning but to severing of the masticatory muscle, thereby separating the lower jaw from the rest of the skull (fig. 9). No corresponding traces were seen on the mandible.

Two *occipital* regions exhibit cut marks, indicating that the head was cut off between the cranium and the atlas (Rogers 1973: 23–24). Corresponding marks were seen ventrally on one *atlas*. One *axis* with cuts ventrally near the cranial articulation presumably shows that decapitation also occurred with a cut between the atlas and axis, which is the easiest way of doing things (Rogers 1973: 18).

Two sagittal cut marks dorso-medially in the symphysis of a *mandible* were perhaps derived from division of the jaw into right and left halves.

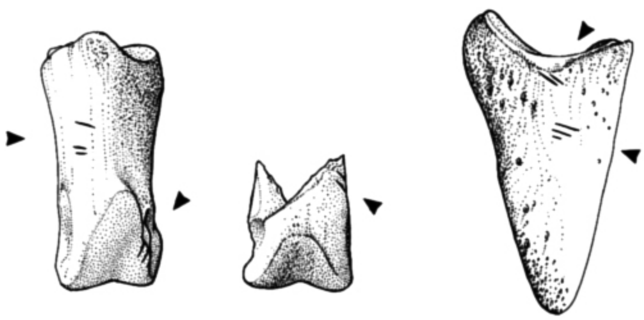



Fig. 8. Skinning marks on phalanges. 3:4.

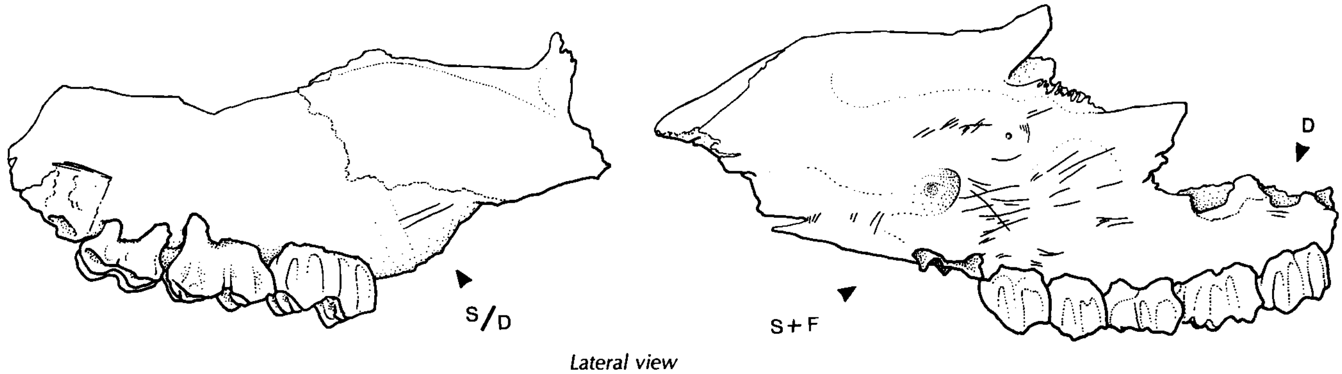



Fig. 9. Filleting marks (F) and possible skinning (S), and dismemberment marks (D) on left maxilla. 1:2.

One of the two *scapulae* with a well-preserved distal end showed that parting occurred at the articulation with the humerus (fig. 14). This was confirmed by cuts on the only two proximal *humeri,* both of which are well preserved with fused epiphyses (fig. 15).

Parting had been effected through the joint distal to the humerus, where six more or less well-preserved distal ends of humeri exhibited cut marks (fig. 16). Confirmation was probably found in the only well-preserved proximal end of an *ulna,* where several transverse cuts were seen (fig. 17). Expected corresponding cuts proximally on the radius were not found, but their absence may be explained by attrition and fragmentation of this area of the bone.

The upper and lower parts of the foreleg had been parted in the *carpal region.* No cut marks were seen on the distal end of either the ulna or the radius. Binford, too, found the latter position rare (1981: 126). There was, however, a single transverse cut in the actual articular surface of the radius. The observed cut marks on the proximal carpals were probably derived from disarticulation (fig. 18). Two sets, each of three proximal carpals, exhibited cut marks: one on three and the other on four of the surfaces of the foreleg. One additional intermedium and an accessorium had well-preserved surfaces devoid of cut marks.

One of two *metacarpals* with well-preserved proximal ends had cut marks that can be ascribed to disarticulation or to filleting/scraping. Disarticulation marks were present on one of the two well-preserved distal ends (fig. 19).

Distinct cut marks about the acetabulum on both well-preserved *pelves* indicated separation between the pelvis and femur in this articulation (fig. 20). Corresponding cuts were seen proximally on all three *femora* with well-preserved surfaces (fig. 21).

Only two distal femoral epiphyses, one of which was well preserved, were found in the material. No cut marks attributable to dismemberment were observed. Correspondingly only two proximal tibial epiphyses were found, both of which had eroded surfaces lacking cut marks.

Cuts on tibiae and tarsals testify to separation of the upper from the lower parts of the hind leg. Two of four well-preserved distal ends of *tibiae* with fused epiphyses showed dismemberment marks, while the others were indeterminant (fig. 11). In addition, cut marks were seen dorso-laterally on one of three well-preserved malleoli

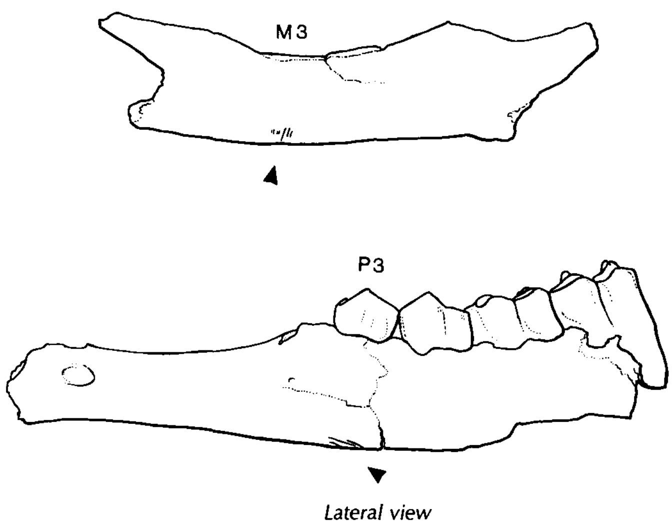
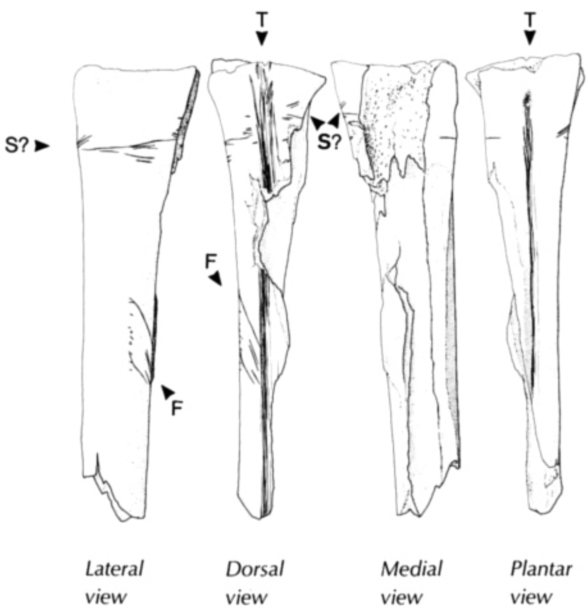



Fig. 10. Skinning marks on left mandible. 1:2.


Fig. 11. Dismemberment (D), filleting (F), and possible skinning marks (S) on right tibia. C. 1:2

(fig. 22). All six *calcanei* with undamaged surfaces and all three *astragali* bore distinct disarticulation marks such as those described by Binford (1981: 116–119) (figs. 23 & 24).

Presumably cuts on metatarsus and distal tarsals were caused by separation of these parts. All *centrotarsals* exhibited small, mainly transverse, cut marks, usually on dorsal as well as both lateral surfaces, in one case also on the



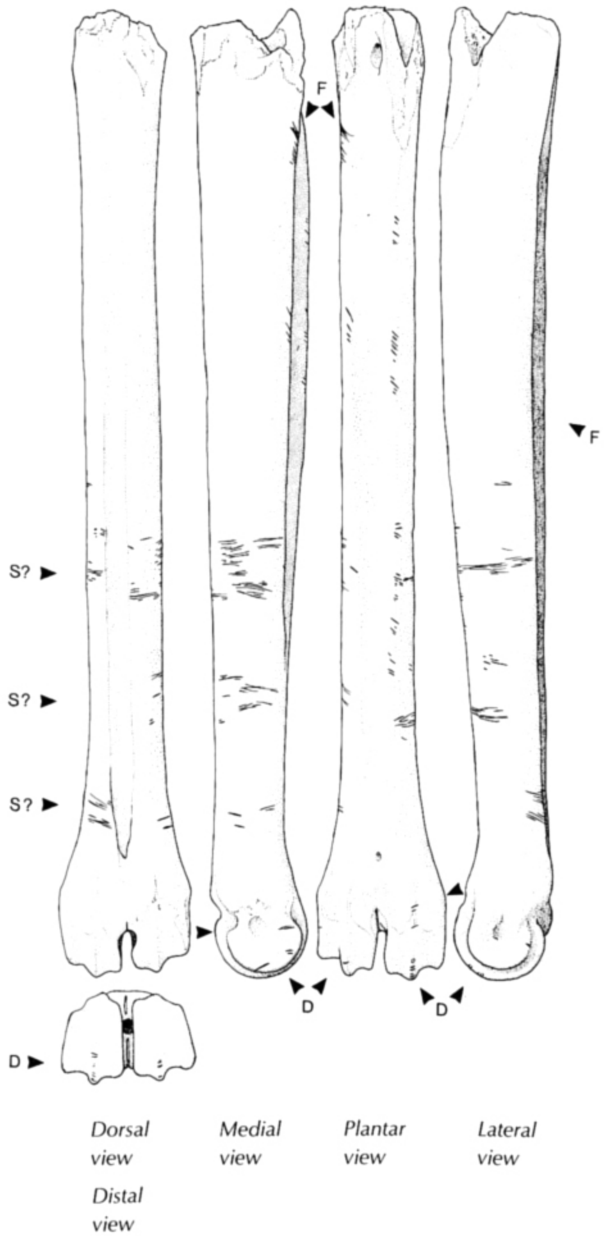




Fig. 12. Cut marks deriving from dismemberment (D), filleting/scraping (F), tool-making (T), and possibly skinning (S) on two right metatarsals. C. 1:2.

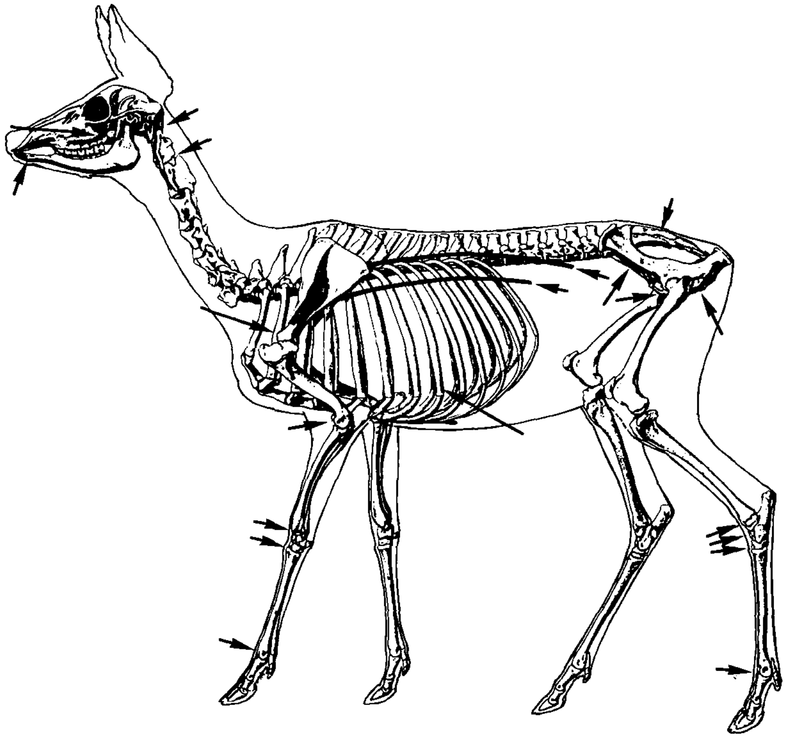


Fig. 13. Red deer skeleton (after Ellenberger *et al.* 1956) showing location of possible marks of dismemberment.

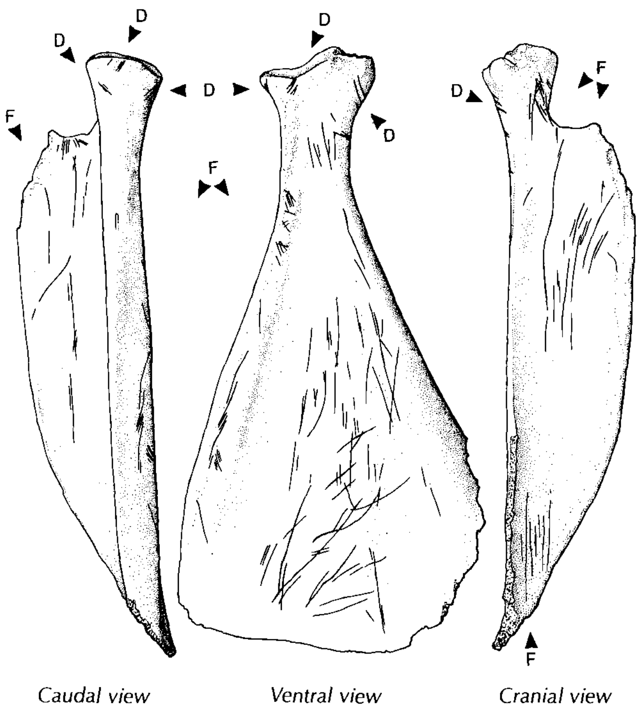



Fig. 14. Dismemberment (D) and filleting marks (F) on right scapula. 1:4.

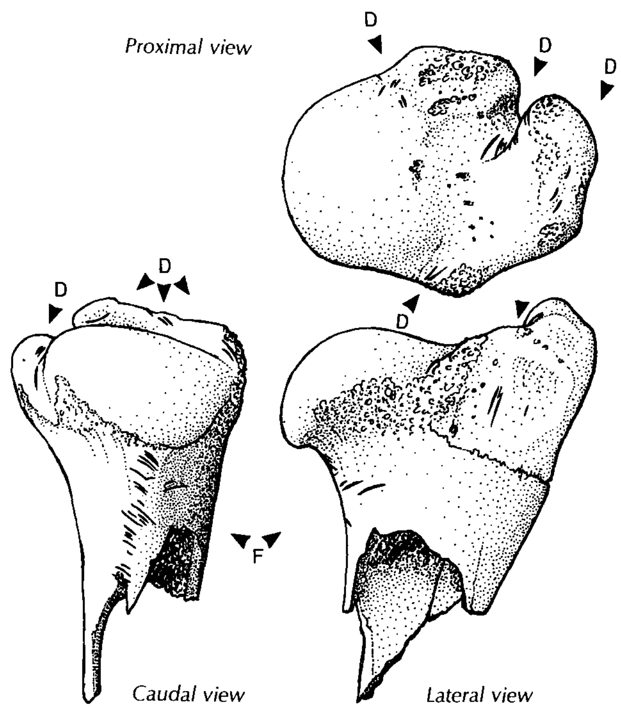



Fig. 15. Dismemberment (D) and filleting marks (F) on proximal part of right humerus. 1:2.

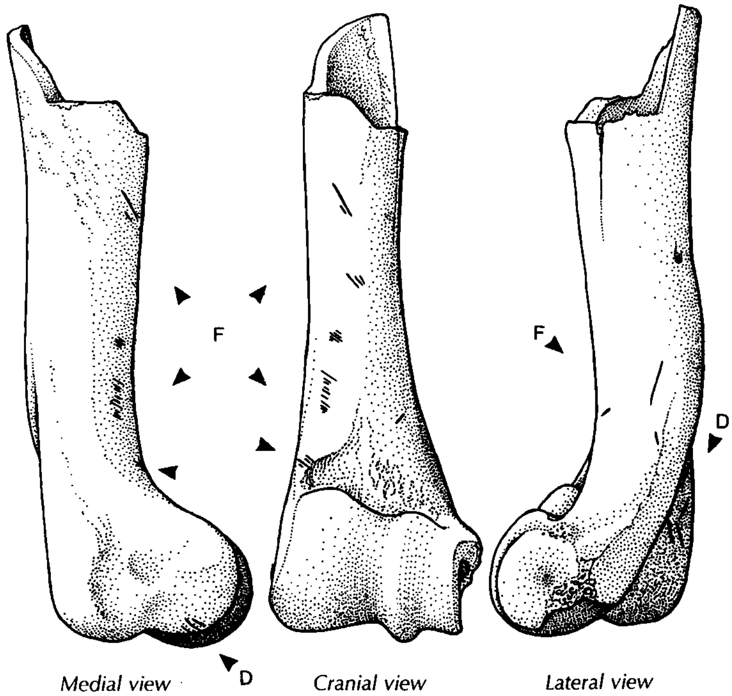



Fig. 16. Dismemberment (D) and filleting marks (F) on distal part of left humerus. 1:2.

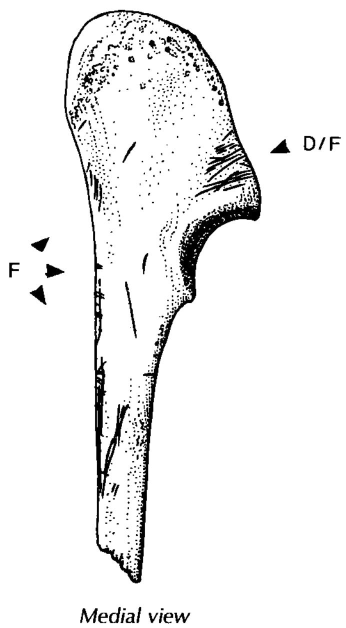



Fig. 17. Filleting (F) and possible dismemberment marks (D) on proximal part of left ulna. 1:2.

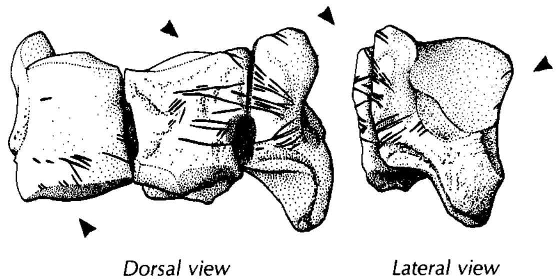



Fig. 18. Dismemberment marks on left carpals. 3:4.

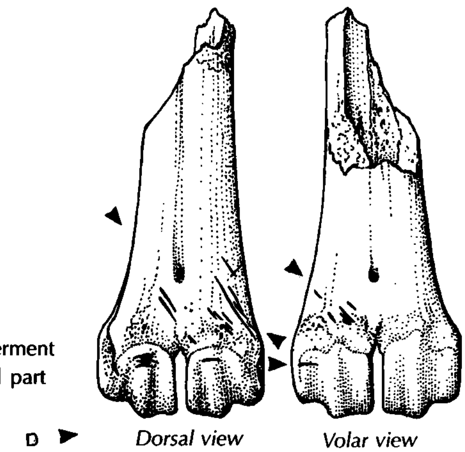



Fig. 19. Dismemberment marks (D) on distal part of left metacarpus. 1:2.

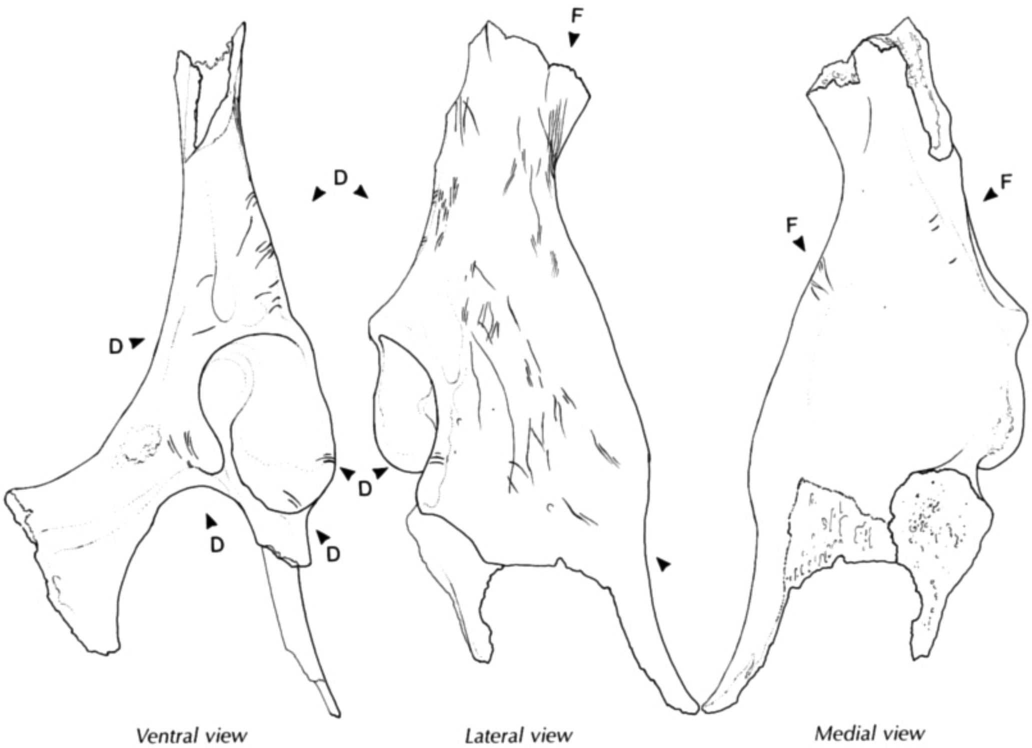



Fig. 20. Dismemberment (D) and filleting marks (F) on left pelvis. 1:2.

plantar aspect (fig. 25). The two latero-intermediate *cuneiforms* both had small, oblique cut marks on the dorsal surface. Three of the five well-preserved proximal ends of *metatarsus* exhibited cut marks that may be attributed to disarticulation (fig. 26).

Cuts distally on the metatarsus, both on the barrels and on the surfaces just above the epicondyle, probably reflect the cutting off of the phalanges (fig. 12). Such traces were seen on three of the eight well-preserved pieces.

### *Filleting and Scraping*

Cuts that may result from the filleting or scraping away of flesh or periosteum, or both, were observed on maxilla, vertebra, cervical, scapula, humerus, ulna, radius, metacarpus, pelvis, femur, tibia, metatarsus, and costa (see Binford 1981: 126–36).

The Nunamiut Eskimo usually carefully scrape and clean the shafts of long bones before extracting the marrow (Binford 1981: 150–159). It is reported that the !Kung Bushmen cut off large lumps of flesh remaining after biltong-making before extracting marrow (Yellen 1977: 292–293). The breaking of the bone followed a specific pattern for each (*ibid.*), and the blows must, therefore, fall precisely, which presumably required that the bones be well cleaned. The cutting and scraping away of meat are also found among Cree Indians (Rogers 1973: 21–22, 25). A similar cleaning of the bones could have preceded their utilization as raw material in prehistoric tool-making.

Flesh had been scraped from the *cranium* in the region of the cheek (fig. 9). The same process is presumably reflected in cut marks observed dorsally on two *cervical vertebrae*, no. 5 or 6 (fig. 27).

Extensive filleting cuts were seen on all three preserved *scapulae* (fig. 14) and likewise on all pieces of *humerus*, where the surface had not been eroded away (fig. 15).

Cuts stemming from filleting, but perhaps also from scraping caused by activities with other purposes, were seen on *ulnae* (fig. 17) and on a large number of *radius* pieces (figs. 28 & 29). Corresponding scraping cuts of different kinds were seen on the shafts of three *metacarpals* (fig. 30).

The parts of the *pelvis* which, according to Binford, primarily display filleting cuts (1981: Fig. 4.36), were not observed in the Tybrind Vig material, which comprises

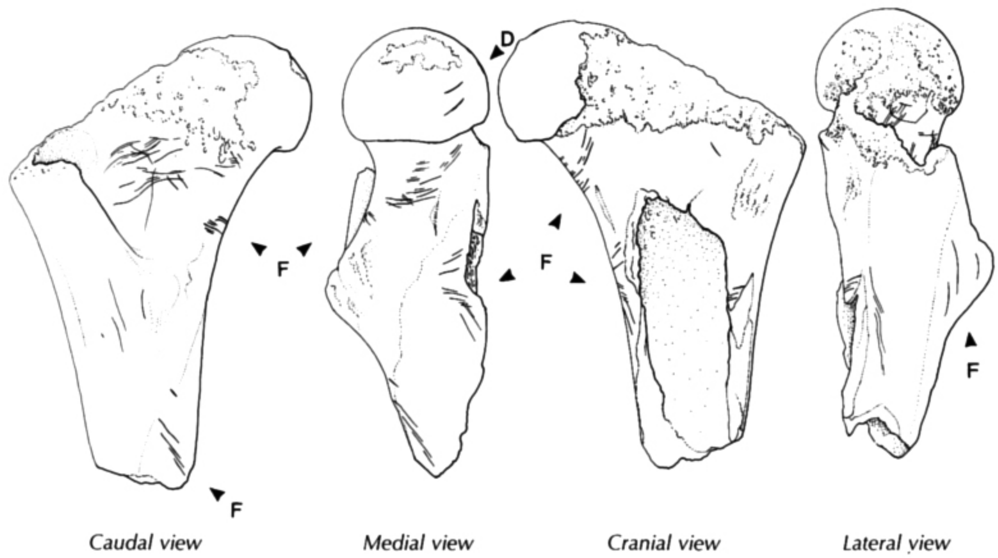



Fig. 21. Dismemberment (D) and filleting marks (F) on proximal part of left femur. 1:2.

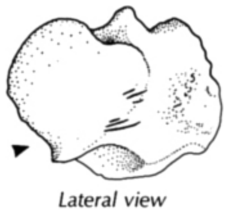



Fig. 22. Dismemberment marks on right malleolus. 1:1.

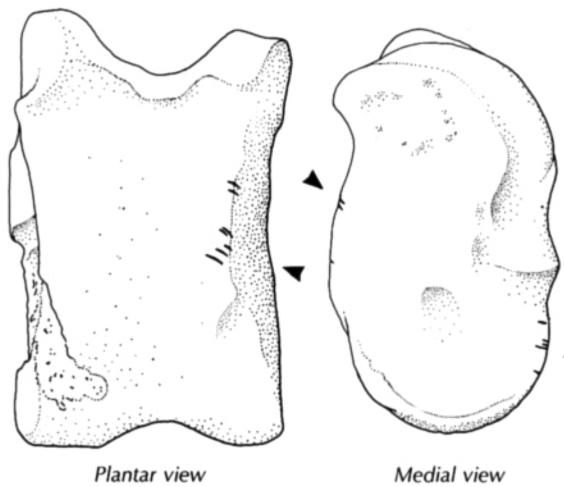



Fig. 24. Dismemberment marks on left astragalus. 1:1.

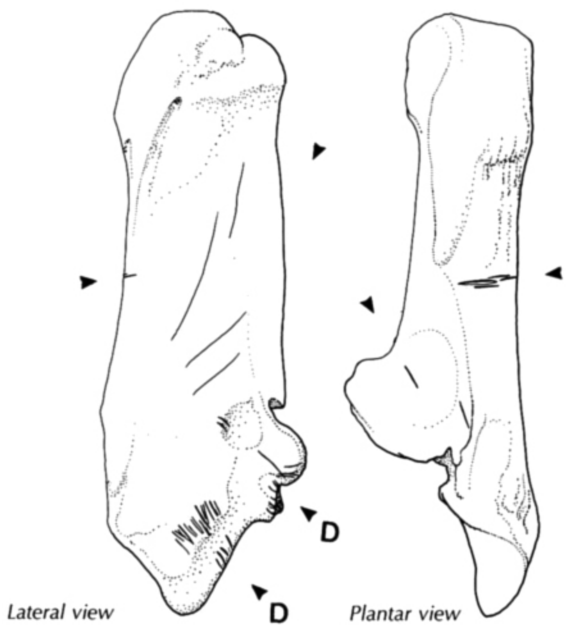



Fig. 23. Dismemberment marks (D) on right calcaneus. 5:7.

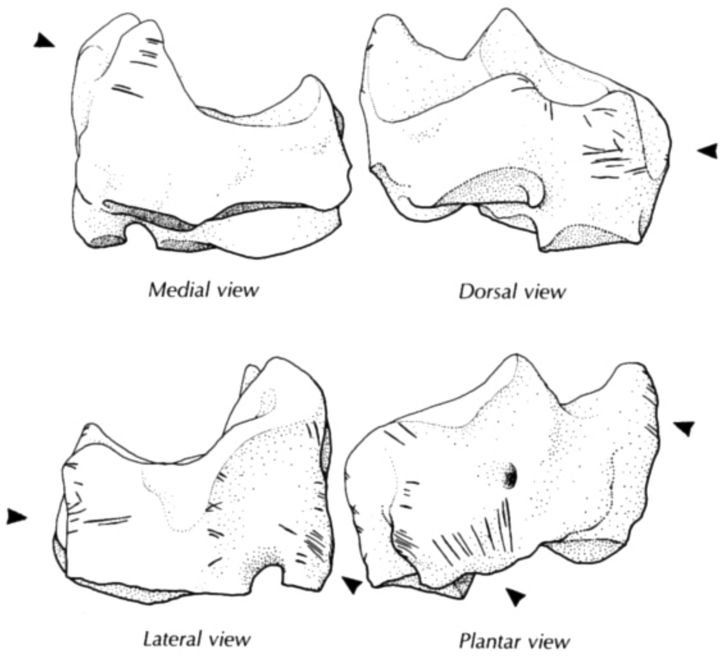



Fig. 25. Dismemberment marks on left centrotarsal. 1:1.

little more than the acetabulum and the area around it. In the existing fragments, a number of cut marks were observed, however, whose presence is best attributed to this activity (fig. 20). *Femora* had many cut marks which, in accordance with Binford, are interpreted as filleting marks (figs. 21 & 31).

Cut and scraping marks on *tibiae* presumably were derived from filleting and perhaps other scraping activity

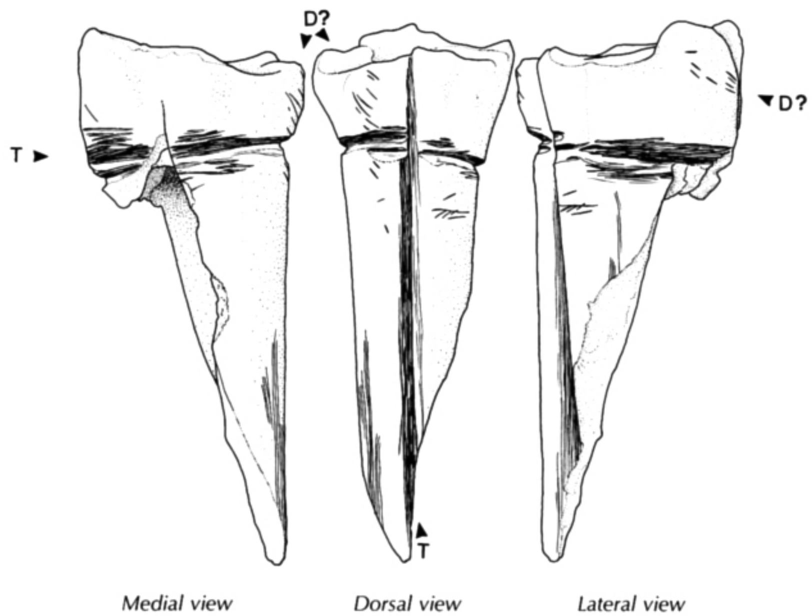



Fig. 26. Marks of dismemberment (D) and tool-making (T) on proximal part of left metatarsus. 3:4.

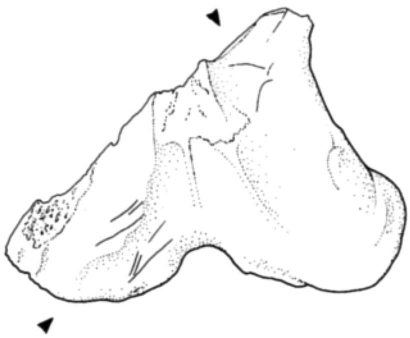



Fig. 27. Filleting marks on cervical vertebra. 2:3.

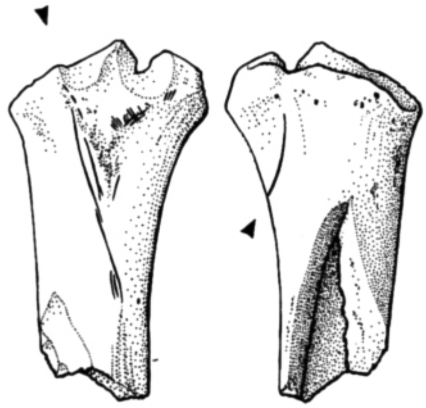



Fig. 28. Filleting marks on proximal part of right radius. 1:2.

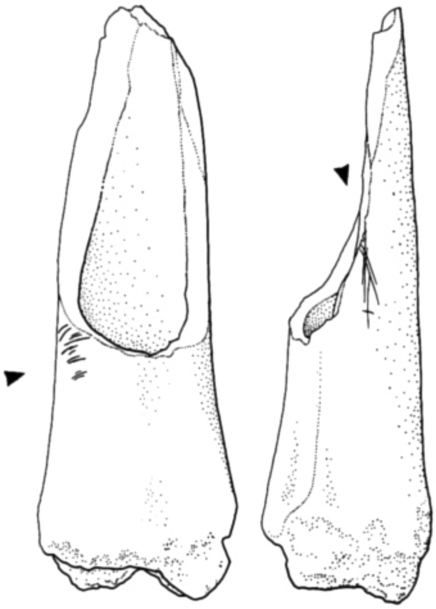



Fig. 29. Filleting marks and possible scraping marks on distal part of right radius. 2:3.

(figs 32. & 33). Corresponding cuts of different types were seen on the shafts of four *metatarsals* (fig. 12).

Longitudinal or transverse cut and scraping marks on the inner *rib* faces were most likely derived from the cutting and scraping away of flesh (fig. 34). Marks of this kind, which were unambiguously recorded in 11 cases, were observed only on the mid- and ventral parts of the ribs, not on dorsal ends.

## Bone breakage

The breakage pattern, fragment morphology and secondary features of the bones showed that human agencies, and not carnivores (for example, dogs), were responsible for the fragmentation (Binford 1981, Gifford 1981). Fragments of long bones were thus found either as isolated epiphyses or as split shafts. Epiphyses with attached shafts occurred only occasionally, and secondary features in the form of marks made by blows showed that the breaks result from human activity.

On a tenth of the bones, marks from the gnawing of scavengers, presumably dogs, were seen (table 1). The gnawing observed can, however, be ruled out as a cause of breaks in the sturdy, thick-walled long bones of the red deer: it is too weak and its marks were concentrated at the epiphysis and not, or only to a lesser degree, around the break.

Ethnographic sources report that normally only a few bones, such as ribs and perhaps pelvis and vertebrae, were snapped or broken in connection with butchering (Birket-Smith 1929: 139–141, Fletscher & La Flesche 1972: 272–274, Rogers 1973: 18, Yellen 1977: 280ff., Binford 1978: 50, 62–63, 94–97, 142–144, Binford 1981: 87ff.). An exception is secondary butchering of frozen carcasses. In that situation, it is not possible to sever the tendons of the joints, and the limbs, for example, have to be further sundered by a break in the centre of the shaft of long bones (Binford 1978: 50). Such a technique is unnecessary in a mild climate such as that which prevailed in Danish Atlantic times. The overchopped and broken bones most

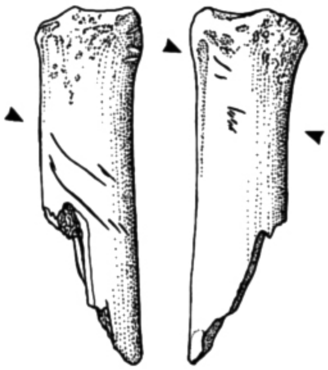



Fig. 30. Cleaning marks on proximal part of left metacarpus. 1:2.

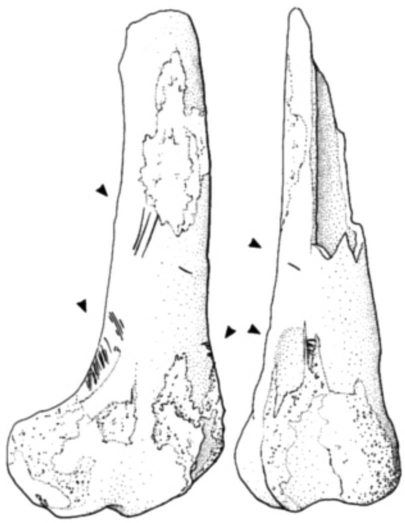



Fig. 31. Filleting marks on distal part of right femur. 1:2.

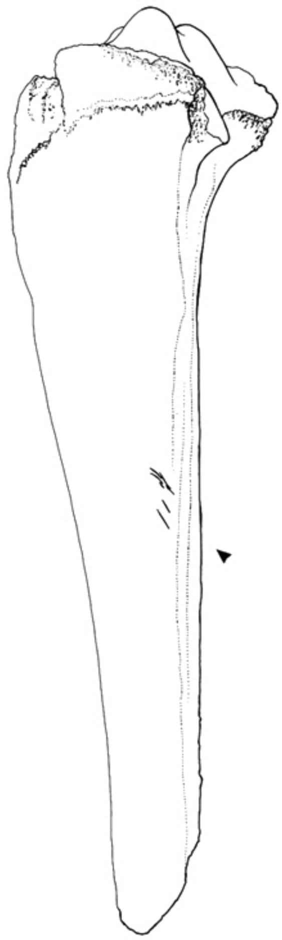



Fig. 32. Filleting marks on proximal part of right tibia. 1:2.

often resulted from food preparation and tool-making, respectively.

Bone breakage associated with food preparation might serve the following ends: (a) reducing the size of the meaty bone pieces, allowing boiling or roasting to occur in a smaller pot or smaller pit, (b) extracting marrow or brain mass, (c) rendering bone grease, and (d) production of bone juice. The rendering of bone for grease and bone juice are both activities which, for the Nunamiut Eskimos and the Mistassini Cree Indians, took place *after* marrow extraction (Rogers 1973: 25, Binford 1978: 157, 164). The raw material consists of the epiphyses of long bones, entire tarsals, and for bone juice also whole carpals and ribs (Binford 1978: 32–38, 164–165). In the course of the process, the bones are effectively crushed, resulting in a greater or lesser degree of pulverization, depending on the hardness of individual bones (Binford 1978: 158, 164–165). In the following, only large bone fragments, such as epiphyses and shaft splinters of long bones, will be discussed, and the production of bone grease and liquor will, therefore, not be touched on in this section.

### *Dismemberment*

The breaking of bones probably during dismemberment was observed in pelvis and ribs.

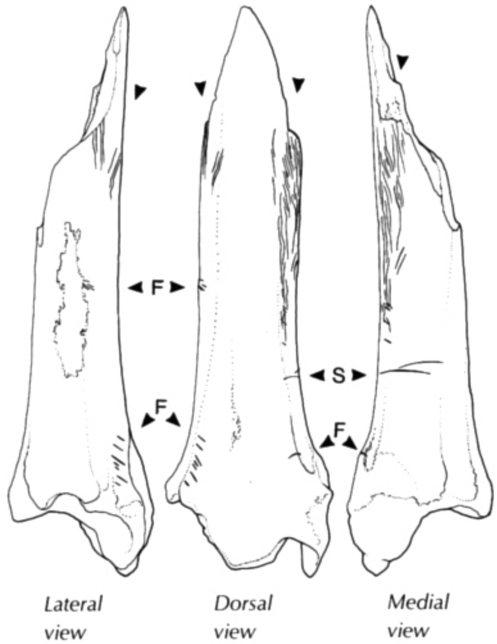



Fig. 33. Filleting marks (F), and possible skinning (S) and scraping marks on distal part of right tibia. 1:2.


Fig. 34. Scraping marks on the inner side of right ribs. 1:2.

All seven *pelvis* pieces were derived from the area around the acetabulum (fig. 35). Right and left halves had probably been parted or broken in the sagittal plane through the symphysis. Considering the conditions of preservation, it is not reasonable to ascribe this pattern to natural agencies after the bone was discarded. Dog gnawing is seen not on the pubis, but caudally on the ischium, where the transverse ramus and tuberosity were usually gnawed away (table 1). According to Binford, it is precisely these two parts, in addition to the dorsal rim of the tuberculum pubis, to which carnivores are partial (1981: 66–67). A first sacral vertebra reveals that the sacrum had been chopped down the middle. Lengthwise division of the pelvis is known from the Bushmen, where it is often split to ease transportation of the kill (Yellen 1977: 283). Nor is the phenomenon altogether uncommon in connection with caribou (Binford 1981: 67–69).

Half caribou pelvis were often broken through at the neck of the ilium (Binford 1981: 69). This seems also to have occurred during dismemberment of red deer from Tybrind Vig where three of the five larger pelvis pieces exhibited a clean break lacking evidence of dog- gnawing, while two were relatively eroded and recently broken.

*Rib* fragments may be classified into four categories according to their anatomical position and size: (a) dorsal pieces, without the head, (b) mid-pieces, (c) combined mid- and ventral pieces, and (d) ventral pieces.

The dorsal pieces showed that the rib- slab was broken at the neck, the heads remaining attached to the spine (fig. 36) (Rogers 1973: 18, Yellen 1977: 283, Binford 1981: 113). It is apparent from the dorsal, mid, and mid-ventral

| Bone | Bones permitting identification | Gnawed | |
|---|---|---|---|
| | n | n | % of identifiable |
| *Cranium* | 5 | 1 | 20.0 |
| *Mandibula* | 10 | 1 | 10.0 |
| *Vertebrae cervicales* | 9 | 1 | 11.1 |
| *Costae* | 21 | 2 | 9.5 |
| *Scapula* | 2 | 2 | 100.0 |
| *Humerus* | 12 | 8 | 66.7 |
| *Radius* | 16 | 3 | 18.8 |
| *Carpal* | 8 | 3 | 37.5 |
| *Metacarpus* | 16 | 5 | 31.3 |
| *Pelvis* | 3 | 2 | 66.7 |
| *Femur* | 13 | 2 | 15.4 |
| *Tibia* | 18 | 1 | 5.6 |
| *Calcaneus* | 8 | 6 | 75.0 |
| *Metatarsus* | 20 | 6 | 30.0 |

Table 1. Frequency of dog-gnawing on different types of red deer bones.

pieces that a deliberate break was also made across the slab more ventrally (fig. 36). The break had apparently been prepared by scoring deeply across the ribs in line with the intended break. These cut marks were too deep to be interpreted as filleting marks. In most cases, namely 11 out of 14, the cut had been scored from the outside, after which the inner side had been broken over, as shown by its scarred or serrated appearance (fig. 37). In only three cases was the opposite pattern, in which the incision had been laid from the inside, seen (fig. 37). The anterior ribs (up to and including no. 3 at least) had not been subjected to this scoring and breaking. Corresponding observations were made in the material from Præstelyngen where the phenomenon was likewise interpreted as deliberate dismemberment (Noe-Nygaard 1977: 228–229). Although more superficial cuts were not observed in the dorsal rib area, one must assume that the fillet was cut away early in the process (Rogers 1973: 18). After this, the rib-slab was broken from the backbone and a more ventral break made by cutting deeply into the bone. The purpose of breaking the ribs was to separate the filleted dorsal part from the still meaty mid- and ventral part.

A rib with strong, transverse, lateral scoring on the ventral end may reflect removal of the sternum (Fletscher & La Flesche 1972: 272–273, Binford 1981: 113). A systematic breakage pattern among ventral rib fragments was not ascertained, and such fragmentation can thus not be attributed to deliberate cultural activity. This is supported by the presence of ten large rib pieces, each of which comprised the entire portion from the ventral end to the point where the dorsal part begins.

### *Marrow Extraction*

The purpose of breaking mandibles, long bones, phalanges, and vertebrae was apparently, first and foremost, the extraction of marrow. The long bone shafts of the newborn animals and young calves 0–3 months old were complete. As early as an age of about 6–10 months, marrow had been extracted from the long bones. The presence of a complete jaw half from a 5-month-old calf shows that marrow was not extracted from mandibles of animals in this age group.

The *mandibles* were breached for marrow extraction, as has been recorded for Bushmen and Eskimos (Yellen 1977: 292, Binford 1978: 149–150). Most of the breaks formed a particular pattern, certain features of which are reminiscent of that described for the material from the coeval locality of Præstelyngen (Noe-Nygaard 1977: 225–226).

At least five pieces showed breaking across the corpus, aboral to the 2nd and 3rd molars (as at Præstelyngen) (fig. 38). The bases may have been broken off in slightly different ways: just under the molars and obliquely up through the diastema (as at Præstelyngen), somewhat further down on the corpus and basal to the incisors, or even more basally so that only the bottom margin of the jaw was broken off.

Fig. 35. Two left pelvis halves with dismemberment breaks across the neck and longitudinally through the symphysis. Parts of the ischium have been gnawed away by dogs. Ventral view.

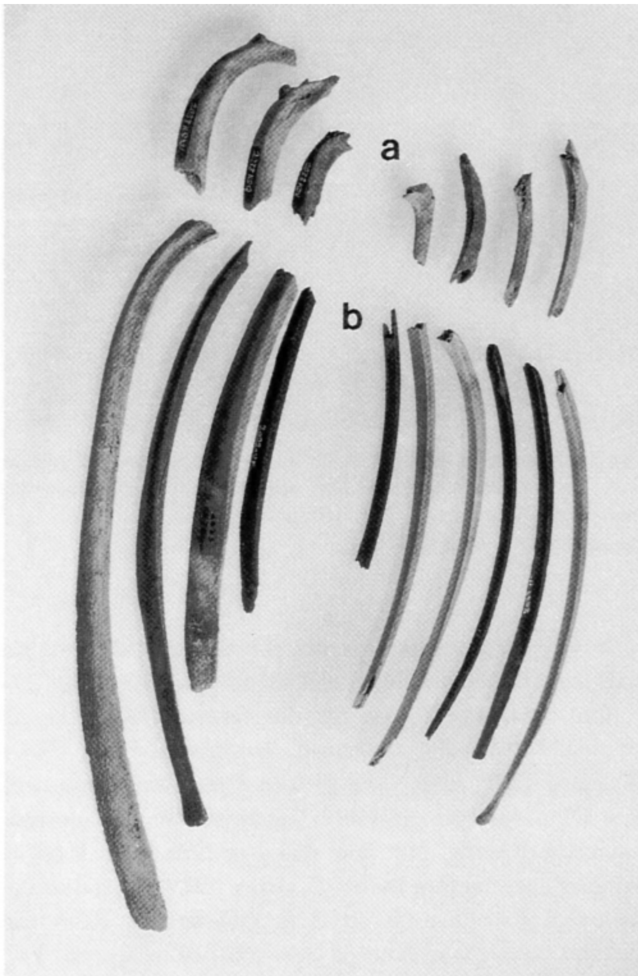



Fig. 36. Anatomical arrangement of rib fragments showing that the rib-slab has been deliberately broken at two places: (a) at the neck, leaving the heads attached to the spine, and (b) somewhat more ventrally.

Besides the dentigerous fragments, four basic pieces of varying size and a single fragment of the oral part of the jaw broken at the diastema were recorded. Four jaw fragments did not fit the pattern described.

Different indications revealed that the long bones had been broken, first and foremost, to obtain marrow. For the !Kung Bushmen and perhaps the Omaha Indians, this is the only, and for the Nunamiut Eskimo and Mistassini Cree, apparently the primary reason for breaking bones (Fletscher & La Flesche 1972: 274, Rogers 1973: 25, Yellen 1977: 292–293, Binford 1978: 144ff.).

Yellen reports that the Bushmen try to make the break so that the marrow can be extracted as entire and unsullied (by bone splinters) as possible, and that different bones are treated in different ways (1977: 293). It has also been established, both from the explanation of the !Kung and direct observation, that random breakage is *not* the rule (*ibid.*).

Neither Bushmen nor Eskimo prepare long bones in a meaty condition, but they fillet them first. Bushmen make biltong from the first meat to be cut off, and boil the rest. The pieces of bone are also added to the stew after marrow removal (*ibid.*). The Eskimo do not put broken bones in their stew, but can sometimes heat the bones in it, preparatory to extracting marrow (Binford 1978: 145–146).

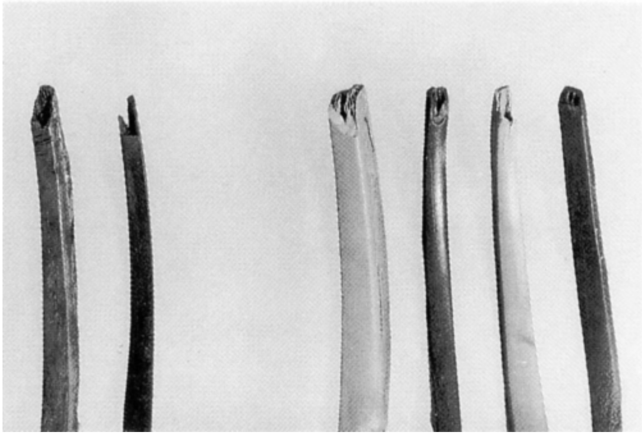


Fig. 37. The broken ends of six rib fragments, inner aspect. Medial view. The two pieces on the left have been cut from the inner side; the four on the right have marks from cutting on the outside and from snapping on the inside.

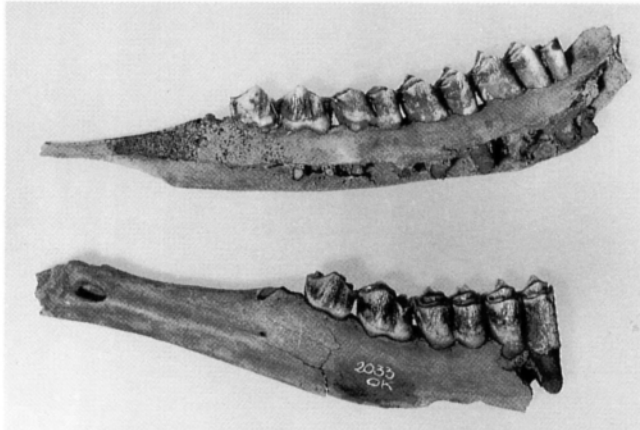


Fig. 38. Dentigerous fragments of marrow-broken left lower jaws. Lateral view.

Among the bone implements, the metapodials were the only long bones that were utilized as raw material.

The breakage pattern for the *humerus* (19 pieces) is reminiscent of that described for Præstelyngen (Noe-Nygaard 1977: 226). The proximal end was broken off just distal to the cancellous tissue where the marrow cavity begins (fig. 39). The distal end was struck off at varying distances up the shaft, either just proximal to the articulation or near mid-shaft (fig. 39). In most cases, the marrow cavity was exposed over most of its length. The shaft was apparently split into at least two parts.

The breakage pattern for the *radius* (26 pieces) did not resemble that observed for the Præstelyngen material (*ibid.*). In most cases, both the proximal and distal ends were struck off (figs. 28–29), after which the shaft was split into two or more pieces. More rarely, the bone was apparently struck across the middle, after which the resulting pieces were split, perhaps followed by another break at the junction of shaft and epiphysis.

The breakage pattern for the *femur* (23 pieces) differed from that at Præstelyngen, six or more instead of four fragments per bone (*ibid.*) resulting. The proximal end was struck off just distal to the cancellous bone (fig. 21); the head and the large trochanter were separated. The distal end was struck off, apparently usually without or with only a little of the shaft. The shaft was struck across the middle, and these pieces were then most often split lengthwise. Four pieces differed in being more intact.

The breakage pattern for the *tibia* (35 pieces) likewise differed from that observed at Præstelyngen; instead of four pieces per bone, six or more were produced (*ibid.* and p. 228). The proximal end was struck off just distal to the spongiosa. The distal end was struck off a short way up the shaft (figs. 11 & 33). The shaft was struck across the middle and split into at least two proximal and at least two distal pieces. Six larger, and thus less broken, pieces deviated from this pattern, but in all cases, the marrow was easily accessible.

Although seven pieces with unequivocal signs of toolmaking were excluded, fragmentation of the *metapodials* (73 pieces) gave a confused picture which presumably reflects a combination of marrow extraction and toolmaking. When extraction of marrow was the primary end, the breakage pattern seemed to accord with that observed for the femur and tibia, and thus different from that observed at Præstelyngen (Noe-Nygaard 1977: 226, 228). Both epiphyseal ends were struck off (figs. 19 & 30), and the shaft was broken across and split lengthwise into at least four pieces.

All five proximal *phalanges* and two out of the four medial phalanges were broken for marrow (fig. 8). The Nunamiut Eskimo boil caribou feet into a stew and, if food is limited, or marrow bones (long bones) are not immediately available for the meal, the proximal and medial phalanges are broken for marrow at mid shaft (Binford 1978: 148), which results in a break exactly like those observed for the Tybrind Vig material. The two distal phalanges were complete and unbroken (fig. 8).

Two almost whole *cervical vertebrae* (an axis and a 5th vertebra) were found, while the remaining 14 pieces,

Fig. 39. Proximal fragments of right and distal fragments of left marrow-broken humeri. Lateral and dorsal views.

Fig. 40. Several marrow-struck cervical vertebrae, ventral aspect. On the left are body fragments and on the right parts of the arch.

which are merely fragments, represented the whole cervical segment of the spine. The body and the arch were in all cases separated (fig. 40), which agrees with the Præstelyngen material (Noe-Nygaard 1977: 228).

Five body pieces were chopped through near the middle in the transverse dorso-ventral line (fig. 40) and one is whole. The vertebral processes were, in some cases, broken off the arch. The left dorsal part of the atlas was found as a chopped-off fragment. The breaks did not seem to be the result of dismemberment, such as described by Yellen (1977: 284), who reports that the Bushmen chop the cervical part of the spine down the middle into two parts to make transport home easier. The fragmentation patterns rather suggest the extraction of marrow for eating, as known from Omaha Indians' exploitation of bison (Fletscher & La Flesche 1972: 272). The vertebral column of neither the large antelope nor the caribou is used for its marrow, the yield being considered too small (Yellen 1977: 292, Binford 1978: 149).

The other ten pieces of both *thoracic* and *lumbar vertebrae* were most fragmented and eroded, and a pattern of breakage could not be distinguished. It can be mentioned, however, that among the former is a specimen that has opened epiphyses in which the spinal process is intact, in contrast to the Præstelyngen material (Noe-Nygaard 1977: 227–228). Also, among the lumbar vertebrae, a cranial body part was seen which was parted in the transverse dorso-ventral plane, while another vertebra was divided sagitally.

*Tool-making*

Bone breakage possibly related to the manufacture of implements was observed on the skull, the scapula, and the metapodials.

Nine proximal *antler* pieces attached to a frontal element were recorded. The cranium was clearly chopped to free the antler (fig. 7) (Rogers 1973: 23–24). Apart from this method sparing the whole antler in the first instance, it should also be the easiest way of removing it, if the purpose is merely to part it from the skull (Binford 1981: 109).

In two cases, breaks observed on the *scapula* may be derived from prehistoric human activity, the spine having been chopped off. This phenomenon should presumably be ascribed to tool-making, a similar break having been seen in material from the coeval settlement of Ringkloster in connection with the production of bone discs from scapula bone (Andersen 1975: 70–72).

Besides seven *metapodials* with unambiguous traces of tool-making, several types of fragments may be associated with this activity (5). For example, proximal pieces, split mediolaterally, are thought to be waste from the production of long bone points fashioned from the caudo-medial or caudo-lateral ridge. In contrast are epiphyses attached to the plantar part of the whole split shaft that are probably blanks for awls, bone points, or the like (fig. 41). At least six fragments exhibited cuts that may be attributed to tool manufacture. Thus, there were many, fine, long, parallel cuts along the length of the shaft, usually in the dorsal or plantar groove (fig. 12).

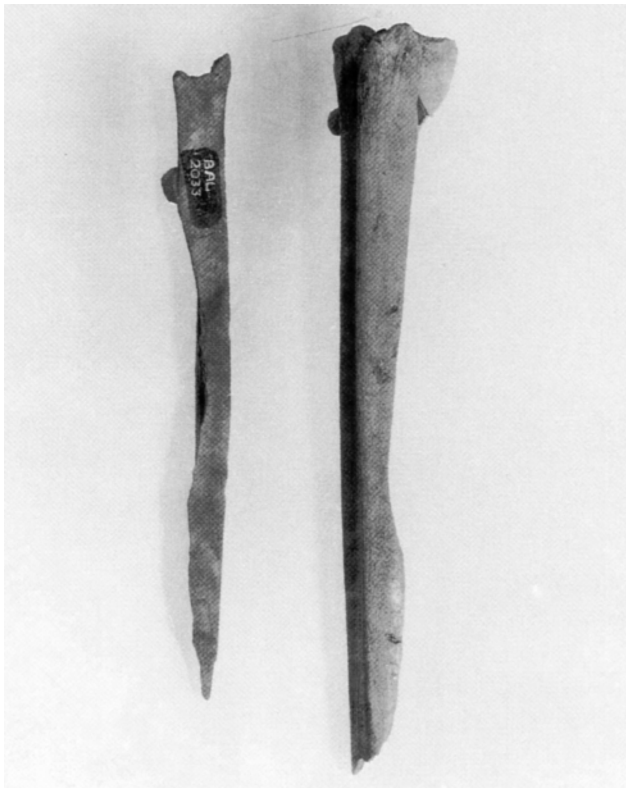


Fig. 41. On the left, a bone point fashioned from a left metatarsus and on the right an (unsuccessful?) unfinished piece for a similar implement fashioned from a right metatarsus. Lateral view.

*Utilization of the Skull*

Skull parts comprising both face and neurocranium were not found. *Facial* fragments consist of parts of maxilla, one of which still has an attached nasal bone, a piece of zygomatic arch, and numerous loose teeth. It could not be established whether these parts were deliberately separated, but the state of preservation of the bones of other species represented, such as pine- marten and polecat, in conjunction with ethnographic observations (Rogers 1973: 23–24, Yellen 1977: 291–292, Binford 1978: 150–151), suggest that that was the case. Fat can be obtained from the nose and from behind the eyes, and breacking the cranial cavities provides a strong soup when the skull is boiled (Ingstad 1952: 127, Binford 1978: 151).

In addition to the earlier mentioned frontal pieces with attached antler, the *neurocranium* was represented by seven fragments. Contrary to the case with the facial skeleton, distinct marks from blows were seen on bones of the cranium, and it was deliberately opened by humans. By a series of blows on the vault, the rear part was chopped away and then broken into left and right halves and perhaps into still smaller pieces, as indicated by half of one occipital condyle. This fragmentation facilitated extraction of the brain for eating or hide preparing, as known from extant populations (Ingstad 1952: 127, Fletscher & La Flesche 1972: 273, Rogers 1973: 23–24, 29, Yellen 1977: 292, Binford 1978: 151).

## Skeletal representation

As mentioned earlier, bones were found from the greater part of the skeleton, with only the hyoid, caudal vertebrae, and sternum absent. Estimates based on the man-

| Part | Number of fragments found | | | Number of fragments expected | | | Number of bone units found | | | Number of bone units excepted | | | Representation % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | sin | dex | indet. | sin | dex | indet. | sin | dex | indet. | sin | dex | indet. | fragment | bone unit |
| *Dentes* | | | 11 | | | | | | | | | | | |
| *Cranium* | 9 | 3 | 1 | | | 88 | | | 3 | | | 11 | 14.8# | 27.3 |
| *Mandibula* | 13 | 8 | 3 | 44 | 44 | | 11 | 5 | | 11 | 11 | | 27.3 | 72.7 |
| *Hyoideum* | | | | | | | | | 0 | | | 11 | 0 | 0 |
| *Atlas* | | | 1 | | | 22 | | | 1 | | | 11 | 4.5 | 9.0 |
| *Axis* | | | 3 | | | 33 | | | 3 | | | 11 | 9.0 | 27.3 |
| *Vertebrae cervicales* | | | 12 | | | 165 | | | 5 | | | 55 | 7.2 | 9.1 |
| *Vertebrae thoracales* | | | 5 | | | 286 | | | 3 | | | 143 | 1.7 | 2.1 |
| *Vertebrae lumbales* | | | 5 | | | 132 | | | 4 | | | 66 | 3.8 | 6.1 |
| *Vertebrae sacrales* | | | 2 | | | 66 | | | 2 | | | 44 | 3.0 | 4.5 |
| *Vertebrae coccygis* | | | 0 | | | 121 | | | 0 | | | 121 | 0 | 0 |
| *Costae* | 25 | 19 | 4 | | | 869 | | | 19 | | | 286 | 5.5 | 6.6 |
| *Sternum* | | | | | | | | | 0 | | | 11 | 0 | 0 |
| *Scapula* | 6 | 7 | | 27.5 | 27.5 | | 4 | 6 | | 11 | 11 | | 23.6 | 45.5 |
| *Pelvis* | 5 | 3 | 1 | 33 | 33 | | 5 | 3 | | 11 | 11 | | 13.6 | 36.4 |
| *Humerus* | 8 | 11 | | 44 | 44 | | 7 | 4 | | 11 | 11 | | 21.6 | 50.0 |
| *Radius* | 12 | 13 | | 44 | 44 | | 2 | 5 | | 11 | 11 | | 29.5 | 31.8 |
| *Ulna** | 3 | 3 | | 22 | 22 | | 1 | 3 | | 11 | 11 | | 13.6 | 18.2 |
| *Carpalia* | 10 | 1 | | 55 | 55 | | 10 | 1 | | 55 | 55 | | 10.0 | 10.0 |
| *Matacarpus III/IV* | 11 | 8 | 14 | see Mp | | | 5 | 6 | | 11 | 11 | | | 50.0 |
| *Femur* | 15 | 8 | | 66 | 66 | | 8 | 3 | | 11 | 11 | | 17.4 | 50.0 |
| *Patella* | | 2 | | 11 | 11 | | | 2 | | 11 | 11 | | 9.1 | 9.1 |
| *Tibia* | 15 | 20 | | 66 | 66 | | 5 | 5 | | 11 | 11 | | 26.5 | 45.5 |
| *Fibula* | 1 | 2 | | 11 | 11 | | 1 | 2 | | 11 | 11 | | 13.6 | 13.6 |
| *Astragalus* | 1 | 2 | | 11 | 11 | | 1 | 2 | | 11 | 11 | | 13.6 | 13.6 |
| *Calcaneus* | 5 | 5 | | 11 | 11 | | 5 | 5 | | 11 | 11 | | 45.5 | 45.5 |
| *Other tarsalia* | 3 | 5 | | 33 | 33 | | 3 | 5 | | 33 | 33 | | 12.1 | 12.1 |
| *Matatarsus III/IV* | 17 | 18 | 9 | see Mp | | | 7 | 7 | | 11 | 11 | | | 68.2 |
| *Metapodium III/IV* | 28 | 26 | 26 | 110 | 110 | | 12 | 13 | 2 | 22 | 22 | | 36.4 | 61.4 |
| *Phalanx p.* | | | 5 | | | 176 | | | 4 | | | 88 | 2.8 | 4.5 |
| *Phalanx m.* | | | 4 | | | 132 | | | 4 | | | 88 | 3.0 | 4.5 |
| *Phalanx d.* | | | 2 | | | 88 | | | 2 | | | 88 | 2.3 | 2.3 |
| *Sesmoides* | | | 1 | | | | | | | | | | | |

# Uncertain figure.

* Some fragments fused with radius.

Table 2. Representation of skeletal parts of red deer older than 3 months (at least 11 individuals).

dible indicate that at least 11 animals older than 3 months are represented. This information was used in producing table 2, together with results from the breakage pattern analysis.

In table 3, the representation of individual bones is shown according to the frequency in which they occur. There is nice agreement between the number of fragments of a specific bone and the frequency with which a bone element occurs, supporting the assumption that the order is characteristic of the material. Only a few bones (marked with an asterisk) occupy different positions in both columns. The radius was, on account of an easily identified shaft, relatively overrepresented among the fragments. The femur was perhaps for the opposite reason

| Fragment | | Bone unit | |
|---|---|---|---|
| *Good, > 20%* | % | *Good, > 40%* | % |
| *Calcaneus* | 45.5 | *Mandibula* | 72.7 |
| *Metapodia* | 36.4 | *Metapodia* | 61.4 |
| *Radius** | 29.5 | *Humerus* | 50.0 |
| *Mandibula* | 27.3 | *Femur** | 50.0 |
| *Tibia* | 26.5 | *Scapula* | 45.5 |
| *Scapula* | 23.6 | *Tibia* | 45.5 |
| *Humerus* | 21.6 | *Calcaneus* | 45.5 |
| | | | |
| *Medium, 10–20%* | % | *Medium, 10–40%* | % |
| *Femur** | 17.4 | *Pelvis* | 36.4 |
| *Cranium* | 14.8# | *Radius** | 31.8 |
| *Pelvis* | 13.6 | *Cranium* | 27.3 |
| *Ulna* | 13.6 | *Axis** | 27.3 |
| *Malleolus* | 13.6 | *Ulna* | 18.2 |
| *Astragalus* | 13.6 | *Malleolus* | 13.6 |
| *Other tarsalia* | 12.1 | *Astragalus* | 13.6 |
| *Carpalia* | 10.0 | *Other tarsalia* | 12.1 |
| | | *Carpalia* | 10.0 |
| | | | |
| *Poor, < 10%* | % | *Poor, < 10%* | % |
| *Patella* | 9.1 | *Patella* | 9.1 |
| *Vertebrae* | 1.7–9.0 | *Vertebrae* | 2.1–9.1 |
| *Costae* | 5.5 | *Costa* | 6.6 |
| *Phalanges* | 2.3–3.0 | *Phalanges* | 2.3–4.5 |
| *Hyoideum* | 0 | *Hyoideum* | 0 |
| *Vertebrae coccygis* | 0 | *Vertebrae coccygis* | 0 |
| *Sternum* | 0 | *Sternum* | 0 |

* Bones not occupying the same position in both columns.

\# See Table 2.

Table 3. Representation of skeletal parts of red deer, with bones ranked by frequency of occurrence at Tybrind Vig (based on Table 2).

slightly underrepresented, while the axis, due to easy recognition of the characteristic knob, is well represented.

It is apparent from table 2 that 12.9% of the expected number of bones and 11.1% of the expected number of fragments were present. A loss of at least 87–89% could, thus, be directly observed. This accords with findings from other investigations at similar places (Noe-Nygaard 1979, Aaris-Sørensen 1983). The actual loss was much greater and could presumably be reconstructed only under very favourable find conditions. Below, attention will be focused on the relative loss, i.e. the quantitative ratio of skeletal remains present.

### *Transport Home*

The bone assemblage from Tybrind Vig so far suggests that the entire deer was usually brought back home. In the first instance, nearly all parts of the skeleton were present, including small and distal bones like the phalanges and, in the second instance, large bones with relatively little utilization value, such as mandible, calcaneus, and axis, frequently occurred (table 4). This agrees with the Mistassini Cree treatment of moose and caribou where the whole animal is brought home and entirely utilized (Rogers 1973: 20–21, 39).

### *Disarticulation*

The presence of small hoof bones in the discarded material is probably an expression of methods used to cut up the carcass. There are, thus, several examples of hoof bones being thrown together into the water, presumably still articulated by tendons. A collection may, for example, consist of the three proximal carpal bones, the two

| Bone | % | Bulk Density | Marrow | Grease | Meat | Food |
|---|---|---|---|---|---|---|
| *Group I* | | | | | | |
| *Mandibula* | 72.7 | 0.57 | 6 | 13 | 31 | 44 |
| *Metatarsus* | 68.2 | 0.51 | 91 | 30 | 11 | 27 |
| *Metacarpus* | 50.0 | 0.53 | 64 | 29 | 5 | 11 |
| *Humerus* | 50.0 | 0.32 | 29 | 51 | 29 | 40 |
| *Femur* | 50.0 | 0.32 | 41 | 63 | 100 | 100 |
| *Scapula* | 45.5 | 0.36 | 6 | 8 | 45 | 43 |
| *Tibia* | 45.5 | 0.40 | 68 | 47 | 26 | 56 |
| *Calcaneus* | 45.5 | 0.64 | 21 | 47 | 11 | 32 |
| Average | 53.4 | 0.46 | 41 | 36 | 32 | 44 |
| Average excl. metapodia | 51.5 | 0.44 | 29 | 38 | 40 | 53 |
| Range | | 0.32–0.64 | 6–91 | 8–63 | 5–100 | 11–100 |
| *Group II* | | | | | | |
| *Pelvis* | 36.4 | 0.27 | 8 | 29 | 49 | 48 |
| *Radius* | 31.8 | 0.43 | 55 | 35 | 15 | 24 |
| *Cranium* | 27.3 | – | – | – | – | |
| *Axis* | 27.3 | 0.16 | 1 | 13 | 10 | 10 |
| *Ulna* | 18.2 | 0.37 | – | – | 14 | 27 |
| *Malleolus* | 13.6 | – | – | – | – | – |
| *Astragalus* | 13.6 | 0.47 | 1 | 32 | 11 | 32 |
| *Other tarsali* | 12.1 | 0.39 | 1 | 30 | 11 | 32 |
| *Carpal* | 10.0 | – | – | – | – | – |
| Average | 21.1 | 0.35 | 13 | 28 | 18 | 29 |
| Range | | 0.16–0.47 | 1–55 | 13–35 | 10–49 | 10–48 |
| *Group III* | | | | | | |
| *Patella* | 9.1 | – | – | – | – | – |
| *Vertebrae cerv.* | 9.1 | 0.19 | 1 | 17 | 37 | 36 |
| *Vertebrae thor.* | 2.1 | 0.24 | 1 | 12 | 47 | 46 |
| *Vertebrae lumb.* | 6.1 | 0.29 | 1 | 15 | 33 | 32 |
| *Costae* | 6.6 | 0.40 | 1 | 8 | 52 | 50 |
| *Sacrum* | 4.5 | 0.19 | – | – | 49 | 40 |
| *Phalanx p.* | 4.5 | 0.42 | 30 | 33 | 2 | 14 |
| *Phalanx m.* | 4.5 | 0.25 | 22 | 25 | 2 | 14 |
| *Phalanx d.* | 2.3 | 0.25 | 1 | 14 | 2 | 14 |
| *Vertebrae coccygis* | 0 | – | – | – | – | – |
| *Sternum* | 0 | 0.22 | 1 | 26 | 66 | 64 |
| Average | 4.4 | 0.27 | 7 | 19 | 32 | 34 |
| Range | | 0.19–0.42 | 1–30 | 8–33 | 2–66 | 14–64 |

*including the tongue.

Table 4. Representation of red deer bone units in relation to bulk density and food value.

distal tarsals, and the proximal part of the metatarsal, or the distal and medial phalanges. In cases where the animal was dismembered differently, and those bones separated from one another, they were perhaps on account of their small size not thrown into the water; among other things, the isolated bones are easier for dogs to manage.

### *Utilization of the Long Limb Bones*

The separation of long bone epiphyses was not equal. There are various reasons for such a differential presence in rubbish. The food value of the bones and the utilization associated with it partly explain the pattern observed. The juncture at which the epiphyses fuse with the shaft, reflecting the size and mineralization of the pieces, seems,

| Bone | Fused and isolated epiphyses | Fused and isolated epiphyses and isolated diaphyses | Approximate time of epiphyseal fusion |
|---|---|---|---|
| *Metacarpus p.* | 7 | 10 | 7 months |
| *Metatarsus p.* | 10 | 10 | 7 months |
| *Humerus d.* | 9 | 10 | 1½–2½ years |
| *Radius p.* | 8 | 8 | 1½–2½ years |
| *Tibia d.* | 7 | 9 | 2½–3½ years |
| *Metacarpus d.* | 8 | 9 | 3½–5 years |
| *Metatarsus d.* | 13 | 13 | 3½–5 years |
| Average | 8.9 | 9.9 | 2½ years |
| Average excl. metapodia | 8 | 9 | 2½ years |
| Range | 7–13 | 8–13 | – |
| | | | |
| *Radius d.* | 4 | 5 | 4½–6½ years |
| *Tibia p.* | 4 | 4 | 4½–6½ years |
| *Femur p.* | 5 | 8 | 4½–6½ years |
| *Femur d.* | 2 | 2 | 4½–6½ years |
| *Humerus p.* | 5 | 5 | 4½–6½ years |
| Average | 5.0 | 4.8 | 4½–6½ years |
| Range | 2–5 | 2–8 | – |

*Complete obliteration of the epiphyseal line.

Table 5. Occurrence of long bone epiphyses related to approximate time of epiphyseal fusion.

however, to have a more general effect on the distribution. The representation of the epiphyses relative to timing of fusion will, therefore, be examined first.

In table 5, bones of individuals older than approximately 6 months were presented in the order in which epiphyses fuse. The first column gives the number of detached and fused epiphyses. The second column includes shaft pieces from the epiphysis end in question. It was apparent from that that the number of earlier fused ends was on average around ten, whereas the average figure for the later fused is just less than five. According to the skeletal part representation (tables 2–4), metapodials were the most frequently occurring long bones, which was presumably due to their being kept more carefully after dismemberment because of their role as a raw material for implement production. When metapodials were omitted from analysis in order to eliminate the effects of toolmaking, the representation of early fused epiphyses fell to nine. Apart from the proximal femoral epiphysis, there thus seemed to be a connection between the incidence of epiphyses and the time at which each fused. Epiphyses that fused at a late stage were underrepresented in relation to those that fused early, perhaps because unfused ends occurred in smaller units (one or more epiphyses and a diaphysis end) and exhibited a lower degree of mineralization than did fused epiphyses.

Skeletal representation can also reflect differential utilization of carcass and skeleton parts, manifested, for instance, by removal from the site of particular parts having high food value, or in differential crushing in the course of food preparation. This illustrates the importance of food value as a selective factor.

In connection with butchering and food preparation in which the crushing of bone was involved, the bulk density of the bone will also be important, that, too, relating to the resistance of the bone to destruction (Gifford 1981): compact bone parts are better able to withstand destruction than low-density pieces. This applies in general, of course, whether destruction is brought about by biological or geological agencies.

The unequal food value and bulk density of the various parts of the game animal thus result in individual bones being used and destroyed with different intensity and effect by both men and dogs. Also of taphonomic importance is the direct relationship between bulk density and food value, as demonstrated by Lyman (1985: 228–231). Thus, compact bone parts have low food and nutritional value, whereas low-density bones tend to have high value.

| Bone | Fused and isolated epiphyses | Bulk density | Marrow | Grease | Meat | Food | Gnawed | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | n* | % |
| *Metatarsus d.* | 13 | 0.46 | 100 | 43 | 11 | 24 | 6 | 54.5 |
| *Metatarsus p.* | 10 | 0.55 | 82 | 18 | 11 | 30 | 5 | 20.0 |
| *Humerus d.* | 9 | 0.39 | 28 | 28 | 29 | 37 | 6 | 83.3 |
| *Radius p.* | 8 | 0.42 | 44 | 38 | 15 | 27 | 4 | 0 |
| *Metacarpus d.* | 8 | 0.49 | 67 | 42 | 5 | 10 | 5 | 40.0 |
| *Metacarpus p.* | 7 | 0.56 | 62 | 17 | 5 | 12 | 5 | 40.0 |
| *Tibia d.* | 7 | 0.50 | 93 | 26 | 26 | 47 | 5 | 20.0 |
| Average | 8.9 | 0.48 | 68 | 30 | 15 | 27 | | 36.8 |
| Average excl. metapodia | 8.0 | 0.44 | 55 | 31 | 23 | 37 | | 34.4 |
| Range | 7–13 | 0.39–0.56 | 28–100 | 17–43 | 5–29 | 10–47 | | 0–83.3 |
| *Femur p.* | 5 | 0.36 | 34 | 27 | 100 | 100 | 4 | 50.0 |
| *Humerus p.* | 5 | 0.24 | 30 | 75 | 29 | 43 | 4 | 50.0 |
| *Radius d.* | 4 | 0.43 | 66 | 33 | 15 | 22 | 4 | 25.0 |
| *Tibia p.* | 4 | 0.30 | 44 | 69 | 26 | 65 | 2 | 0 |
| *Femur d.* | 2 | 0.28 | 49 | 100 | 100 | 100 | 1 | 100.0 |
| Average | 4 | 0.32 | 45 | 61 | 54 | 66 | | 45.0 |
| Range | 2–5 | 0.24–0.43 | 30–66 | 27–100 | 15–100 | 22–100 | | 0–100.0 |

*Number of bone fragments permitting identification of gnawing, if present.

Table 6. Occurrence of long bone epiphyses related to bulk density, food value, and dog-gnawing.

In table 6, the column with detached and fused epiphyses was arranged in order of frequency. The bulk density, marrow, grease, meat, and total food value were given for each bone (after Lyman 1985: 227, table 2, partly referring to Binford 1978). Estimates of bulk density have been provided for two North American species of deer (*Odocoileus hemionus* and *O. virginianus*) and are believed to be of general validity for artiodactyls (Lyman 1985: 226ff.). The food values given refer to caribou, but comparisons with sheep show that the artiodactyl pattern is relatively uniform (Binford 1978: 13–58, 72–75). The percentage representation of dog-gnawed bones is also given. Eroded bones for which the presence of dog- gnawing cannot be evaluated were omitted from this column.

In agreement with the already demonstrated connection between the incidence of an epiphysis type and the timing of its fusion, the five last fusing epiphyses were seen to be the most poorly represented. At the same time, these bone parts had much greater food value than those with a higher incidence in the material. This was due to the high meat and grease value of the group, whereas the marrow value was actually generally somewhat lower than in the other group. A possible reason for the observed pattern could, therefore, be the transport of unfilleted meat away from the settlement. Only the femur, however, has a significant meat value that justifies this interpretation. Another reason for these epiphyses rarely being discarded could be that grease extraction crushed them. Judging by the grease values for the various bones, this would apply to the proximal part of the humerus, proximal part of the tibia, and distal part of the femur. These very parts are the ones with the lowest bulk density and, therefore, are the easiest to crush.

Both food value and bulk density must also be factors of importance to understanding which bones dogs prefer to gnaw and which they can destroy. No pattern was, however, apparent from the percentage distribution of gnawed bones (table 1). Part of the explanation for this is no doubt that dogs had access to the original bone material only after site inhabitants had already utilized it and drastically reduced its palatability.

Several factors in prehistoric behaviour seem to have contributed to the low representation of certain epiphyses. It is presumably of importance that these particular epiphyses were those which fuse later and which will, therefore, occur in several smaller parts and with a lower degree of mineralization in site deposits. They have also relatively high meat and grease value, and their density is generally low. This means that both men and dogs would, to a greater degree, both be interested in and able to crush these very epiphyses, and that dogs can devour them completely, while man would not find them a nuisance and would not, therefore, have cause to throw them into the cove. Although the metapodials might be imagined to deviate from the illustrated pattern because of their special role as potential raw material, that was, in fact, not the case, perhaps because it was the cannon bone shaft that was most often used for making tools.

### *Interpretation of the Total Skeletal Representation*

All bones in table 4 were ranked according to the frequency with which they occurred in the faunal material, and their bulk density and trophic value were also stated (after Lyman 1985). For the long bones, the mean value for both the proximal and distal end was given.

From the food values given, it was not immediately possible to identify patterns that may be connected with transport away from the site or food preparation. The utilization of tarsals, carpals, and ribs for the extraction of bone grease and juice, as described for the Nunamiut Eskimo (Binford 1978: 32–38, 164–165), was not apparent from skeletal representation data. A low occurrence of ribs is more likely to be due to small fragment size as an effect of the dismemberment method described above.

An actual direct relationship between the representation of a bone and its compactness or fragment size seemed to be generally present. That a bone was poorly represented may thus be due to low density, small fragment size, or both. Low density implies that the bone was easier to break and crush. The fragment size could affect the frequency with which a particular type of bone was thrown out and on the chance of its being recovered by archaeological excavation. Since prehistoric behaviour involved bone breaking associated with the cutting up of the carcass, food preparation, and the manufacture of implements, all of which affected the size of fragments, these activities must have affected skeletal representation differentially.

The composition of the studied refuse was consistent with the settlement having been occupied at many seasons and, thus, perhaps for long periods, and with both intensive and varied activities. Thus, several quite small bone pieces were represented, including some from other species, and a large amount of antler (which neither rots nor smells) was cast away.

## CONCLUSION

This paper has presented data and interpretations pertaining to the exploitation of red deer by prehistoric hunters. A reconstruction was attempted of the material aspects of haulage, butchering, and food preparation.

Apparently whole animals were usually brought back to the settlement. Individuals of all ages from newborn up to 15 years were killed. Whether skinning and primary dismemberment occurred at the kill site first, or later at the settlement, could not be determined from the bone material alone. Ethnographic observations suggest, however, that animals as large as the Danish subfossil red deer were cut up before transportation away from the kill site (Fletscher & La Flesche 1972: 271–275, Rogers 1973: 18–20, 35–37, Marks 1976: 121–122). The means of transport then available was probably important (Binford 1978: 48). Possibly the prehistoric hunters, like the Mistassini Cree, used canoes for transporting the butchered game. Among the finds from Tybrind Vig was an almost whole, 10-m-long dug-out and the remains of a similar but somewhat larger canoe (Andersen 1983, 1985).

There were several examples where the skin was cut free around the base of the antler (see fig. 6) during skinning of the deer. Apparently the skin was freed from the rostrum by cutting around this, after which a cut was presumably made in the ventral mid-line and out along the inside of the four limbs. Sometimes even the fingers and toes were skinned out using a transverse cut. In other cases, the skin was probably cut across more proximally around the cannon bone or right up on the shank.

Dismemberment has been carried out both by parting through the articulations and by breaking bones (fig. 13). Decapitation was effected with a cut above the first or second vertebra of the neck. The lower jaw was probably separated from the rest of the skull by cutting the masticatory muscle, and it was then divided at the symphysis.

The foreleg was divided into at least five parts, consisting of each of the four long bones (the metacarpal or radius/ulna perhaps with the carpals still attached) and the phalanges. The carpals may have been cut off as one or two units, and the phalanges possibly separated from one another, for example, before marrow extraction. The hind leg was correspondingly partitioned into at least six parts, one of which included all the tarsals or only the proximal ones. Parting through the femoro-tibial articulation was not documented, but it probably occurred.

The pelvis, including the sacrum, was split down the middle and the pieces further reduced in size by breaking at the neck of the ilium. The brisket was presumably removed, and the ventral end of the ribs sometimes touched by the knife. Presumably, after the cutting away of the fillet, the rib- slab, from and including the fourth rib, was broken away just below the chin. A more ventral break, prepared by cutting across the ribs, was then made.

Parts of the dismemberment process could not be immediately identified. Thus, no cut marks were found indicating partitioning of the chine, but the sparse occurrence of vertebral fragments, among other things, shows that this took place. The many breaks on the vertebrae are thought, first and foremost, to have been made in conjunction with marrow extraction (see below); but the possibility that certain of the recorded breaks had occurred in the process of dismemberment could not be ruled out.

Filleting, and the scraping away of flesh from head, neck, shoulder, rump, fore and hind legs, and the whole of the ventral rib portion, were documented. Some of the observed cut marks presumably originated during the cleaning of long bones preparatory to marrow extraction, and, in the case of cannon bones, also to tool-making. After the large muscles were cut from the bone, any small lumps of meat and periosteum that remained were probably cut and scraped off.

The type and size of skull fragments showed that breaking of the skull did not solely serve to free the antlers. The extraction of the brain for food or skin preparation, and possibly the removal of fat from the nose and behind the eyes, also occurred.

The mandibles, long bones, phalanges, and vertebrae were apparently, first and foremost, broken for marrow extraction. Only the cannon bones showed a breakage pattern reflecting both marrow extraction and utilization in tool-making. The extraction of bone grease and juice in a form requiring crushing of epiphyses of long bones, and of tarsals, carpals, and ribs, could not be unequivocally demonstrated, since the low representation of, for example, the actual epiphyses of the long bones may result from other causes. That bone grease and juice were used in one way or another seems likely, however.

No evidence of selective removal from the settlement of meaty parts was forthcoming. The observed skeletal part representation, combined with calculated food values for the individual bones, did not suggest that that was the case.

Comparative studies of butchering practice have been suggested by Wiessner (1982) as one of several means by which knowledge may be gained about the social aspects of production in a given society. Among the means available to groups of hunter-gatherers for reducing subsistence risks, sharing and storage were mentioned. It was argued that, in societies that primarily depend on sharing as a risk-reducing factor, a greater regularity in butchering practice is to be expected, whereas less regularity is to be expected for those that depend on storage (Weissner 1982: 174). Settlement refuse (the later archaeological material) usually occurs, however, in consumption units and not in original butchering and sharing units (Binford 1984: 249). Detailed analyses of bone assemblages, by which attempts are made to isolate butchering practices, must, therefore, precede comparative studies of butchering variability. It may also be possible, when bone evidence is considered alongside other archaeological evidence, that social relations connected with the later stages of food preparation can be inferred and interpreted.

*Translated by Peter Crabb*

Tine Trolle-Lassen, The National Museum, Department of Natural Science, Ny Vestergade 11, DK-1471 Copenhagen K.

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NOTES

1. The results presented in this paper are based on parts of an unpublished dissertation for a master's thesis submitted to the Institute of Prehistoric Archaeology, Aarhus University, in 1985. See Trolle-Lassen (1985). The manuscript was presented as a "precirculating paper" at the World Archaeological Congress, Southampton 1986.
2. The archaeological excavation was carried out by S. H. Andersen, Institute of Prehistoric Archaeology, Aarhus University.
3. Enquiries about possible marine predators were kindly answered by J. Just, University Zoological Museum, Copenhagen, and V. H. Jacobsen, Danish Fisheries and Marine Exploration, Charlottenlund.

4. L. B. Nielsen, Museum of Natural History, Aarhus, took part in the experiments on fur animals. P. Lassen, Jægersborg Dyrehave, Copenhagen and P. Rasmussen, The National Museum, Copenhagen, participated in the experiment on red deer.
5. See illustrations of bone implements in Andersen (1980, 1985).

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# An Early Neolithic Grave at Bjørnsholm, North Jutland

by SØREN H. ANDERSEN and ERIK JOHANSEN

## INTRODUCTION

Since 1979 extensive archaeological research has taken place in NW-Himmerland in the central Limfjord area. Here, at a distance of only c.8 km from each other, lie the two largest Late Mesolithic/Early Neolithic Danish "køkkenmøddinger": Ertebølle and Bjørnsholm (fig. 1). Between 1979 and 1984 investigations took place at the *"locus classicus"* Ertebølle, from which a preliminary report was published in 1987 (Andersen & Johansen 1987). Between 1985 and 1989 the køkkenmødding Bjørnsholm was the main subject of this research[1].

The main purpose of the new investigations at Ertebølle and Bjørnsholm was to answer a series of questions such as: What was the size of the middens, how long a timespan did they cover, what types of sites were they, were they similar or different, what was the chronological range of the middens, and last, but not least, – was there any relationship between these two large "køkkenmøddinger", and if so, what was the nature of this relationship? Finally, an up-to-date sample of the artefact assemblage and faunal remains was required in association with well-defined stratigraphy and the cultural and chronological context.

Prior to the new excavations, the Bjørnsholm site had only once been the subject to research, in 1931, when the National Museum conducted an excavation[2]. Subsequent to this an area 30×30 m of the best preserved southern and southwestern part of the køkkenmødding was protected by law. As was the case with Ertebølle, the "old" excavation at Bjørnsholm produced a large number of artefacts, but lack of information as regards stratigraphy etc. was evident. This problem was very relevant in the Bjørnsholm-case, as the 1931 excavation produced both Late Mesolithic (Ertebølle culture), Early Neolithic (Funnel Beaker culture), and Iron Age material (Late Pre-Roman/Early Roman period)[3]. The records gave the impression that the site was archaeologically very "mixed", and this is probably the main reason why this site has only played a minor role in descriptions and discussions of the Ertebølle culture, and why it has only been mentioned in secondary connections in the literature, (Brøndsted 1938: 98,333; Mathiassen 1940:40-41; Mathiassen et al. 1942:54-56; Becker 1947:99,145,149).

Preliminary results from the new investigations indicate that the occupations of these two køkkenmøddinger were contemporary in an archaeological sense, but despite their close geographical position they differ in artefact style and also to some degree in their economies. Such a situation poses some very interesting questions regarding settlement patterns, population density, and environmental productivity within this part of the Limfjord.

In parallel with the new excavations, a large-scale reconnaissance of the whole coastal region of NW-Himmerland was begun in order to obtain information on the Late Mesolithic-Early Neolithic settlement pattern in the region, i.e. to see the two køkkenmøddinger as parts of a larger social structure in this area rather than separate and individual settlement sites.

A preliminary report on the results of the excavations at the Bjørnsholm køkkenmødding will soon follow in this journal. The present article deals only with a minor aspect of the Bjørnsholm excavations, that of an Early Neolithic grave, and serves as the archaeological background for the article by Sv.Th.Andersen (Sv.Th.Andersen 1992, this volume).

## THE BJØRNSHOLM KØKKENMØDDING

The køkkenmødding is situated along the northern shoreline of a former fjord opening up into the modern Limfjord (fig. 2). Today the site is positioned between the contours 5-6.50 m above present sea level, hereby giving an impression of the geological uplift in this region since the Stone Age (Strand Petersen 1985:19). In the Stone Age the fjord was larger, it was orientated NE-SW and was c.8 km long and between c.0.7 and 2.5 km wide (fig. 1). The shell midden is c.160 m long, c.10-30 m wide, and up to 1.20 m thick. The actual settlement area (as defined by flint scatter on the modern surface) is however, much larger – c.200 m long, c.30-50 m wide and it continues to

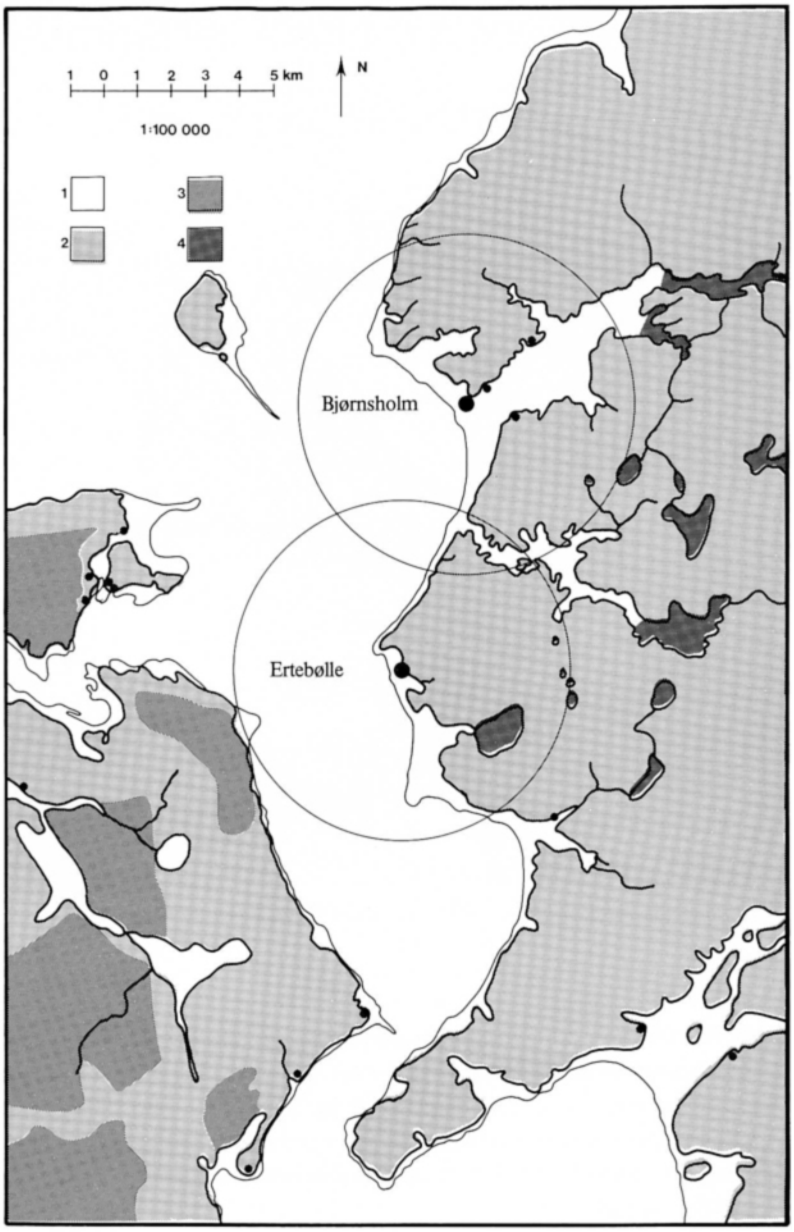


Fig. 1. The position of the Bjørnsholm "køkkenmødding" on the Limfjord in Northern Jutland. The distribution of the various resource types is indicated. A distance of 5 km from the site is marked by a circle. The modern and Mesolithic coastlines are marked by a thin and a broad line respectively.

the northeast into the Åle køkkenmødding which is 150 m long and 25 m wide (fig. 3).

The Bjørnsholm complex (the Bjørnsholm and Åle køkkenmøddinger) is, therefore, the largest preserved shell midden in Denmark today.

The Bjørnsholm køkkenmødding is a stratified shell midden with a lower, Late Mesolithic level belonging to the Ertebølle culture capped by an Early Neolithic horizon from the Funnel Beaker culture.

The Ertebølle layer is radiocarbon dated to the period 4140±100 b.c. (K-5304) – 3350±90 b.c. (K-5068) – while the Early Neolithic phase is dated to 3160±95 b.c. (K-5516) – 2810±90 b.c. (K-5721) (see below); all dates are for oyster shells *(Ostrea edule)* and given in conventional radiocarbon years. The Neolithic horizon is characterized by the dominance of shells of cockle *(Cerastoderma edule)*, black sandy earth with flints, pottery, bones, and firecracked stones. The maximum thickness of this layer is c.50 cm and the maximum extension (E-W) is c.10 m.

The new excavations consisted of a 27 m long and 1 m

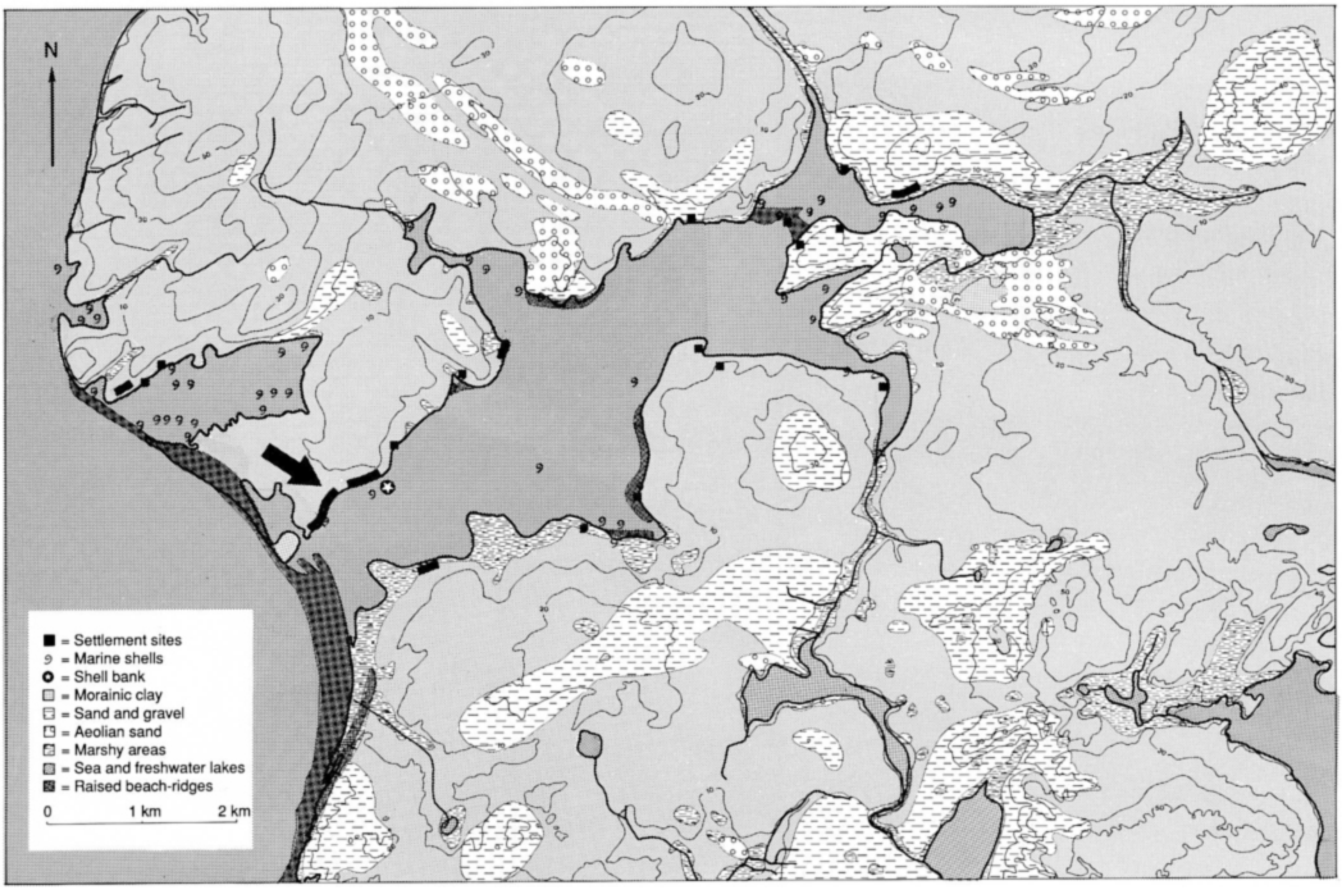


Fig. 2. Topography and geology of the Bjørnsholm area in the Late Mesolithic.

wide NW-SE section through the midden in the protected area followed by several smaller sections and test squares, both in the midden and to the rear of the shell deposits. The area to the rear of the shell midden was very carefully investigated in order to find traces of a distinct habitation area (Fig. 3 and 17).

## THE BURIAL STRUCTURE

In 1988 a large stone-lined pit (2911 AAYU) was found in one of the test squares to the rear of the køkkenmødding, and the subsequent trial excavation revealed that the pit was connected to a ditch aligned in a northerly direction. The ditch ended in another large stone-lined pit (see below).

A group of three vessels of typical Early Neolithic type were found only c.1 m to the north (fig. 11). The structure was found only c.12 m from the western border of the midden; in an area which today is a ploughed field. In connection with the excavation of the pit 2911 AAYU an E-W section was established through it and the surrounding area, and a series of soilsamples were taken for pollen analysis (fig. 5).

The combination of two large pits, a ditch and three intact Early Neolithic pots was interpreted as the remains of the east end of a long barrow with a timber facade set in a trench, as known from other Danish Early Neolithic long mounds (Madsen 1979; Liversage 1981; Kaul 1987; Kjær Kristensen 1991). Several new finds have been excavated and published in the last few years (Kjær Kristensen 1991).

If the interpretation was correct, then the barrow and any potential grave(s) should lie in the area west of the pits and ditch. Therefore, in 1990 two large areas measuring 13×11 m, around and to the W of the ditch system were excavated. Apart from the Norsminde settlement

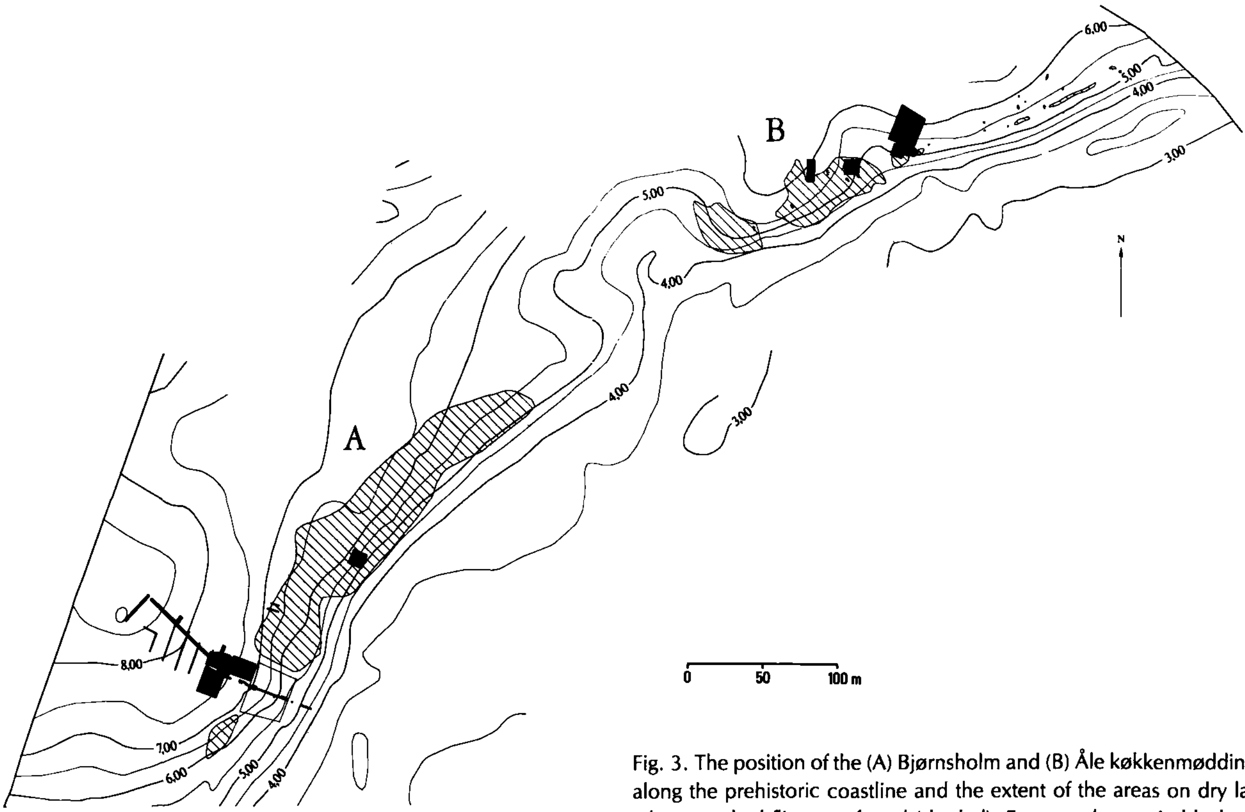


Fig. 3. The position of the (A) Bjørnsholm and (B) Åle køkkenmøddinger along the prehistoric coastline and the extent of the areas on dry land where worked flints are found (shaded). Excavated areas in black.

site (S.H.Andersen 1991, pp. 13–40) this was the first time that a large area had been excavated to the rear of such an Early Neolithic midden.

A stone-lined grave was found only c.8-9 m west of the ditch, from which it was evident that an Early Neolithic burial structure had been identified. By analogy with other Danish finds of this type, there was a possibility that more graves could be found further to the west. Therefore, a 57 m long NW-SE trench and a system of 5 parallel 10 m long trenches aligned NE-SW were excavated to the west of the grave, but without revealing any traces of other burials[4)].

The proximity of the grave and ditch structure – and the lack of other graves in the area – suggests that this grave belongs with the timber structure, and that they are two parts of the same unit.

The Bjørnsholm structure is thus one of the few fully excavated long barrows with timber facade and ditch, which has not been disturbed by later megalith chambers. The individual elements will be described below.

## THE GRAVE

The grave (2911 ACRS) was dug into the top of a very low, natural hill of yellow, sandy morainic clay which slopes gently to the E-SE, i.e. towards the prehistoric shoreline. Its position is c.20 m west of the shell midden (fig. 17), and it appeared undisturbed just below the ploughed soil horizon.The orientation was ESE-WNW, the maximum dimensions were 4 m (SE-NW), 1.75 m (NE-SW) and the depth below the prehistoric soil surface was 0.60 m. The outline was rectangular with slightly rounded corners, and it was built of large stones (morainic boulders and flint nodules of uniform size, 20-30×20-30 cm). The flint boulders are a local raw material and their presence indicates that the stones were collected in close proximity to the site. At the beginning of the excavation the grave was only indicated by a "bathtub-like" outline of stones with a central area filled with fine grey, homogeneous sand with charcoal flecks (fig. 6). The long sides were slightly concave indicating some movement of the stones, and this was especially clear on the north side of the grave. The long sides were built vertically with c.2-3 courses of stone, while the short ends

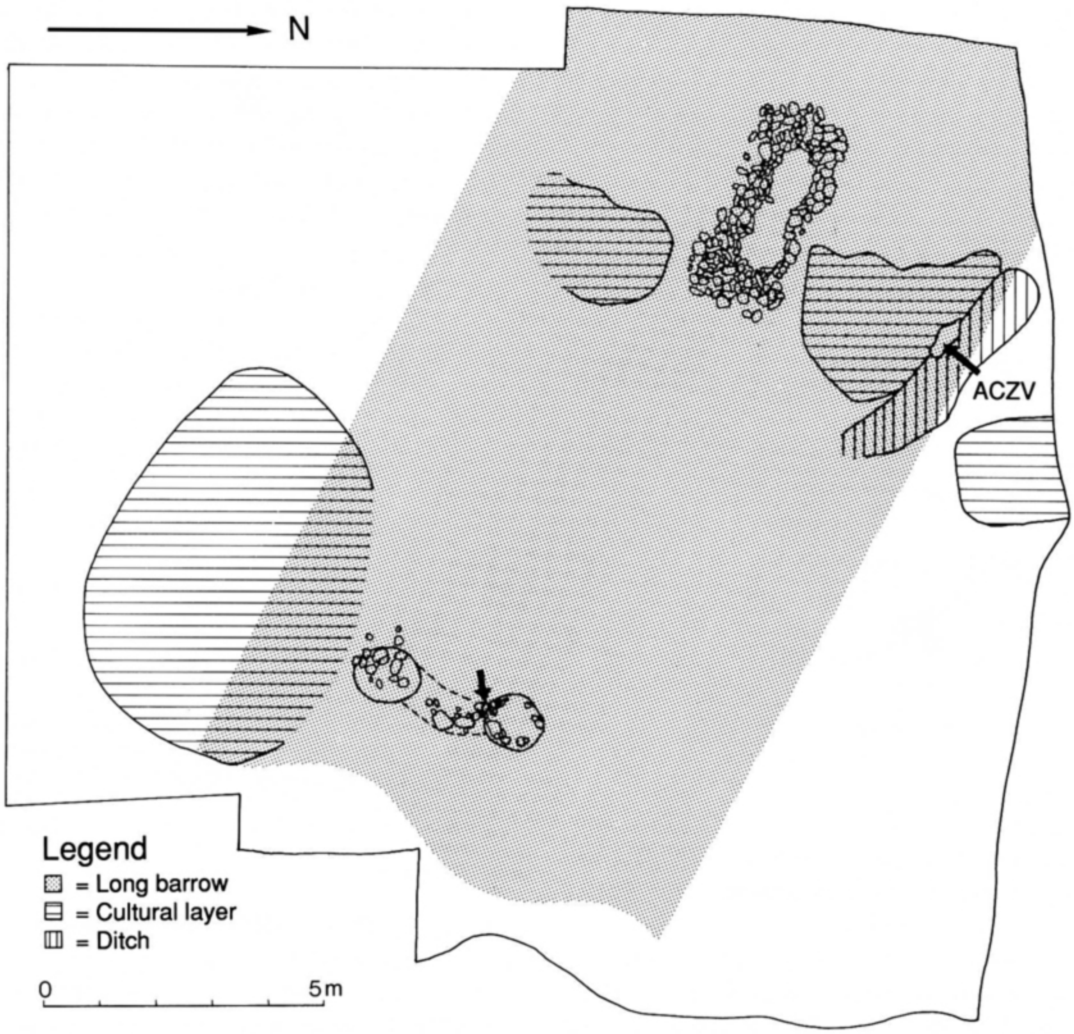


Fig. 4. Plan of the area excavated behind the midden. The positions of the grave, the grave ditch, timber structure and the small Early Neolithic settlement area are indicated. The position of the large lugged jar no. 2911 ACZV is indicated with an arrow.

sloped and had up to 6-8 courses. In the east end of the grave a single transverse arrowhead (2911 ACUM) made from a thin, irregular flintflake was found; one corner of the edge has been broken off, probably as a result of use (Fischer et al. 1984:23). After removing the grave fill of the central depression (caused by the collapse of a wooden coffin) it was possible to follow the stone lining down to the bottom. When the stone layer was removed it was possible to distinguish the outline of a rectangular (wooden) coffin which measured 2.20 m (ESE-WNW) × 0.6 m (NE-SW). The concave outline of the sides demonstrates that the grave originally was built of planks, most probably lying horizontally, but at an angle against the longsides. No traces of such wooden planks or posts were however observed.

The grave floor consisted of a 2-4 cm thick black horizontal layer – probably a secondary precipitation of manganese and/or charcoal dust; but nothing remained of the corpse. However, the position of the grave goods showed that a body had been buried, probably with the head at the west end.

In the centre of the grave, lying on the grave floor, were the grave goods: a thin-butted polished flint axe (2911 ACYK), a flat, thin-butted diabase axe (2911 AGAK) and three transverse arrowheads (2911 AGAJ) (fig. 8-10). The flint axe was positioned perpendicular to the long axis of the grave with the blade pointing north, while the diabase axe lay obliquely and closer to the southern side of the grave, with the blade pointing south (fig. 6). The butt ends of the two axes lay very close (fig. 7) and the three arrowheads lay near to the northern side of the grave (fig. 8) (see below). These finds indicate that the grave contained a man armed with a flint axe, ceremonial axe, bow and arrows.

The large burial-pit had a volume of c 4.2 m$^3$, but where was all the fill? One answer to this question is probably a 5-10 cm layer of sterile, yellow sand covering a greyish cultural layer just north of the grave. The yellow sand is most probably a remnant of the fill from the grave. If this interpretation is correct, the stratigraphy indicates that the grave is younger than the cultural layer (see below).

The Bjørnsholm grave has no direct parallels among the group of published Early Neolithic graves (Madsen 1979; Kjær Kristensen 1991). It is a new variant within this group, but it shows some similarities to the Konens Høj type (Stürup 1966; Madsen 1979). However, the Bjørnsholm grave differs from the main group of these burials by the absence of large wooden posts in the grave (Madsen 1979:309); at the same time it is larger and deeper than most of the others.

The thin-butted flint axe (2911 ACYK) (fig. 9) is of a grey-greyish-black flint with embedded small fossils, and is probably of local senonian-type flint. The narrow sides are almost flat, while the broad faces are convex; the butt is partially sharp and partially blunt. The sides narrow towards the butt, and one has a small nick which increases its angle (fig. 9). It is 26 cm long, 7.6 cm wide across the edge, 5.2 cm across the butt, which is 2.0 cm thick. The greatest thickness is 3.0 cm. The width of the narrow sides is 1.5 cm. The angle between the sides is 5° (all measurements according to Nielsen 1978:63). It is very highly polished all over and does not have any trace of resharpening or use. According to Nielsen's classification it is a type IV-axe, with its main distribution around the western Limfjord (Nielsen 1978:126). In addition it is also the most common type found in the so-called "earth-graves" (Nielsen 1978:108). This type of flint axe is dated to the Early Neolithic, phases B and Early C (Nielsen 1978:108-109).

The thin-butted diabase axe with splayed edge (2911 AGAK) (fig. 10): The raw material is a light-brown, fine-grained, slightly-banded diabase. The axe is very well preserved and all faces are highly polished, but due to secondary erosion one of the faces has become coarse. The edge is blunt, but as it does not show any trace of

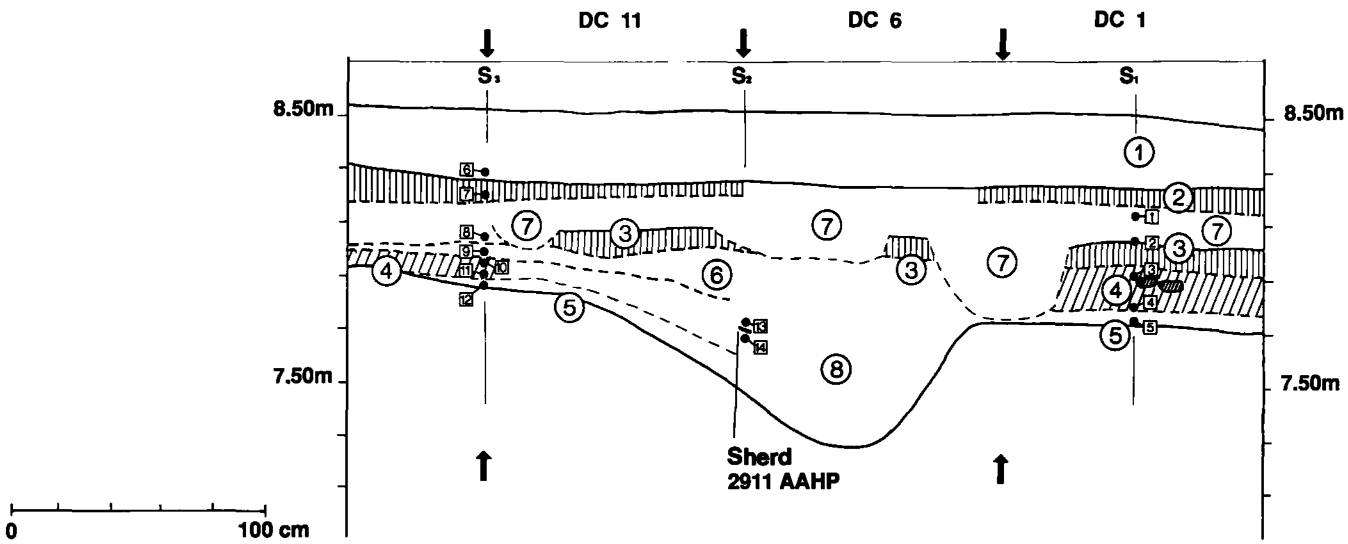


Fig. 5. Section of the southern posthole in the ditch at the eastern end of the long barrow. Soil samples taken for pollen analysis are indicated. Legend: 1, grey-brown sand with humus, present topsoil. 2, dark brown sand with charcoal, burnt clay, and potsherds; Iron Age level. 3, dark-brown sand. 4, black-greyish sand with scattered flints, charcoal, and fire-cracked stones; Stone Age level. 5, light-yellow, fine sand, subsoil. 6, light-yellow, fine sand; material from the posthole (layer 8). 7, brown, sterile sand and secondary Iron Age pits. 8, Stone Age posthole no. 2911 AAYU.

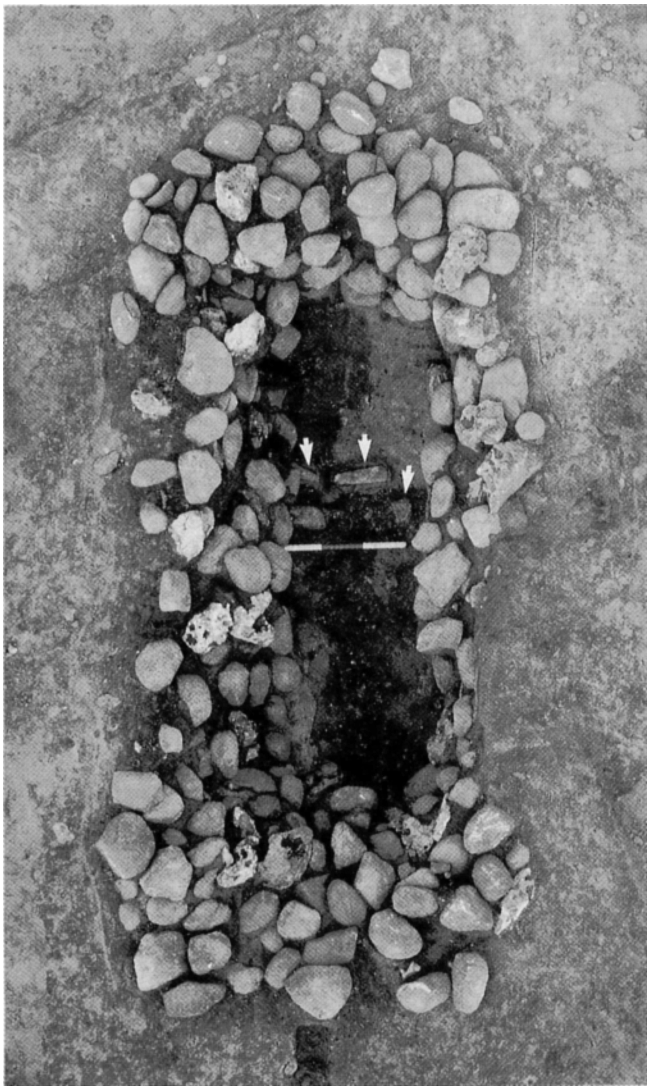

Fig. 6. Vertical photo of the Early Neolithic grave. Grave goods are indicated by white arrows. Photo E.Johansen.

Fig. 7. The thinbutted flint axe and the symbolic diabase axe *"in situ"* on the grave floor. Photo E.Johansen.

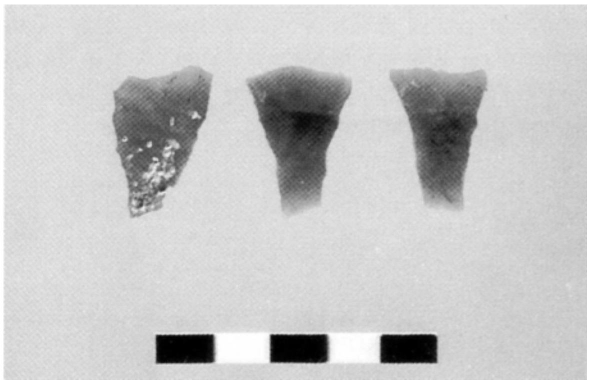

Fig. 8. The transverse arrowheads nos 2911 AGAJ 1–3. 3:4. Photo P.Dehlholm.

wear or resharpening, it is evident, that this axe was never intended for any real use. The broad faces are convex and the narrow sides slightly concave in section. The sides converge towards the butt which is blunt, then become very concave close to the edge which is splayed. The axe's measurements are: length 16.3 cm, width across the edge 6.3 cm, across the butt 3.5 cm, and the thickness is 2.7 cm.

The axe belongs to the group of slender thin-butted diabase axes with splayed edge, Danske Oldsager II, no.110 (Glob 1952) or Ebbesens type IV B (Ebbesen 1984:127, fig.2.9). Axes of this type are extremely rare, only half a dozen have provenience, most of them from Northern Zealand (Ebbesen 1984:127). The closest parallel, geographically, to this Bjørnsholm axe comes from Torup Mark in Dronninglund parish (Ebbesen 1984:148 and note 21). None of the Danish pieces are found in dated contexts, but one axe comes from an uncharacteristic undated stone-built cist from Mejls, north of Varde in Western Jutland (Ebbesen 1981:21, note 9). With this information, the new axe from Bjørnsholm is very important as it is the first from a sealed context. In his survey Ebbesen dates this type to the

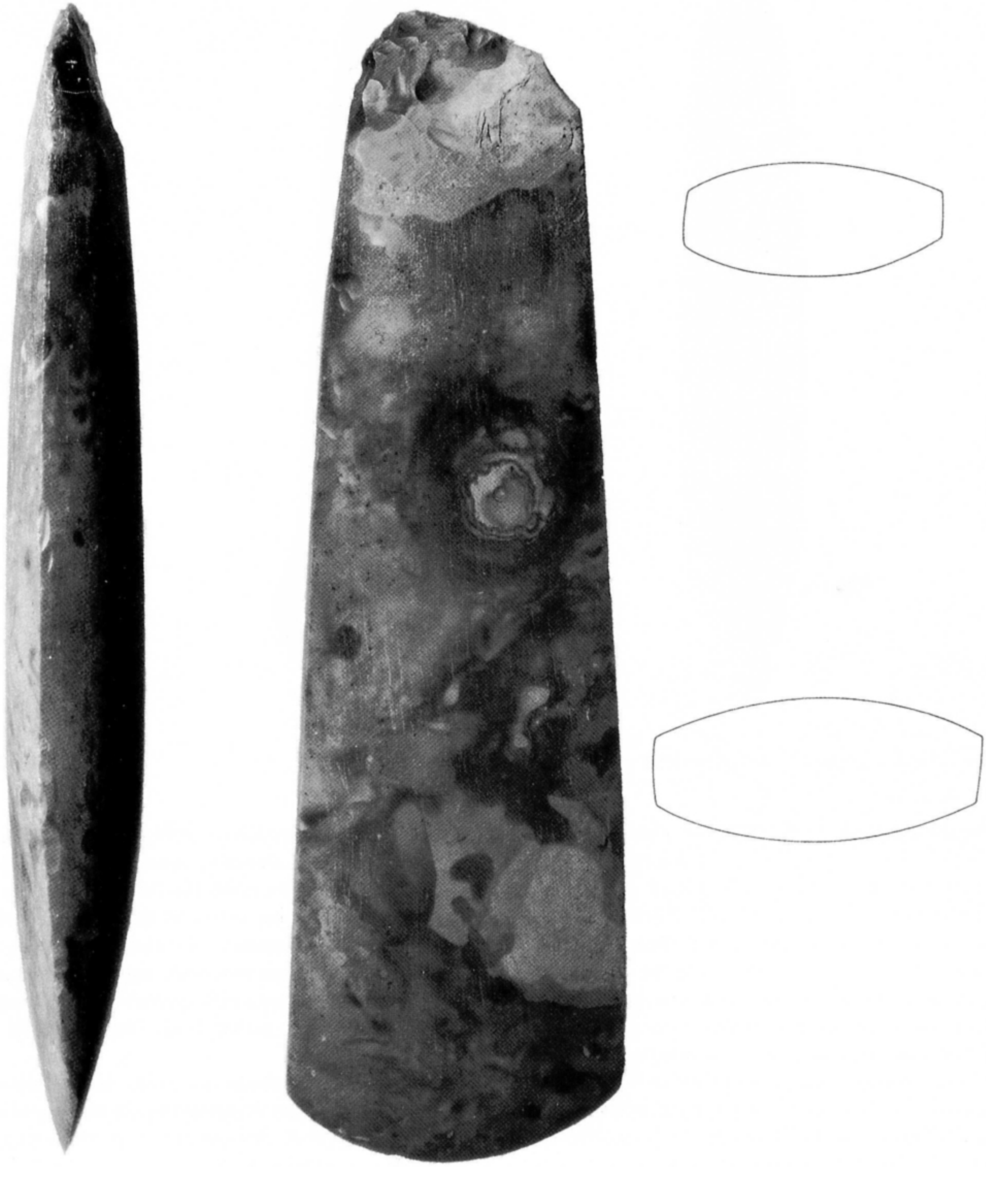

Fig. 9. The thin butted flint axe. 3:4. Photo P.Dehlholm.

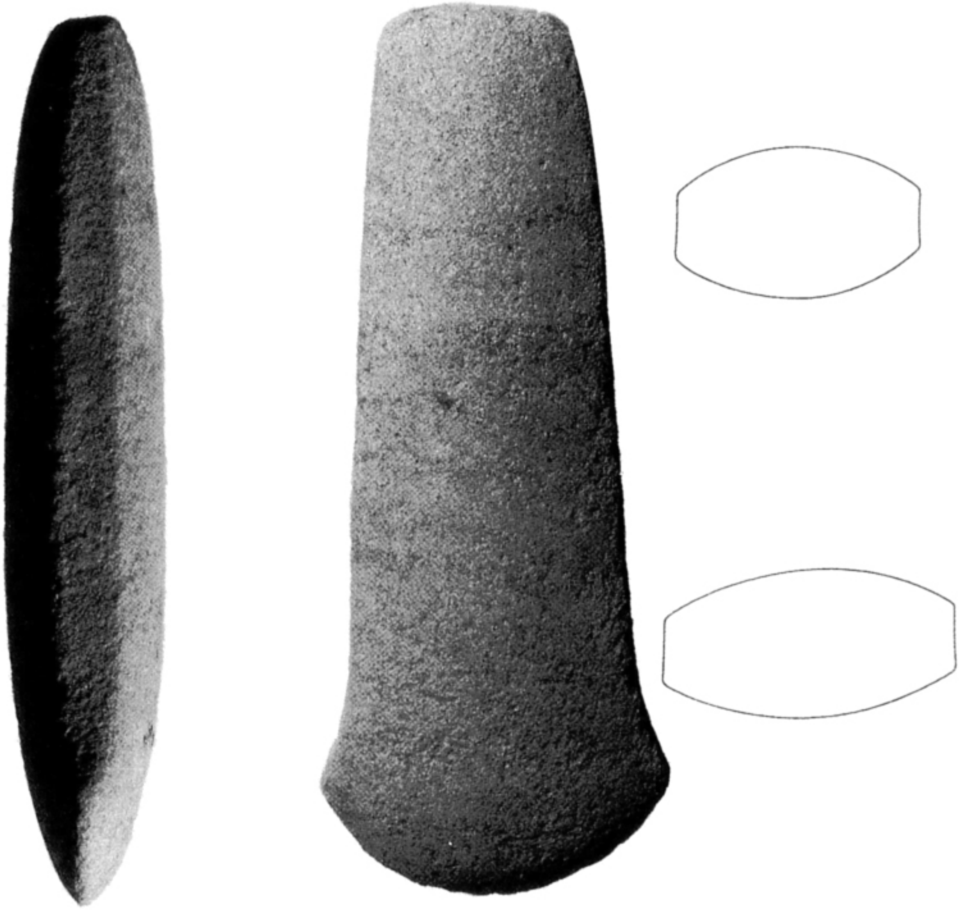

Fig.10. The diabase axe. 3:4. Photo P.Dehlholm.

Middle Neolithic Ia-II (Ebbesen 1984:127,131). This dating is exclusively based on typological similarities between these axes and the axe-shaped amber pendants, Danske Oldsager II, nr.299–300 (Glob 1952) and the copper axes in the Bygholm hoard (Reinecke 1933).

Both the light-brown colour and the form clearly indicate that the diabase axes with a splayed edge are imitations of Central European copper axes. The dating of these stone axes is, therefore, closely connected with the presence of such metal axes in Southern Scandinavia. The Bygholm hoard is dated to the Fuchsberg phase of the Funnel Beaker culture (end of the Early Neolithic). However, no Danish finds give any clue as to how long a period such axes, in reality, were circulating in Denmark. In a wider European perspective these copper axes seem to be present in Central Europe contemporary with the transition Mesolithic-Neolithic and Early Neolithic in Denmark (Müller-Karpe 1974, Kibbert 1980, Menke 1989). There is, therefore, every reason to believe that similar copper axes could also have been present in Denmark during a long period of the Early Neolithic. The dating of their imitations, the diabase axes, might, thus, be much wider than previously supposed. Therefore, the thin-butted stone axes with splayed edge should simply be dated within the period Early Neolithic-Early Middle Neolithic.

That the Bjørnsholm axe really is an imitation of a metal axe is further supported by the absence of a cutting edge which clearly demonstrates that this is a ceremonial axe or a "symbolic axe".

The three transverse arrowheads (2911 AGAJ) (fig. 8) were found close together in the centre of the grave, indicating the presence of bow and arrows. All three are typical Neolithic arrowheads; both their form and the raw material of irregular flint flakes is characteristic and demonstrates their chronological and cultural affinity, e.g. Danske Oldsager II nr. 263 (Glob 1952). Two of the arrowheads (2911 AGAJ 2 and 3) are symmetrical with slightly expanded edges with an irregular outline and are made from thin flakes. Their lengths are 2.6 and 2.7 cm respectively and the width across the edge of both of them is 1.8 cm.

The third arrowhead (2911 AGAJ 1) is different. It was manufactured from a very irregular flint flake partially covered by cortex, and the edge is oblique and concave. However, the dimensions are almost identical to the others, the length is 2.9 cm and the width 1.7 cm. This arrowhead is very interesting because it is badly damaged. Both corners of the edge exhibit fractures and the tip of the base has been broken off, producing a "step terminating fracture" (Fischer et al. 1984:25,fig.7,B,D and 32,fig.18). This indicates that the arrowhead was in this damaged state when it was placed in the grave. An explanation for this is that the arrowhead had been used, but still was fixed in its shaft at the time of the burial.

### *Traces of the mound*

Was the grave covered by a mound, and if so, what was the outline and size of this mound? Around the burial was a thin (20–25 cm) horizon of fine, grey sand. This sand layer which is best interpreted as the remains of mound material could be followed 5–6 m to the north and south of the grave, an indication of the width of the prehistoric mound. The presence of the same grey sand in the grave indicates that originally such a layer must also have been deposited above the grave. An estimation of the width of the barrow is given by the fact that scattered potsherds of Middle-Neolithic II type were found on the old ground surface just 5 m S of the grave – a position which would have been impossible if the mound had extended that far. Together with the extension of the grey sand layer this observation indicates a width for the barrow of c.10 m. Towards the W no traces of a mound were found, but this is probably a result of modern ploughing as the area is the highest point on the natural hilltop. To the E it was possible to follow the grey layer to the ditch, and from here only 2–3 m further to the E where it disappeared. No form of structure (i.e. grass or turf) was observed in the greyish layer, and it contained only very small amounts of scattered flint debris and pottery.

To summarize: There are several indications pointing to the presence of a covering mound of sand, but there is no definite information as to its shape or outline and size although most observations point in the direction of an E-W oriented rectangular/elongated mound, with a width of at least 10 m. In contrast to other Danish Early Neolithic long barrows no traces of posts along the perimeter of the mound were observed (Madsen 1979; Kjær Kristensen 1991).

### *The facade at the E end of the mound*

The pit (2911 AAYU), which was found in 1988, was oval in outline and measured 1.40 m (N-S) × 1.20 m (E-W). It was discovered c. 8.5 m from the east end of the grave, and the bottom of the pit was c.80 cm below the prehistoric soil surface. The sides, which were lined with stones (20–30×20–30 cm) all the way to the base, were sloping, especially on the west side. The excavation revealed that the sides must, originally, have been more vertical, but they then collapsed causing the stones to slide down to the bottom. The filling of the pit consisted of fine, homogeneous sand with flecks of charcoal, and apart from a single potsherd of Stone Age type and a blade scraper no further cultural remains were found. A charcoal sample from this pit has been identified as oak *(Quercus sp.)*[5].

The ditch: To the north the pit was connected to a c.1 m long curved ditch running c.8–9 m from the east end of the grave and perpendicular to the long axis of the grave, i.e. N-S (fig. 11). The ditch was 100–120 cm wide at the top (from the ancient soil surface), 20–40 cm wide at the bottom, and only c.20 cm deep. The ditch was U-shaped in section and the east side was almost vertical and lined with stones, some as large as 25×40 cm. They were positioned with their flat sides facing the center of the ditch, indicating that the stones served as support for posts or a timber structure standing in the ditch (fig. 11). The fill contained a great deal of powdered charcoal within a matrix of black-grey, homogeneous sand, darker in colour than the fill both of the pit mentioned above and the large pit mentioned below. Only a few scattered potsherds, mainly belonging to one of three pots (see below), were found in the fill. In both the ditch and the pits, darker colourations were observed, which were probably vestiges of wooden posts, but it was not possible to tell how many there were and with what shape.

The ditch ended in another large pit (2911 ACTH) with a semi-circular outline measuring 110 cm (N-S) × 100 cm (E-W) and 85–90 cm in depth (fig. 12). This pit

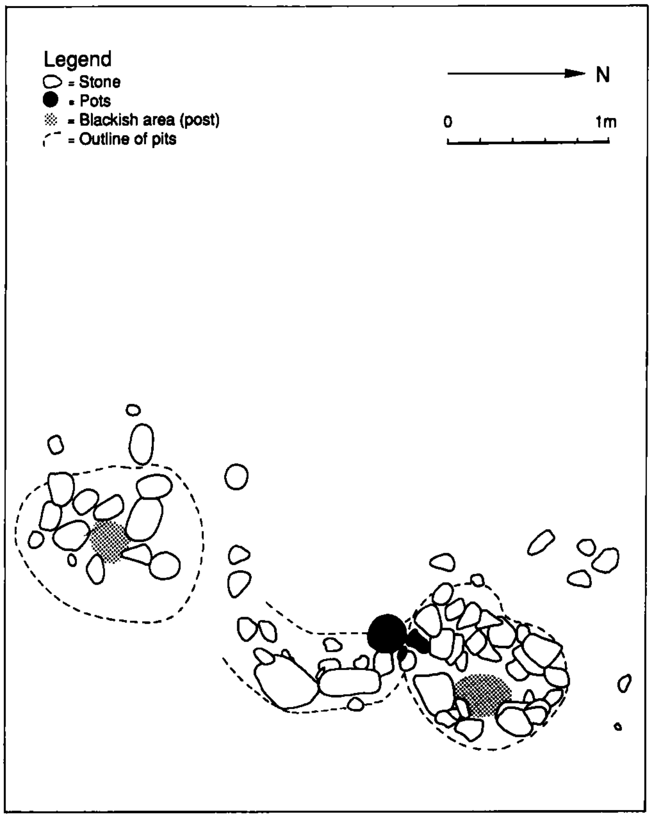


Fig. 11. Plan of the ditch and the two large post holes. The position of the three ornamented Volling pots is indicated.

had vertical, stone-lined sides, well built with 3–4 horizontal courses of large stones (of the same size as in the southern pit and the grave) and the bottom was flat and with no stones. The arc-shaped outline of the pit reflected a split tree trunk with the flat side towards the barrow, and the fact that the sides were still vertical indicated that the post, which had been standing in the pit, had not collapsed with resulting destruction of the sides as was the case in the southern pit. The fill was a fine greyish-black homogeneous sand without any finds. A darker colouration was observed in the pit, probably the vestiges of the wooden post (fig. 13).

Judging from the outline of the northern pit the two large pits were most likely prepared for large wooden posts. The posts were probably diagonally-split tree trunks with a diameter of c.100–110 cm. The two post holes are very similar, the only difference being that the west side in the southern pit had slipped, probably as a result of the collapse of the post. The two post holes and the ditch together formed a N-S oriented timber facade at the eastern end of the mound; a feature known from most of the recent excavations of such mounds (Kjær Kristensen 1991). The facade does not seem to have been deliberately burned down as known from other contemporaneous mounds (Madsen 1979). Neither stones, the earth, or the finds show any evidence of fire.

Three ornamented Volling pots (2911 AAVT, AAVW, and AAVX) were found in the ditch, where it connected with the northern pit (fig. 11 and 14a-c). The pots lay together in the northern end of the ditch and very close to the prehistoric soil surface. This position indicates that the pots originally were deposited together as a group. They may have stood on the old soil surface at the edge of the ditch and later fallen down into it, or alternatively were deposited in the top of the ditch fill. This position also explains why the largest pot (2911 AAVT) was eroded and broken near the rim and down one side, the side which was closest to the surface, and therefore most exposed. The large pot lay at an angle with its rim to the east while the second (2911 AAVW) lay on its side, just to the north of the former and with its mouth to the southwest. Finally, several fragments of a third pot (2911 AAVX) were found between the other two (fig. 14b). During the excavation several sherds of this pot were found scattered within a few square metres and all observations point to this pot also having been originally intact (see below).

The three pots are most probably ritual deposits (offerings) in connection with burial rites for the dead in the grave. Apart from a few small flint flakes and two rimsherds of a decorated funnel beaker no other cultural remains were found in this area.

To summarize: About 8–9 m east of the grave a system of two large stone-lined post holes – foundations for wooden posts – were encountered. The pits were connected by a 1 m long curved ditch partially lined with stones and in which traces of wooden posts also were observed. The ditch and posts are arranged symmetrically across an E-W axis running through the centre of the grave. In this ditch three Early Neolithic pots which belong to the Volling style were found.

1) *Large lugged beaker (like Danske Oldsager II,nr.26) (2911 AAVT), fig. 14a.*
This vessel is nearly complete with only a part of the rim and one side missing due to secondary erosion. The vessel is thin-walled with a cylindrical neck, globular body, and round base. The transition from neck to body is sharply defined and accentuated by a single narrow horizontal groove. At the transition are three small applied lugs; (a fourth had been positioned on the missing part of the side). The surface

is completely covered with decoration from the rim to base and the composition of the neck and body is very similar (fig. 14a).

Immediately below the rim is a single, horizontal row of short vertical stabs, followed by 4 horizontal rows of small paired semi-circular stabs and spaces arranged alternately. The lower part of the neck is decorated by large vertical fields filled with random vertical lines of stab impressions, separated by narrow plain bands. Each band is bordered by one or two parallel and continuous lines formed of stab-and-drag impressions (fig. 14a). The upper part of the body is ornamented with a single, horizontal row of vertical lines in stab-and-drag technique followed by a series of large vertical fields filled with rows of stab impressions like the neck. The fields are separated by narrow, plain bands, each edged with two parallel lines in stab-and-drag technique. The composition of the decoration on both neck and body is somewhat displaced to give variation to the composition. The height of the vessel is 16.6 cm, the diameter of the rim is 17.6–19.5 cm, and the maximum diameter of the body is 18.3 cm, while the neck is 8.4 cm high.

2) *Lugged jar (2911 AAVW), fig. 14c (like Danske Oldsager II, no 63–64).*

This is a thin-walled vessel with a cylindrical neck and globular-oblong body with 4 small lugs at the round base. The transition between neck and body is distinct and like the above vessel has a narrow horizontal groove between the two. The whole surface is covered with ornamentation in stab-and-drag technique similar to the above vessel. Immediately below the rim is a single horizontal row of short, vertical stabs followed by three horizontal lines of small paired semi-circular impressions with spaces. These lines are arranged alternately on the collar. Below, are vertical fields filled with short stab-and-drag strokes, separated by narrow and vertical, blank bars bordered by parallel, vertical lines in stab-and-drag technique. The top of the body is ornamented by a single horizontal row of short, vertical lines in stab-and-drag impressions. The rest of the body is covered by a composition of vertical fields filled with stab-and-drag technique, in an alternating pattern separated by narrower vertical bands edged with one or two parallel lines with impressions in stab-and-drag technique. These vertical bands are filled by offset and paired stab-and-drag impressions and spaces of the same type as below the rim. The composition of the ornamentation of neck and body is also displaced relative to each other. The height of the vessel is 14 cm, the diameter of the rim is 8.5–9 cm and the maximum diameter of the body is 12.3 cm. The diameter of the neck is 4.7 cm and the height of the neck is c.4.5 cm. A very similar, but smaller vessel is known from Kappelhage, Stagstrup s., Thisted county (Mikkelsen 1989:130). This vessel was also found in an Early Neolithic

Fig. 12. The ditch and part of the northern post hole seen from the NW. Photo E.Johansen.

Fig. 13. Vertical view of the northern post hole and the ditch (left) and the northern post hole seen from the north (right). Photo E.Johansen.

structure with timber construction. In a ditch belonging to this structure three funnel beakers were found. Decorated lugged jars are also known from other Early Neolithic graves, i.e. the graves from Rimsø and Skivum (Madsen & Nielsen 1977:29, fig. 4 and 32, fig. 8 A and C).

3) *The "small" beaker (2911 AAVX), fig. 14b (like Danske Oldsager II, no 17–18).*

A large fragment of this pot was found in close association with the other two, while more sherds were encountered in the immediate vicinity. Although, this vessel is rather fragmented it has, however, been possible to reconstruct it, even though the rim and bottom are not present[6].

It is a thin-walled funnel beaker with a cylindrical neck, round base and body, a type well known from northern Jutland, (i.e. Becker 1947:144, fig. 31; Ebbesen & Mahler 1980:31, fig. 15). The surface is totally covered with decorations in stab-and-drag technique like the other vessels. At the top of the pot is a single horizontal row of vertical impressions, followed by vertical fields filled with short stab-and-drag lines, separated by narrow vertical bands (fig. 14b). The transition between neck and body is marked by a horizontal groove (fig. 14b). The composition on the neck and body is identical, but the decorative bands are offset in relation to each other in order to give variation to the ornamentation (fig. 14b). The height of the vessel is c.12–13 cm and the maximum diameter c.12 cm.

As already mentioned the position of the three vessels indicated that they originally were deposited together as a group. This observation is further substantiated by the ornamentation. Their style is very similar, and this similarity goes as far as to suggest that the individual tooling on the two larger vessels is identical (compare the rim decoration of the two large pots (fig. 14a+c)). They must have been ornamented by one person using one and the same tool.

The grave structure belongs to the oldest Neolithic graves found in Denmark and is one of the richest: Firstly, there are the three beautiful decorated vessels from the ditch system, and secondly the thin butted flint axe – the symbol of the farmer, the ceremonial axe -symbol of male power, bow and arrows – symbol of the hunter in the grave. To this is added the investment and labour of the whole construction: the very large, deep grave pit, two large pits with posts, the mound, and finally the large collection of stones of the same size.

## THE CULTURAL LAYER

Bordering the north side of the grave structure, a grey, sandy cultural horizon rich in flint debris, flint artefacts, and potsherds was found (fig. 4). The layer was roughly circular in outline and had maximum dimensions of c.6×6 m, but its main concentration only measured 3.5×2 m. The layer was very confined and outside its perimeter almost no cultural debris was found. Below this horizon was a curved, 0.75 cm wide, 4 m long, and 15–20 cm deep, "U"-shaped ditch also filled with a similar grey homogeneous sand with many flint artefacts and potsherds. On the bottom of this ditch a lugged jar (2911 ACZV) was found (fig. 4 and 15). The ditch followed the outline of the north- and east side of the grave with a distance of c.4 m (fig. 4).

The find material from the cultural layer is uniform in character and belongs to the Funnel Beaker culture (fig. 16). A closer analysis of the material gives a clear date in the earliest part of the Early Neolithic, i.e. the "North-Jutland non-megalithic C-group" according to Becker (Becker 1947) or the Volling group (Ebbesen & Mahler 1980; Madsen & Petersen 1984). The finds from the ditch below the grey cultural layer also point to the Volling group (fig. 15), and it is reasonable to assume that the ditch and the covering cultural layer are more or less contemporary. A similar cultural layer and an associated ditch were not found south of the grave.

The occurrence of flint debris, flint artefacts, and potsherds indicate a settlement. It is reasonable to interpret the ditch as the remains of a structure – probably a foundation trench for a hut wall. The rather confined culture layer and the small number of cultural remains indicate a very small settlement site and/or a short lived duration of occupation at the site.

The Neolithic layer in the køkkenmødding – only c.30 m away – contains similar types of flint artefacts and pottery decorated in typical Volling style (fig. 16). Stratigraphic observations, homogenity of flint types, ceramics, and the topographic situation, indicate contemporanity. We may assume, therefore, that the grey cultural horizon is the habitation area proper on higher, dry ground contemporaneous with the køkkenmødding at the seashore.

At the north side of the grave, the grey cultural layer was partially covered with a c.10 cm, sterile layer of yellow-brownish sand which is most probably morainic material derived from the excavation of the grave. These observations give a clear picture of the relative order of these findings. Firstly, some kind of building and a small settlement must have been situated here. After the destruction of the building and levelling of the cultural layer the grave was then constructed.

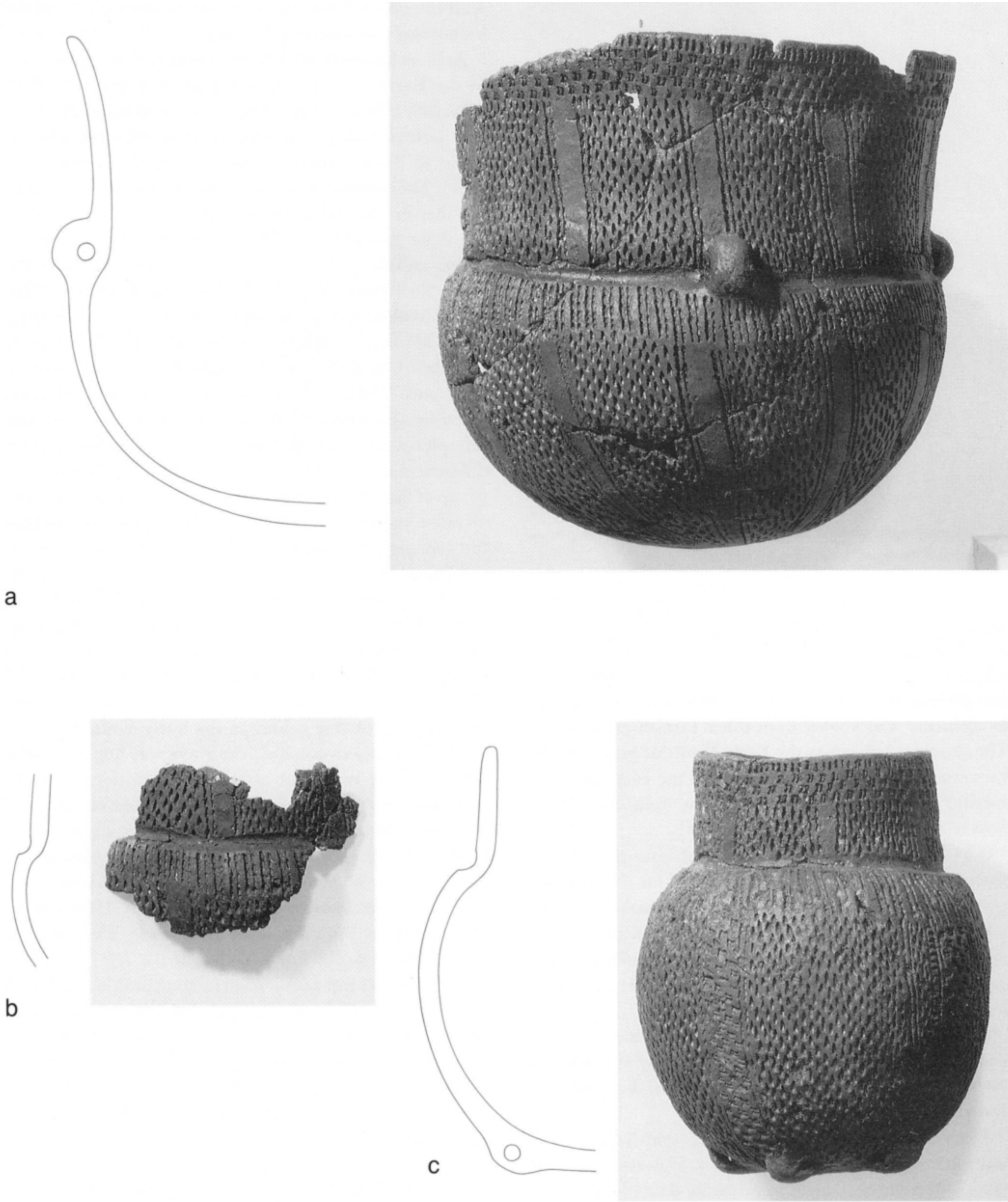


Fig. 14. The three Volling pots from the ditch. C. 1:2. Photo P.Dehlholm.

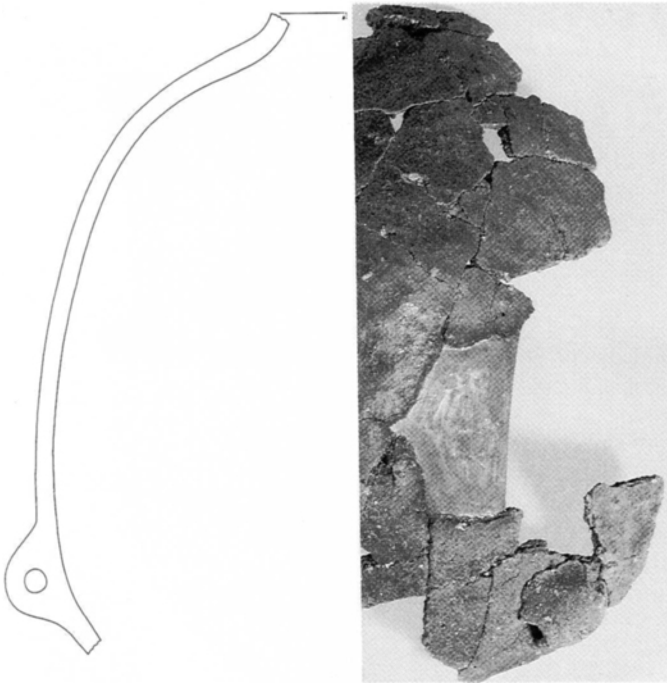

Fig. 15. Large lugged undecorated jar from the ditch below the cultural layer around the grave 1:3. Photo P.Dehlholm.

## DATING AND CULTURAL CONTEXT

The grave, mound, and timber structure from Bjørnsholm may be looked upon as one synchronous event constituted by elements well known from other Danish excavations. The structure belongs to the Early Neolithic group of long barrows with timber constructions at the east end. This specific type of grave is only known from the Funnel Beaker culture (Kjær Kristensen 1991).

C-14 date: Two samples of charcoal from the foundation of the timber facade were submitted for AMS-dating at the Institute of Physics, University of Aarhus:

1) Excavation sample no. 2911 AAYW (*Quercus sp.*) was found 1 m below the surface at the very bottom of the southern pit of the timber facade, *c.f.* fig. 4. It was dated to 3100±160 b.c. (uncalibrated) (AAR-802).

2) Excavation sample no. 2911 ACSY (*Alnus sp.*) came from the area between the two posts and only 40 cm below the surface and was dated to 1100±100 b.c. (uncalibrated) (AAR-803).

The second date is clearly too young (mid-Bronze Age), and must represent a later intrusion. However, the first date, 3100±160 b.c., gives at probable date of the timber facade which is structurally and stratigraphically related with the grave. This date is in good accordance with the archaeological-typological dating.

Archaeological date: The thin-butted flint axe belongs to the Early Neolithic B and Early C-periods (Nielsen 1978:108–109) corresponding to the Volling group. The thin butted diabase axe with splayed edge can only be dated to the period Early Neolithic-Early Middle Neolithic. The transverse arrowheads are of a Neolithic type, but they do not give a narrower dating. Finally, there are the three pots from the ditch. Both their type and decoration clearly place them in the regional group of the Early Neolithic of N Jutland, that of the "non-megalithic C" or Volling group (Becker 1947; Ebbesen & Mahler 1980; Madsen & Petersen 1984). This group, which is well dated by C-14, covers a 300–400 year period from 3100 until 2800/2700 b.c. in C-14 years, or c.500 years when using calibrated dates. It is possible to subdivide this phase into shorter phases in North Jutland. Some differences in ornamentation and composition within this group of material has been observed and seem to indicate an older Volling and a younger Volling phase out of which the younger phase probably was influenced by the southern Danish Fuchsberg-group (Andersen & Madsen 1978; Madsen 1975:146,148; Madsen & Petersen 1984:99; Andersen 1979:14,fig 9 and note 15). However, as the relevant material is still too sparse and geographically scattered, it is impossible to decide whether such observed differences are chronological. If so, the three pots from the ditch most probably belong to the Early Volling.

As previously mentioned, the grave was dug through a cultural layer with flint artefacts and pottery of Early Neolithic character. Several of the sherds are ornamented in Volling-style and no younger or older objects were found (fig. 16). This stratigraphical observation suggests that the grave is younger, but probably not very much so, than the cultural horizon and the finds in it. However, no scientific dates from this layer were made. The artefacts date the layer to the Early Volling.

From the central Limfjord-area comparable settlement material is known from a small shell midden at Vojel Kær on the island Fur (Becker 1947:148), the shell midden Aggersund (S.H.Andersen 1979:22–23) and the long barrow at Tolstrup (esp. the Tolstrup III) (Madsen 1975:129, 138–139), but these finds do not help solve the dating problems.

The Neolithic layer in the nearby køkkenmødding contained similar types of flint artefacts and pottery decorated in typical Volling-style (fig. 16). This horizon has been C-14 dated: 3160±95 (K-5516), 3100±90 (K-4790), 3010±90 (K-4796), 2940±95 (K-5515), 2890±95 (K-5720) and 2810±90 (K-5721) (all datings on oyster shells). As these datings are taken at different positions and levels within the Neolithic horizon, together they indicate that this occupation belongs to the earliest Funnel Beaker culture and that the habitation seems to have taken place over a chronologically very short period. These results fit with the archaeological material which only reflect "pure" Volling-types, and no younger types were found.

There is a close similarity with respect to type and ornamentation between the three pots from the ditch system of the mound and the material from the top horizon in the midden as well as from the grey cultural layer. This observation indicates that the mound and grave should most probably be dated to a very early stage of the Early Neolithic – probably about c.3100–2800 b.c. This dating is comparable to the material in the grave. However, it must be stressed that it is not possible to exclude a later date within the Early Neolithic, but still within the "pure" Volling and definitely earlier than the Fuchsberg-influenced "Late Volling" in North Jutland. In conclusion the grave belongs to the Earliest Funnel Beaker culture and most probably to the period 3100–2800 b.c. (Conv.C-14 years).

Danish long barrows with timber facades have been C-14 dated in 6 cases: Storgård IV: 2875±140 bc (UA-441), 2840±115 bc (UA-443) and 2760±115 bc (UA-442) (Kjær Kristensen 1991:79). Rustrup I: 3030±100 and 3010±100 bc (K-2254), and 2960±100 bc (K-2253). Rustrup II: 2970±100 bc (K-2355) (Fischer 1976:40,61). Lindebjerg: 3060±100 bc (K-1659) (Liversage 1981:97). Rude: 2960±90 bc (K-3124) and 2860±70 bc (K-3125) (Madsen 1980:95-96), and Konens Høj: 2900±100 bc (K-919) (Stürup 1966:16). A similar structure, partially destroyed by a younger megalith, is the long barrow at Mosegården. This feature gave a C-14 dating of 3130±90 bc (K-3463) and 2940±90 bc (K-3464) (Madsen & Petersen 1984:75). All these datings correspond well with the datings from Bjørnsholm.

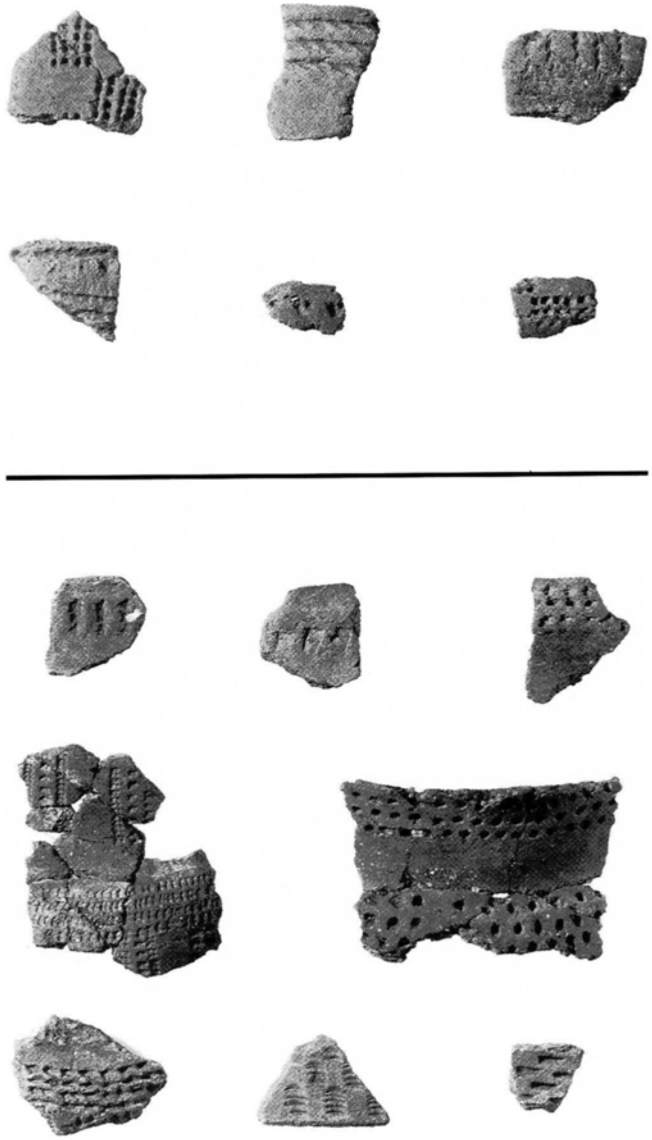

Fig. 16. Ceramics from the cultural layers on dry land (above) and the top horizon of the køkkenmødding (below). 1:2. Photo P.Dehlholm.

## THE RELATIONSHIP BETWEEN THE SETTLEMENT AND THE MIDDEN

As already mentioned, the grave was discovered only c.20 m west of the midden. At present it is not possible to determine exactly where the prehistoric shore line was located during occupation of the site, but it, probably, lay only c.40 m away from the grave and the grey cultural layer.

Exact contemporanity of the grey cultural horizon and the køkkenmødding cannot be proved, but stratigraphic observations, the flint type inventory, the ceramics, and the topographic position make it a reasonable assumption, that the grey cultural layer is the habitation area used at the time when the Neolithic part of the køkkenmødding was deposited.

The pattern of the Bjørnsholm site, therefore, indicates a settlement area with an associated køkkenmødding c.20–40 m away, situated on the seashore (fig. 17).

A similar pattern has been documented at the stratified, Early Neolithic Funnel Beaker site Norsminde in E Jutland; here the distance between settlement area and midden was c.50 m (S.H.Andersen 1991:13–40).

These two independent observations indicate that some of the Early Neolithic coastal settlement sites include both a habitation area proper on high dry land and an associated midden separated by an area with very few finds of debris and artefacts. As the køkkenmøddinger is the most archaeologically visible part of such settlements it is understandable why "the other part" has been overlooked. The shell mound is only a part of the total settlement area and is not the site itself, as it normally is expressed in the literature (Madsen 1982:203–205; Skaarup 1982:40,45). This new perception of a group of the Early Neolithic settlements (the coastal ones) has only been made possible because of the new large scale excavations of the area(s) behind the middens. At present our knowledge of the size and time-range of the occupation on such Early Neolithic settlements is still very limited, but if the Bjørnsholm and Norsminde settlements are typical, such settlement sites are very limited in extent and limited with regards to the amount of debris they contain; the combined effects of both factors make these sites very difficult to locate by reconnaissance. The only structure which makes such sites "archaeologically visible" is the midden (s) – a point to bear in mind in connection with analysis of settlement patterns etc.

## THE RELATIONSHIP BETWEEN THE GRAVE AND THE SETTLEMENT

The location of a grave directly on a settlement site proper is typical of many of the oldest Danish Early Neolithic mounds, i.e. Konens Høj (Stürup 1966), Barkær (Glob 1949), Stengade (Skaarup 1975), Lindebjerg (Liversage 1981), Mosegården (Madsen & Petersen 1984), Rustrup (Fischer 1976), Moesgård Skovmølle (Madsen & Petersen 1984), Tolstrup (Madsen 1975), and Søgaard (Sterum 1980) – just to mention a few. All these (and several more) examples clearly demonstrate a very direct association between grave(s) and settlement – both coastal and inland – and therefore suggest a close association between the living and the dead by a visual consolidation of the surrounding land or territory. The reason for burying the deceased on the site must reflect a wish to legitimize the site location and the surrounding exploited territory.

Based on the new observations it seems reasonable to assume that similar graves may have been present at several other settlements. With another excavation technique – and an excavation concentrated on the midden alone, such graves would never have been found, especially if the habitation area lay some distance from the midden as was the case at Bjørnsholm and Norsminde.

The association of grave and settlement at Bjørnsholm is further substantiated by the fact that this grave was not only situated in the settlement proper, but was obviously located upon an old house foundation. An identical situation seems to have been present at the Bygholm Nørremark site (Rønne 1978; 1979).

These observations indicate that such sites must have been essential sites and/or settlements of a high level of social importance and economic value for the population and the society as a whole. Settlement sites like Bjørnsholm are normally classified as "catching sites" in contrast to the "residential sites" (Madsen 1982:203–205; Skaarup 1982:39–42) – the distinction very often purely based on the topographic positioning and/or the presence of a shell midden. The new information from Bjørnsholm indicate that these sites must represent settlements essential for the social-economical structure of the society. It seems reasonable, therefore, to argue, that such sites could not only have been short term seasonal or ad-hoc catching sites.

This observation does not fit with the current model of settlement in the Early Neolithic, which distinguishes between "catching sites" and "residential sites". Instead, we should speak of "settlement sites", which sometimes are located at the sea shore and sometimes inland. At some of these small sites settlement continuity from the Late Mesolithic to the Early Neolithic can be demonstrated.

## ECONOMY

Soil samples from the mound filling and the fill of the two vessels 2911 AAVT and AAVW were investigated for pollen (see Sv.Th.Andersen this volume). The result of this analysis demonstrated birch *(Betula sp.)* woodland

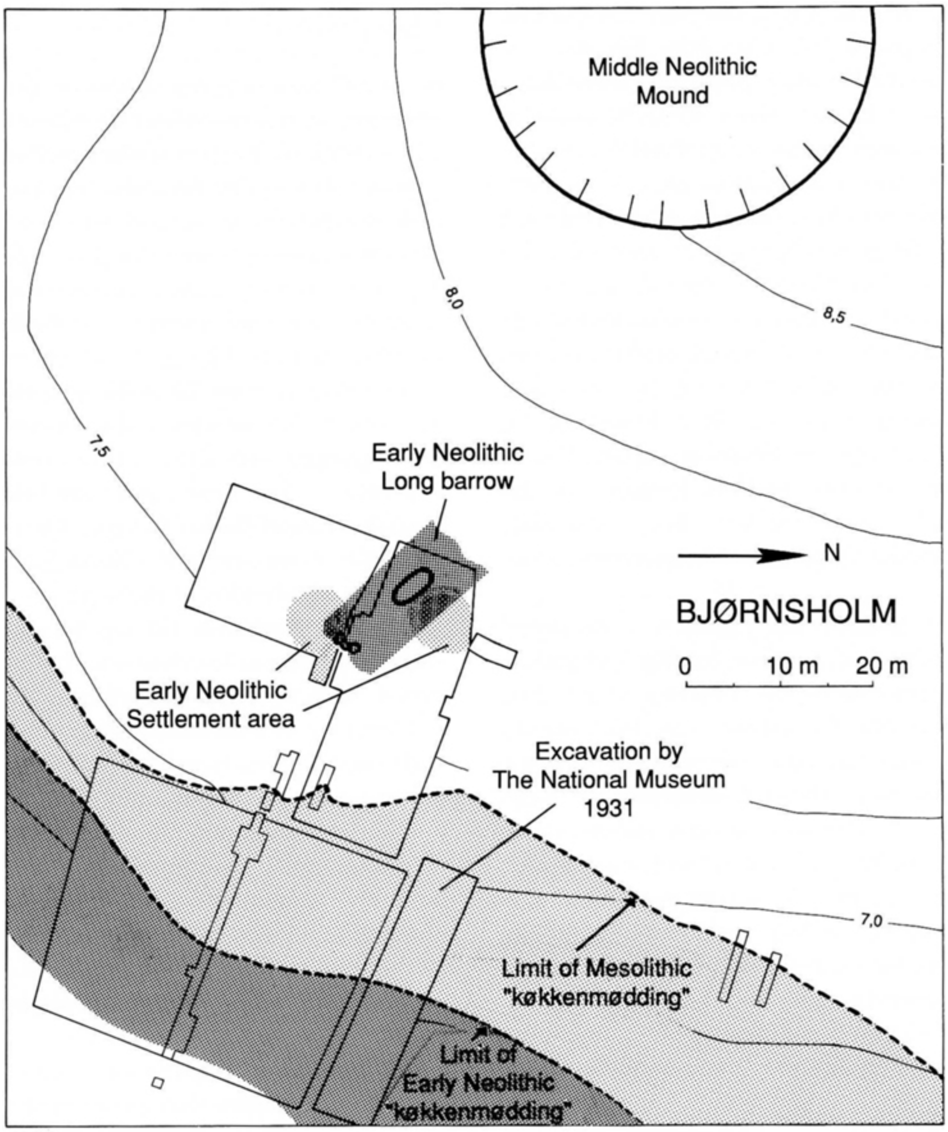


Fig. 17. Plan of the settlement and the associated køkkenmødding.

growing in the neighbourhood. Many of the birch pollen showed signs of heating or burning which indicates that the birch woodlands were intentionally worked and used for swidden cultivation.

Traces of agriculture are indicated by the presence of pollen of wheat and pollen likely to belong to barley *(Hordeum sp.)*. This "birch-maximum" is a well known (second) stage of the "Landnam-phase" of Denmark (Iversen:1941:11). The pollen analytical results demonstrate that the "birch-maximum" at Bjørnsholm is contemporary with the Early Volling and thereby with a very early phase of the Early Neolithic Funnel Beaker culture i.e. c.3100–2800 b.c. It is very important to emphasize that at Bjørnsholm it has been possible to link the botanical and archaeological results directly.

Wheat *(Triticum sp.)* and club wheat *(Triticum compactum)* have also been identified from impressions in a potsherd from the Early Neolithic level of the køkkenmødding (Mathiassen 1940:41. Det. H.Helbæk).

As the top horizon of the køkkenmødding is most probably contemporary with the small settlement on higher, dry ground, the bone material from the midden also gives information about the economy of the site. The preliminary identification of the bones includes domesticated animals such as sheep *(Ovis aries)*, cattle *(Bos taurus dom.)*, pig *(Sus scrofa dom.)*, and dog *(Canis fam.)*. As could be expected at such a mixed habitat as the Bjørnsholm area, hunting, fowling, gathering, and fishing played an important role in the economy. Bones of grey seal *(Halichoerus grypus)*, wild boar *(Sus scrofa)*, fox *(Vulpes vulpes)*, red deer *(Cervus elaphus)*, roe deer *(Capreolus capreolus)*, wild cat *(Felis silvestris)*, red throated diver *(Gavia stellata)*, ducks *(Anas sp.)*, and crane *(Grus grus)* were found in the køkkenmødding[7)]. The fish bones have not yet been analyzed[8)], but stingray *(Dasyatis pastinaca)* was found in this layer (Rosenlund 1985:23–24). Shells of cockle *(Cerastoderma ed.)* dominate the Early Neolithic horizon, but also oyster *(Ostrea edulis)*, mussel *(Mytilus edulis)*, periwinkle *(Littorina littorea)*, and whelk *(Buccinum undatum)* were identified.

The available information clearly point to a very mixed economy based on farming, hunting, fishing, and gathering, but it is not possible to say anything about their relative importance. The Bjørnsholm site demonstrates how dangerous it is to determine the economy of a site purely from the existence of a shell midden or the topographic positioning. At this site, swidden cultivation of wheat and barley took place combined with stock breeding of goat, cattle, and pig. This subsistence aspect was combined with hunting, fishing, and gathering in the surrounding habitat which included primeval forest, the Bjørnsholm fjord and the open sea (Limfjord) with all their possibilities for fishing and hunting of sea mammals as well as collecting shell fish on the nearby banks in the fjord.

A similar and contemporary settlement is the small shell midden Aggersund – also with a mixed economy comprising both cattle breeding, hunting, fishing, and collecting. From this site bones of aurochs *(Bos primigenius)*, domesticated oxes *(Bos taurus dom.)*, wild boar *(Sus scrofa)*, pig *(Sus scrofa dom.)*, roe deer *(Capreolus capreolus)*, red deer *(Cervus elaphus)*, sheep/goat *(Ovis/Capra)*, dog *(Canis familiaris)*, swan *(Cygnus sp.)*, duck *(Anas sp.)*, and vertebrae of cod *(Gadus morhua)* as well as man *(Homo sapiens sapiens)* are recorded (S.H.Andersen 1979:13–14 and note 16).

## CONCLUSION

In connection with excavations in the Bjørnsholm køkkenmødding an area behind the midden was investigated. C.20 m west of the shell midden an Early Neolithic grave was discovered. The Bjørnsholm grave was covered by a E-W orientated long mound with two large timber posts and a ditch with a timber structure at the east end. In this ditch three funnel beakers ornamented in stab and drag technique were encountered – probably positioned there as ritual offerings. The grave, which has no exact parallel in the group of Early Neolithic graves, is very large and has contained a wooden coffin containing the body of a man equipped with a flint axe, a symbolic axe, and bow and arrows. The whole structure belongs to the Early Neolithic Funnel Beaker culture. The pottery in the ditch places the monument in the North Jutland Volling group. Based on similarities in the ceramics between the ditch and the material from the top horizon from the nearby køkkenmødding at the seashore, the grave is dated to the period 3100–2800 b.c. (uncalibrated C-14 years).

The grave structure was located directly upon a small settlement site representing a very short occupation, also belonging to the Volling phase of the Early Neolithic Funnel Beaker culture. This settlement seems to represent the habitation area proper on high dry land corresponding to the køkkenmødding along the seashore. The results of the Bjørnsholm excavation indicate that such Early Neolithic coastal sites comprised both a habitation area on dry land and an associated kitchen midden at the coast.

The location of a grave on a settlement is typical of many Early Neolithic sites – both coastal and inland. This observation indicates that such sites had a high social and economical value in the settlement system. This does not fit with our present models of settlement patterns according to which such a site as Bjørnsholm would have been termed "catching site" and thereby indirectly giving it a lower rank than the (farming) "residential sites". The results from Bjørnsholm indicate that the model of the Early Neolithic settlement system need modification. The authors prefer only to use the term "settlement sites" – sometimes located at the coast and sometimes inland. Such a modified settlement model fits very nicely with the very mixed economy of the Bjørnsholm settlement site.

Birch woodland occurred near the site. Pollen of wheat and probably barley have been identified and indicate agriculture, and the presence of burned pollen document swidden land use. At Bjørnsholm it has been possible to make a direct correlation between an early "Landnam" phase and the Volling phase of the Early Neolithic Funnel Beaker culture, i.e. c.3100–2800 b.c.

The faunal remains of the køkkenmødding included bones of cattle, domesticated pig, and sheep/goat as well as bones of species hunted in the surrounding forest and on the open sea, along with fishing and gathering.

The Bjørnsholm site complex is an Early Neolithic coastal settlement with a very mixed economy – highly adapted to the mosaic-like biotope with its many ressources.

Søren H.Andersen, Department of Prehistoric Archaeology, University of Aarhus, Moesgård, DK 8270 Højbjerg, Denmark.
Erik Johansen, Ålborg Historiske Museum, Algade 48, DK 9000 Ålborg C, Denmark.

## NOTES

1. The new excavations at Bjørnsholm are part of a joint research project by the Department of Prehistoric Archaeology, University of Aarhus and Ålborg Historiske Museum. The scientific aim is to investigate the Late Mesolithic and Early Neolithic settlement system and subsistence basis in the NW-Himmerland area. The Bjørnsholm køkkenmødding has Sb.nr.20 Ranum s., Slet h., Ålborg County. After the excavation in 1931 an area measuring 30×30 m was protected by law. The project has been sponsored by Ålborg Historiske Museum, The State Antiquary, *G.E.C. Gads Fond,* The Danish Research Council for the Humanities, *Dronning Margrethe d.II's Arkæologiske Fond* and *Aarhus Universitets Forskningsfond.*
2) The excavation by the National Museum in 1931 was conducted by H.C.Broholm. Report in the archives of The National Museum, j.nr.356/30 og 361/31. An area of c.77 $m^2$ was investigated. Later smaller excavations have been performed west and southwest of the Bjørnsholm køkkenmødding by C.L.Vebæk (a Late Neolithic grave, The National Museum j.nr.1107/57. Sb.no.26 and museum no.NM 1.A 48150) and C.L.Vebæk (an Early Middle Neolithic grave), The National Museum j.nr.1107/57 = Sb.no.25 of Ranum s. The finds have no.NM 1.A 48151–59 og C 27501.
3) All three occupation periods are well represented at Bjørnsholm. They form a clear stratigraphic sequence; the Early Neolithic horizon superimposing the eastern part of the Late Mesolithic Ertebølle midden while the Iron Age (Late Pre-Roman period) is clearly separated from the Stone Age layers by a c.10–40 cm thick sterile sand/humus horizon.
4) The C.L.Vebæk's excavation was positioned c.90 m from the westborder of the køkkenmødding.
5) The charcoal sample has been identified by Claus Malmros, The National Museum, Natural Sciences Research Unit, Copenhagen. Verbal communication by C.Malmros.
6) Even though several large fragments of this pot do not fit, it is, however, possible to reconstruct the relevant measurements of the pot.
7) The animal bones are in the process of being identified by stud.lic. Bodil Bratlund. Dept.of Preh.Arch., University of Aarhus, Moesgård, 8270 Højbjerg.
8) The fish bones are being analyzed by cand.scient. Inge B. Enghoff, The Zoological Museum, Copenhagen. The results are forthcoming.

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# *Pollen Spectra from two Early Neolithic Lugged Jars in the Long Barrow at Bjørnsholm, Denmark*

by SVEND TH. ANDERSEN

## INTRODUCTION

The long barrow at Bjørnsholm, northwest Denmark, was excavated and described by Søren H. Andersen and Erik Johansen (this volume). A longitudinal section through the eastern part of the barrow showed a 12 cm deep horizon of grey-brown sandy brown earth over subsoil of yellow stony sand and covered by brown-grey sandy fill with humic horizons and recently plowed soil (Andersen and Johansen 1992, this volume fig. 5). In the section was seen traces of a transversal ditch, which had been filled with grey-white sand. Two complete lugged jars, and fragtments of a third, of Volling style (labelled AAVW and AAVT), and other objects were found in the ditch during the excavation. Similar pot-sherds were found in the top layer of the nearby kitchenmidden. Oyster shells from this layer were radiocarbon-dated at 3160±95 and 2940±95 $^{14}$C years BC (see Andersen and Johansen 1992, this volume, average date 3940–3700 BC, calibrated, note 1). Samples of soil found within the jars were secured by the excavator.

## POLLEN ANALYSES

None of the samples from the soil horizon and the fill contained pollen. The destruction of pollen can be ascribed to seepage of oxygenated rain water through the shallow sandy deposits, and a high biological activity, which is indicated by numerous vertical earthworm-casts.

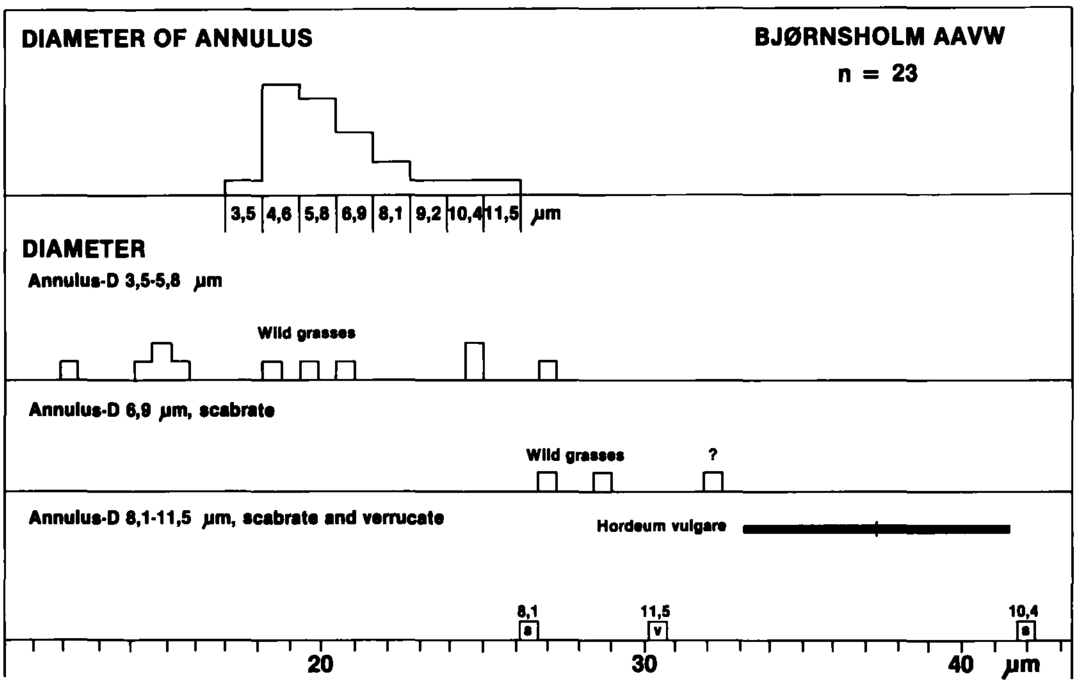


Fig. 1. Diameter of pore *annulus* (an1-D) in 23 Gramineae pollen, and average size (M+ + M-/2) of individual pollen grains from jar AAVW from the long barrow at Bjørnsholm, and size range (x ± 2s) for modern pollen of barley (*Hordeum vulgare*, from Andersen 1979).

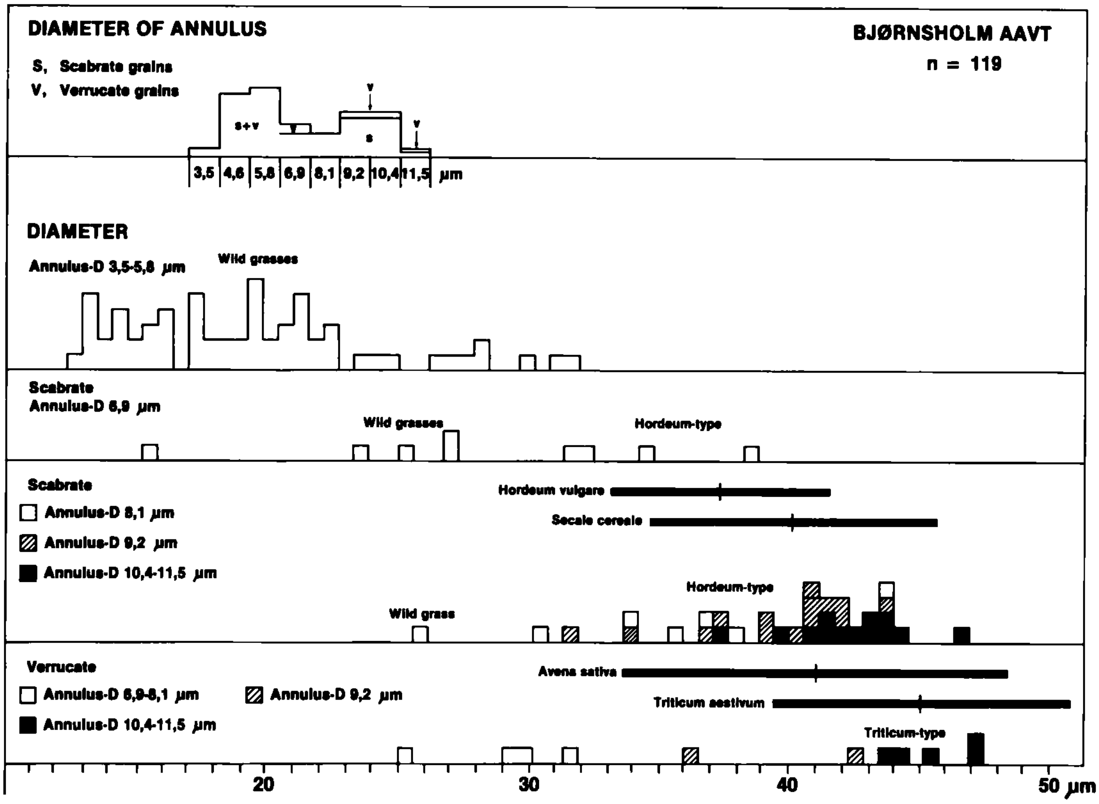


Fig. 2. Diameter of pore *annulus* (an1-D) in 119 Gramineae pollen, and average size (M+ + M-/2) of individual grains from jar AAVT, and size range (x ± 2s) for modern pollen of barley (*Hordeum vulgare*), rye (*Secale cereale*), oats (*Avena sativa*), and wheat (*Triticum aestivum*, from Andersen 1979).

The samples from the lugged jars, in contrast, contained abundant pollen. It can be suggested that soil moisture created an oxygen-poor environment unfavourable for pollen destruction inside the jars.

One sample from jar AAVW and two from AAVT were examined by pollen analysis. They were treated with potassium hydroxide, hydrofluoric acid, and acetolysis mixture, and were mounted in silicone oil. Pollen preservation varied considerably. In jar AAVW all pollen grains were crumpled. In jar AAVT there occurred crumpled as well as excellently preserved, inflated grains. The numbers of pollen grains counted vary 210–352. The names of plant species in latin follow *Flora Europaea*.

## IDENTIFICATION OF GRASS POLLEN AND CEREAL POLLEN

In order to separate pollen of cereals from wild grass pollen, the pore *annulus* was measured in all grains. The average pollen diameter (largest and smallest diameter, divided by 2) was measured in all grains with *annulus* larger than 6 µm, except for ruptured pollen, and the sculpturing (scabrate or verrucate) was noticed with phase contrast equipment. The pollen diameter is more or less modified in crumpled grains, whereas the *annulus* diameter is not affected. The pollen grains with *annulus* diameter smaller than 6 µm belong to wild grasses, and grains with a larger *annulus* may belong to cereal species (Andersen 1979). The pollen of barley (*Hordeum vulgare*) and rye (*Secale cereale*) have a scabrate sculpture, those of wheat (*Triticum*) species and oats (*Avena sativa*) are verrucate, and are larger than most wild grasses. Inflated rye pollen grains can be distinguished from barley pollen by shape, whereas crumpled grains of rye and barley cannot be separated.

Wild grasses with small pollen grains (less than 30 µm) and *annulus* diameter (less than 7 µm) dominate in the sample from jar AAVW (fig. 1). 4 grains with a larger *annulus* and scabrate sculpture belong to barley or some wild grasses such as couch-grass (*Agropyron*), lyme-grass (*Leymus arenarius*), and marram-grass (*Ammophila arena-

| | AAVW | AAVT | |
|---|---|---|---|
| Analysis, nr. | 1 | 2 | 3 |
| Pollen sum, P | 357 | 210 | 240 |
| Tree pollen sum, AP | 315 | 134 | 75 |
| Trees, % P | 88,2 | 63,8 | 31,3 |
| Birch, *Betula*, % of trees | 93,0 | 91,8 | 90,7 |
| Hazel, *Corylus avellana* | 3,2 | 6,7 | 5,3 |
| Alder, *Alnus glutinosa* | 3,2 | 1,4 | 4,0 |
| Oak, *Quercus* | 0,6 | – | – |
| Deformed tree pollen, % AP | 57,3 | 23,9 | 36,0 |

Table 1. Tree pollen in samples from the two lugged jars from the Bjørnsholm long barrow. The tree pollen percentages were corrected according to Andersen (1970, 1980).

*rius*). One grain with verrucate sculpture and a large *annulus* (11,5 μm) belongs to wheat or oats.

Wild grass pollen with small pollen grains and *annulus* diameters are less frequent in the samples from jar AAVT and there is a considerable proportion of pollen with a large *annulus* (8.1–11.5 μm), most of which are scabrate (fig. 2). 6 inflated grains belong to rye. The other scabrate pollen grains larger than 32 μm or with *annulus* larger than 7 μm belong to barley, rye or the wild grasses mentioned above (*Hordeum*-type in figure 2). The verrucate grains with *annulus* larger than 9 μm are likely to belong to wheat or oats (*Triticum*-type in fig. 2).

## RESULTS OF THE POLLEN ANALYSES (TABLES 1–2)

Pollen numbers and tree pollen spectra are shown in table 1, and pollen spectra for non-tree pollen in table 2.

The pollen of ligulate composites (Liguliflorae) and ferns (*Dryopteris*-type) were calculated outside the pollen total. The pollen of ligulate composites often occurs in large numbers in soils and are likely to have been buried by burrowing bees (see Andersen 1988). Their presence with high frequencies (10–14%, table 2), may be taken as an indication that the jars were filled with near-surface soil, probably fetched in the surrounding area at the time when the trench was filled.

The *tree* pollen frequencies differ considerably in the three pollen spectra (table 1). Tree pollen dominates in jar AAVW (88%), it is less frequent in one sample from AAVT (64%), and non-tree pollen dominates in the other sample from this jar (31% tree pollen). In contrast, the tree percentages in the three pollen analyses are very alike each other. Birch (*Betula*) dominates strongly (91–93%), and there are only slight traces of other trees. Much of the tree pollen was deformed due to heating (24–57%, see Andersen 1988). It can be concluded that the tree pollen derives from birch populations, which had been burned before the soil was dug.

The two *non-tree* pollen spectra from jar AAVT are very alike each other, and differ considerably from jar AAVW (table 2). Plants from bare soil (including cereals), dry

| | AAVW | AAVT | |
|---|---|---|---|
| Analysis, nr. | 1 | 2 | 3 |
| Non-tree pollen, NAP | 42 | 76 | 165 |
| Bare soil, % NAP | 21,4 | 31,6 | 32,1 |
| Barley, *Hordeum*-type | 9,5 | 7,9 | 17,0 |
| Wheat, *Triticum*-type | 2,4 | 7,9 | 3,0 |
| Rye, *Secale cereale* | | 1,3 | 3,0 |
| Sheep's Sorrel, *Rumex acetosella* | 9,6 | 9,2 | 6,7 |
| Knot-grass, *Polygonum aviculare* | – | 3,9 | 1,2 |
| Corn Spurrey, *Spergula arvensis* | – | 1,3 | – |
| Corn-flower, *Centaurea cyanus* | – | – | 0,6 |
| Goose-foot Family, Chenopodiaceae | – | – | 0,6 |
| Dry Meadow | – | 3,9 | 5,4 |
| Ribwort, *Plantago lanceolata* | – | 2,6 | 1,2 |
| White Clover, *Trifolium repens* | – | 1,3 | 3,6 |
| Hoary Plantain, *Plantago media* | – | – | 0,6 |
| Other herbs | 47,6 | 57,9 | 56,4 |
| Wild grasses, Gramineae undiff. | 42,9 | 38,2 | 29,7 |
| Milfoil, *Achillea*-type | 2,4 | – | – |
| Bedstraw, *Galium*-type | 2,4 | – | – |
| Crucifer Family, Brassicaceae | – | 17,1 | 26,7 |
| Cinquefoil, *Potentilla* | – | 1,3 | – |
| Dropwort, *Filipendula* | – | 1,3 | – |
| Shrubs | 4,8 | 1,3 | 0,6 |
| Black Elder, *Sambucus* nigra | 4,8 | 1,3 | – |
| Hawthorn, *Crataegus* | – | – | 0,6 |
| Forest and coppice | 21,4 | – | 4,2 |
| Mugwort, *Artemisia* | 19,0 | – | 4,2 |
| Bracken, *Pteridium aquilinum* | 2,4 | – | – |
| Heaths and bogs | 4,8 | 5,3 | 1,2 |
| Heather, *Calluna vulgaris* | 2,4 | 3,9 | 1,2 |
| Club-moss, *Lycopodium annotinum* | 2,4 | – | – |
| Sedge, *Carex*-type | – | 1,3 | – |
| Ligulate Composites, Liguliflorae, % P | 14,3 | 12,4 | 10,0 |
| Ferns, *Dryopteris*-type | – | 1,0 | – |
| Mugwort, *Artemisia*, deformed, % | 75,0 | – | 71,4 |

Table 2. Non-tree pollen in samples from the lugged jars from the Bjørnsholm long barrow, in percentages of non-tree pollen (NAP) and total pollen (P, Liguliflorae, ferns).

meadow, and other herbs, are more frequent in the two samples from jar AAVT than in AAVW. Pollen of rye occurs in jar AAVT and pollen of plants from the crucifer family (Brassicaceae) are very frequent in the samples from this jar.

As mentioned above, there were many excellently preserved pollen grains in the samples from jar AAVT (cereal and crucifer pollen in particular). Rye, moreover, did not occur in the Danish Neolithic. One therefore suspects that much of the non-tree pollen in the samples from this jar derives from more or less recent vegetation, in particular cereal fields and fields with rape (*Brassica napus*) or mustard (*Sinapis alba*, both from the crucifer family), and was transported downwards by burrowing earthworms. The jar had a wide opening (19,5 cm in diameter) and was found with the opening turned upwards (Andersen and Johansen 1992, this volume). Vertical earthworm casts were frequent in the section, and it would not be unlikely that earthworms would migrate downwards in dry periods and seek out the moist interior of the jar, to deposit gut material with pollen grains from the surface. The tree pollen in this jar is likely to be original and was apparently mixed with differing amounts of young pollen in the two samples. It is impossible to evaluate the origin of other non-tree taxa, in these samples.

The sample from jar AAVW did not contain rye and crucifer pollen, and no well preserved pollen grains were seen. It therefore seems justified to assume that the pollen spectrum from this jar is uncontaminated with younger pollen. In contrast to the other jar, jar AAVW is narrow-necked (the opening is 6,9 cm wide), and was found with the opening pointing in a horizontal direction or obliquely downwards (see Andersen and Johansen 1992, this volume). This difference in accessibility explains the difference in the pollen spectra.

The high dominance of tree pollen in the sample from jar AAVW (88% of the pollen total) indicates that the soil was retrieved shortly after the burning of the birch woodland and before the site was invaded by extensive herbaceous vegetation. *Artemisia* pollen is frequent (19%). The majority was deformed by heating (75%, table 2). It can therefore be assumed that *Artemisia* was present in the birch woodland before it was burned. Of the *Artemisia* species, mugwort (*A. vulgaris*) is nitrophilous and often occurs in agriculturally disturbed habitats. Nitrophilous plant communities are typical of edges around and openings within coppices (Burrichter et al. 1980). The presence of *Artemisia*, therefore, indicates human disturbance at the establishment of the birch woodland.

Although the pollen of *Hordeum*-type cannot be identified to barley with certainty, its presence together with pollen of wheat and sheep's sorrel (*Rumex acetosella*) may be taken as an indication of the growing of cereals at the site after the burning of the birches. Cultivation of wheat at that time is confirmed by the grain impressions in sherds from the kitchenmidden (see Andersen and Johansen 1992, this volume). The wild grasses (43%) may have been associated with fields or they may have grown around the site. Other non-tree taxa are scarce in the sample.

## CONCLUSIONS AND DISCUSSION

The pollen spectrum from soil within the lugged jar AAVW found in a transversal ditch near the eastern end of the long barrow at Bjørnsholm indicates a recently burnt birch woodland with traces of cereal growing. It is assumed that the soil found in the jar was fetched in the vicinity of the long barrow and was deposited there during the filling of the ditch at the construction of the barrow. The birch woodland was, therefore, nearly contemporaneous with the jar and the youngest parts of the neighbouring Early Neolithic kitchenmidden.

The birch woodland at Bjørnsholm occurred there around or just after the elm (*Ulmus*) decline (about 4200–3700 BC, note 2). At that time lime (*Tilia cordata*) dominated the forests in Denmark, even on sandy soils (see Andersen 1984). It can, therefore, be assumed that cleared lime woodland preceded the birch woodland. The abundant presence of *Artemisia* (probably mugwort, *A. vulgaris*) emphasizes that the birch woodland was artificial and was influenced by agricultural disturbance. Birch propagates easily in cleared forest soil, and birch woodlands were formerly used for swidden cultivation of cereals in Finland in a regular rotation (Linkola 1916). Sheep's sorrel, found also at Bjørnsholm, was the most frequent weed in these swidden fields. It can therefore be suggested that birch woodlands were intentionally propagated to be used for swidden cultivation. Traces of similar birch woodlands occur at other early Neolithic barrows (Andersen, in print). Swidden cultivation based on self-propagated birch woodland may, therefore, have been widespread in early Neolithic time, together with pasture of husbandry in cleared areas (Andersen, in print). This assumption would explain the increase in birch seen in many Danish pollen diagrams just after the elm decline (in Jutland: Andersen 1975, Andersen 1984, Aaby 1986a and 1986b).

Svend Th. Andersen, The Ministry of Environment, The Geological Survey of Denmark, Thoravej 8, DK-2400, Copenhagen NV, Denmark.

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## NOTES

1. The radiocarbon dates were calibrated according to the programme $C^{14}$-CAL by J. van der Pflicht 1988, which is based on the calibration curve of Pearson et al. 1986 (and modified by Madsen 1990). The intervals in years BC indicate the range of possible ages with one standard deviation.
2. Radiocarbon dates of the beginning of the elm decline in Jutland. Draved Bog, SW Jutland (K-738): 4980±100 before 1950 (Tauber 1967, calibrated age 3940–3690 BC).
   Elsborg Bog, Djursland (K-2220): 5160±80 before 1950 (Andersen 1984, calibrated age 4218–3814 BC).
   Two dates appear from the pollen diagrams in Aaby 1986a and 1986b. Fuglsø Bog, Djursland: about 5050 before 1950 (calibrated age about 3900–3800 BC).
   Abkær Bog, SE Jutland: about 3900 BC (calibrated age).

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# A Metallurgical Study of 12 Prehistoric Bronze Objects from Denmark

by VAGN F. BUCHWALD and PETER LEISNER

## INTRODUCTION

Scandinavian museums are rich in bronze objects. Only an insignificant fraction of them have been examined with a view to studying their metallurgy and structure. While prehistoric copper or bronze finds from Sweden (e.g. Oldeberg 1974), Britain (e.g. Coghlan 1967, Northover 1982, Parker 1982), Wales (e.g. Savory 1980), Switzerland (e.g. Rychner 1984), Italy (e.g. Matteoli and Storti 1982), and Sardinia (e.g. Tylecote et al. 1983) have been thoroughly discussed, much remains to be done on bronzes from Denmark.

The present paper is the first of a small series, in which ancient Danish bronze objects will be described from a metallurgical, a chemical, and a technological point of view. Since our method requires the removal of a substantial sample, the available objects are limited to common tools and weapons, while more valuable museum pieces will normally be out of reach.

Ten of the objects presented here have previously been analyzed by classical spectrographic methods (Junghans et al. 1960, 1968), and we have compared our new data with the spectrographic data. Generally there is very good agreement.

It has not been a primary goal of this study to map and discuss the trace elements in bronze. Rather, we have concentrated on the major elements which confer strength, coherence, castability, and corrosion resistance to the objects, in short the technological factors. While we do report some trace element data, our sample of only 12 objects is too small for any far-reaching conclusions to be drawn with respect to the origin of the bronze and the raw materials.

## THE SELECTION OF SAMPLES

The present sample consists of ten axes from the Neolithic or earliest part of the Bronze Age and two lurs from the Late Bronze Age. All of them were found in Denmark, but a couple of the bronze axes are not further provenanced. Information about datings has been kindly communicated to us by Dr. D. Liversage, National Museum, who has also been helpful in other ways. The specimens have not been subjected to major conservation, so the analytical and structural data should provide a true picture of the ancient technology and the subsequent long exposure to soil corrosion.

## SAMPLE PREPARATION – REQUIREMENTS AND LIMITATIONS

Wedge shaped pieces were removed from the cutting-edge and the side of each axe using a fine-toothed jeweller's saw, so that these different parts could be compared with respect to composition and technology. A trial made by the National Museum's conservation laboratory showed that the axes could if wished be restored so well that the cuts were virtually invisible.

The lurs were sampled by hacksawing or breaking small pieces from larger fragments.

The weight of the samples removed and embedded was usually less than 3 g, and the loss by hack-sawing less than 0.3 g. Generally, 60–150 $mm^2$ cut and polished surface was available for the study of each sample, sufficient for revealing both macrostructure, including segregation and porosity, and microstructure.

After cutting, the sample was set in cold-curing resin (Struers Epofix) in a small vacuum box. For this operation a thick-walled glass-desiccator with water-jet pumping was found to be sufficient. The vacuum impregnation served to fill pores and crevices, and to bind any loose particles that might otherwise become loose under the grinding and polishing operations and thereby scratch the finished surface.

Most samples were after mounting ground and polished on a horizontal wheel revolving at about 300 rpm, using carborundum of increasing fineness from 80 to 1000 mesh in three or four steps. During grinding, a copious stream of water served to remove the dust and cool the sample. For the smaller samples the coarser grits were usually omitted and grinding was limited to wet emery paper, grade 1000.

Polishing was carried out on horizontal discs with cloths impregnated with diamonds (Struers DP-9 and DP-U2). The grain sizes were 3 and 1 μm.

The samples as polished were examined for defects, pores, slag distribution, and corrosion products. Afterwards, the samples were etched, either with $Cu(NH)_4Cl_2$ or with $FeCl_3$, and photomicrographs were taken and microhardness tests performed. Finally, the samples were repolished, carbon-coated, and analyzed.

## CHEMICAL COMPOSITION, X-RAY ANALYSIS

The structural examination of the etched samples formed the basis of the subsequent bulk chemical analysis, which was carried out as an X-ray microprobe examination. Sufficient area was scanned so that a true picture of the bulk composition was reached, including inclusions and segregation (coring) effects. After a number of introductory analyses of various standards it was decided to scan whenever possible areas of $0.4 \times 0.25$ mm$^2$ in order to include a sufficient number of dendrite arms, coring, and sulphide inclusions.

The analytical equipment was a scanning electron microscope with an energy-dispersive X-ray analytical detector attached (Philips SEM 505 with EDAX 9100). The method is based upon element-specific X-ray fluorescence (Goldstein et al. 1984). When a plane-polished sample is exposed to a beam of high-voltage electrons, some electrons of the sample will be excited and leave their normal shells and be replaced immediately by other electrons from higher energy levels, thereby emitting X-rays characteristic of their loss of potential energy. The energy (eV) of the emitted X-rays is analyzed in a detector; the location of the channels identify the element, the intensity of the channels the concentration of the element. The equipment was operated at 30 kV, tilt 30°, take off 38.7°, and background generally at 2.8 and 14.0 eV.

The X-ray microanalytical technique was used to study the average chemical composition of a volume by scanning a typical polished area of $0.4 \times 0.25$ mm$^2$. Since the penetration of the electron beam is about 1 μm, the volume scanned is about $10^{-4}$ mm$^3$, corresponding to only about $8 \times 10^{-7}$ g. Even this minute amount appears to give a true picture of the composition to better than ±5%.

In addition, the technique was applied for identification of inclusions as small as 5 μm across. The electron beam can be focused for spot analysis of, for instance, sulphide inclusions. Further possibilities are photographing the area analyzed by scanning electron microscope (SEM), e.g. fig. 2, and mapping the element distribution by photographing the X-ray image of characteristic scanned areas, e.g. figs. 56–62.

Spectral lines from two different elements may overlap making it difficult to quantify some pairs of elements correctly. It requires, for example, caution when the sample contains both lead and sulphur, or tin and antimony, or arsenic and lead. Also, it is necessary to correct for fluorescence and absorption effects, but these problems have been well studied and the machine programs (NBS/EDAX FRAME C) usually handle them satisfactorily.

We present quantitative data for the following nine elements: tin, sulphur, iron, nickel, zinc, arsenic, silver, antimony, and lead. The limit of detection with our method is 0.07–0.1 wt.%.

*Sulphur* occurs as the copper sulphide, $Cu_2S$, which may be identified on polished sections and measured by planimetry. For example, a specimen which exhibits 1.5% by volume $Cu_2S$, contains about $32 \times 1.5/(32+2 \times 63.5)$ wt.% S, or 0.3 wt.% S. The precision is estimated to be ±10%. The composition of the sulphides may be verified by EDAX. Sometimes small amounts of iron substitute for copper in the sulphides. Sulphur may also be determined by EDAX. However, if lead is also present the S value becomes erroneously high, and the only reliable method is planimetry.

*Iron, nickel, cobalt, zinc,* and *silver* were found to be present in small amounts only. They were determined by EDAX and presented no analytical problems on either polished or etched sections on the level of ±10%. Iron turns out to be essentially concentrated in the copper sulphide inclusions. Nickel is partitioned between the α- and the δ-phases, and concentrated by a factor of more than 3 in the δ-phase.

The quantitative determination by EDAX of *lead* in bronze surprisingly turned out to be a problem, even when no sulphur was present. Lead occurs as discrete, interdendritic blebs, typically 2–20 μm across, which are rather uniformly distributed through the alloy. On routine polishing, the ductile copper phase is smeared over the soft lead pockets, thereby erroneously increasing the Cu-signal and decreasing the Pb-signal. It was found that the best procedure for a good lead analysis was to polish and etch, then polish and etch again. By these repeated operations the smeared copper was dissolved and the lead pockets exposed to their true extent. The lead amount was, in addition, estimated by planimetry under the optical microscope.

*Tin*, on the other hand, was determined on repolished sections, since it was found that it became enhanced upon etching, probably because copper was selectively dissolved. Tin occurs in solid solution in the copper phase, and at higher concentrations forms the intermetallic compound $Cu_{31}Sn_8$, the so-called δ-phase.

*Antimony* is determined by EDAX on polished sections. Antimony segregates with tin in the cast alloy but will be homogeneously distributed after annealing. Since tin and antimony have overlapping lines we found it necessary to introduce correction factors for the two elements, based upon the examination of polished standard-alloys.

*Arsenic* may be determined by EDAX on polished sections when lead is not present in the alloy. If lead is present, and this may be verified on microscopical examination, the arsenic and the lead values become unreliable, because the two lines (As $K_\alpha$ 10.530 eV and Pb $L_\alpha$ 10.550 eV) cannot be separated quantitatively by the Philips machinery and program. Lead is then determined by planimetry (see above), and the lower limit of arsenic is quoted. In some cases it was noted that arsenic was difficult to reproduce, perhaps because of segregation effects. On the whole, arsenic turned out to be the least reliable in our analytical set.

*Copper* has been found by subtraction from 100%.

All analytical results are the average of at least three analyses, performed on three different, uncorroded areas.

## THE HARDNESS TEST

A technologically important characteristic of metal alloys is the hardness. The Vickers hardness number is in the order of 35–45 for unalloyed, annealed copper, but increases to above 300 for cold-worked arsenical and tin bronzes. A great deal is known about hardness and its variation, and it is safe to say that a hardness determination combined with a structural examination and a chemical analysis will usually fully characterize any sample.

The Vickers hardness test is an indentation method, where a small diamond in the shape of a pyramid is pressed into the surface by a standard load. The hardness is a measure of the resistance to indentation as measured by the diameter of the impression. The hardness number HV is defined as the load of the indenter (kg) divided by the projected area of contact between the pyramid and the metal ($mm^2$). In the present study the load was chosen as 5 kg in order to produce a sizable indentation, that integrated a number of grains and/or dendrite arms. Sometimes on porous or corroded materials it was difficult to arrive at reproducible hardness values. Porous objects give too low a hardness value. The test machine is a Universal Test Apparatus (Otto Wolpert Diatestor), equally well suited for Vickers, Brinell, and Rockwell tests in the range 1–250 kg.

For the detailed study of inclusions, coring etc., a microhardness test with a load of 100 g was carried out using a special test machine, the Leitz Durimet (Blau & Lawn 1985). The microhardness testing is slightly slower than the macrohardness testing and it requires a perfect, vibration-free support. With the microhardness method the gradual hardness increase from the massive interior of an axe to the work-hardened cutting-edge could easily be determined.

The hardness of all axes has been mapped in both the cutting-edge (A) and the bulk (B), see e.g. fig. 22. The values obtained at 5 kg load (underlined) are considered the most representative, and they may be directly compared to the experimental data of the curves, figs. 1, 18–20, and 87. The other values, obtained at 100 g load, are considered supplementary; they are especially important on porous or corroded objects.

## A COMPARATIVE STUDY OF SYNTHETIC ALLOYS

In order to study the properties of copper alloys within the range encountered in ancient bronze objects, a number of alloys were prepared and studied. The alloys were prepared from analytical grades of tin, antimony, bismuth, sulphur (added as CuS), iron, zinc, and silver. The copper itself was cable copper (electrolyte copper with 99.95% Cu), while arsenic was added as a copper-arsenic alloy with 10.3% As. The samples were produced without phosphorus additions, since phosphorus is not present in ancient alloys.

Samples of 20 g were cast in graphite crucibles covered with graphite lids. The solidification from the casting temperature (1100–1125 °C) took place by free cooling in air, resulting in solidification within a few minutes and formation of dendrites with an arm spacing of typically 30–50 μm, figs. 2–3.

*Copper-tin*

According to the equilibrium diagram (Metals Handbook 1973) copper can dissolve up to 15.8% tin. The homoge-

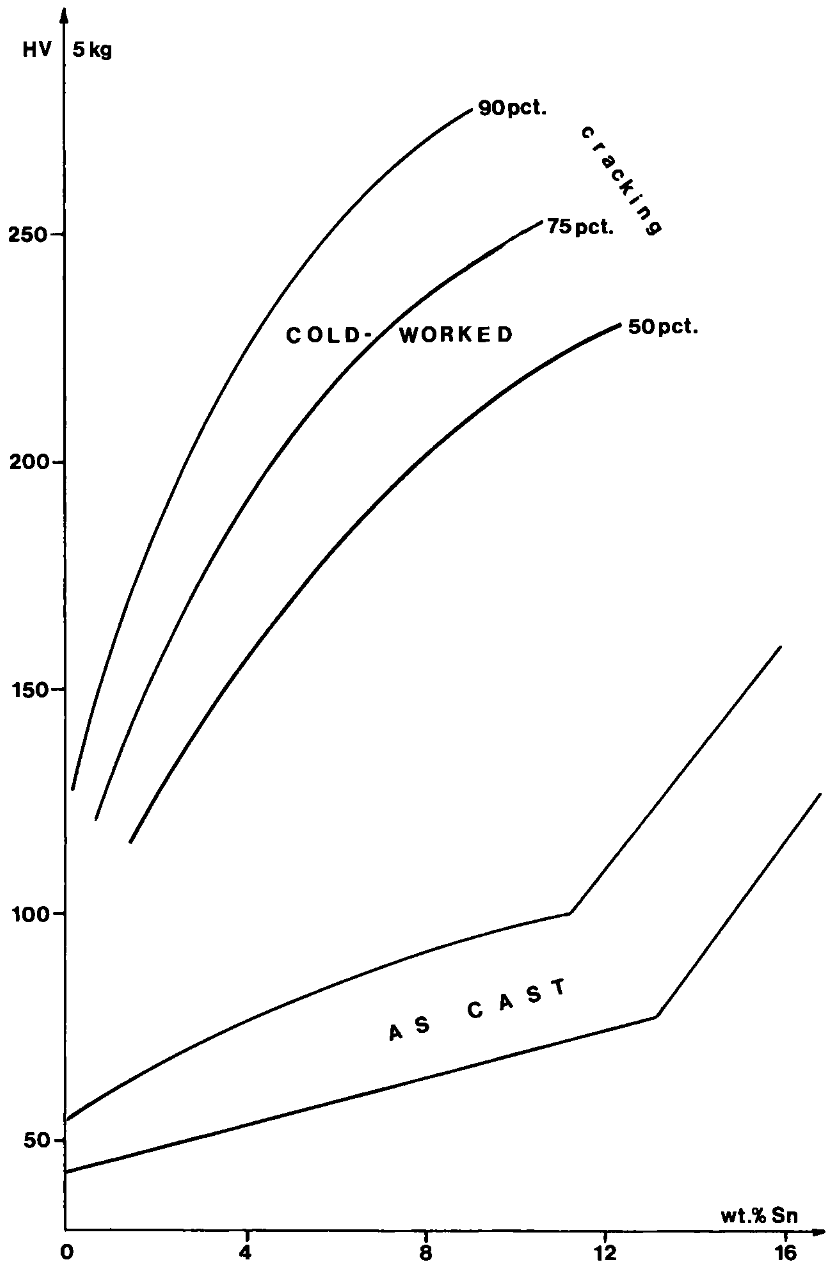



Fig. 1. Vickers hardness (5 kg load) of Cu-Sn alloys (no P-additions). Cast objects are found within the basal band. Small, rapidly cooled objects lie near the upper limit, large, slowly cooled objects near the lower limit. Fully annealed (or recrystallized) alloys are also near the lower limit. Cold-working leads to progressively harder alloys. Excessive cold-work makes the objects crack.

neous α-phase will with increasing amounts of tin in solid solution increase in hardness from about 40 to about 80. When the homogeneous phases are cold-worked, by hammering, rolling, or bending for example, the hardness increases substantially. For an evaluation of the degree of cold-work the approximate expression

$$D = (t_o - t)/t_o$$

may be used. $t_o$ is the specimen thickness at start, and t is the thickness after cold-work. D is the degree of reduction (cold-work) in percent – it can approach but never reach 100%. It is difficult in practical work to exceed reductions of 80% in copper alloys of our interest. The more δ-phase the less reduction in cold-working is achieved before the material splits open.

In fig. 1 the hardness of copper-tin alloys is shown. Cast alloys are found within the lower band. The band is rather wide, because hardness is also a function of grain size, fine-grained alloys being harder than coarse-grained. Thus, small objects being cast in stone – or clay moulds solidify in a fine-grained structure and will tend to have hardnesses along the upper limit, while kilogram-sized objects cast in sand will be coarse-grained and have hardnesses near the lower limit. Fully annealed copper-alloys, regardless of their former treatment, will also lie near the lower limit.

Up to 15% Sn, or in normal practice to about 13% Sn, the annealed Cu-Sn alloys are homogeneous, one-phased α-alloys. With more tin increasing amounts of the hard δ-phase, $Cu_{31}Sn_8$, will occur, which will considerably increase the hardness of the alloys. In unequilibrated cast alloys the δ-phase is very common, even down to about 5 wt.% Sn. This is one reason for cast alloys having a slightly higher hardness than annealed ones.

As mentioned above, cold-working increases the hardness. In fig. 1 three curves show the progressive hardening as samples are reduced 50, 75, and 90% by cold-working. Cold-working may increase the hardness by a factor of up to 3.5 relative to the hardness of the annealed state. On recrystallization and annealing the high hardness will revert to the low values shown in the basal band. No doubt, the ancient metal worker was well aware of these facts and was able to work and anneal repeatedly until what he was making had reached the desired shape and strength. The internal structure of the metal changes very much during this work. A selection of typical structural steps are shown in figs. 3–9.

The hardness of a metal is a property which is rather easily measured. It is interesting to note that the mechanical strength is closely related to the hardness. The ultimate tensile strength, measured in $N/mm^2$, is about 3 times the hardness measured on the Vickers scale.

For further information on the hardness and strength of copper alloys the reader may consult, e.g., Metals Handbook, Wilkins & Bunn (1943), Dies (1967), and Hanson & Pell-Walpole (1951).

*Copper-tin-sulphur-lead*

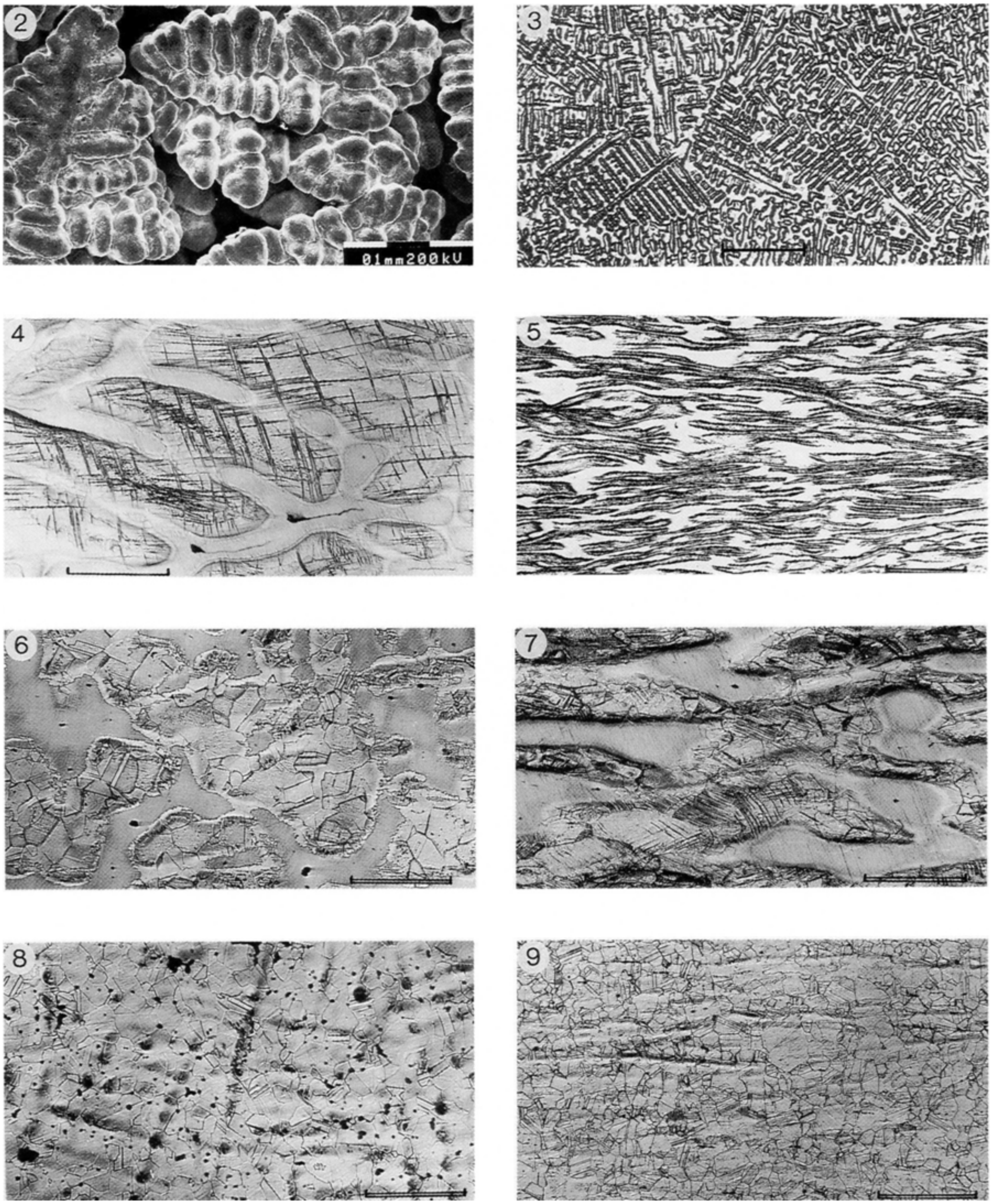
In the many publications on ancient bronzes, sulphur has received little attention and usually is not analyzed for. It came as a surprise for us to find that ten of our twelve bronze objects contained significant amounts of sulphur. We therefore decided to expand our range of synthetic alloys to include several sulphur-containing series, of which we here report a few in order to demonstrate their mechanical and structural properties as a function of deformation and annealing.

The alloys A, B, C, and D were chosen to represent alloys which were typical of ancient compositions (table 1). They were melted under a cover of charcoal and cast in dry sand moulds in the shape of long bars, 50 × 5 × 1 cm, fig. 10. The cast alloys were allowed to cool to room temperature in the moulds.

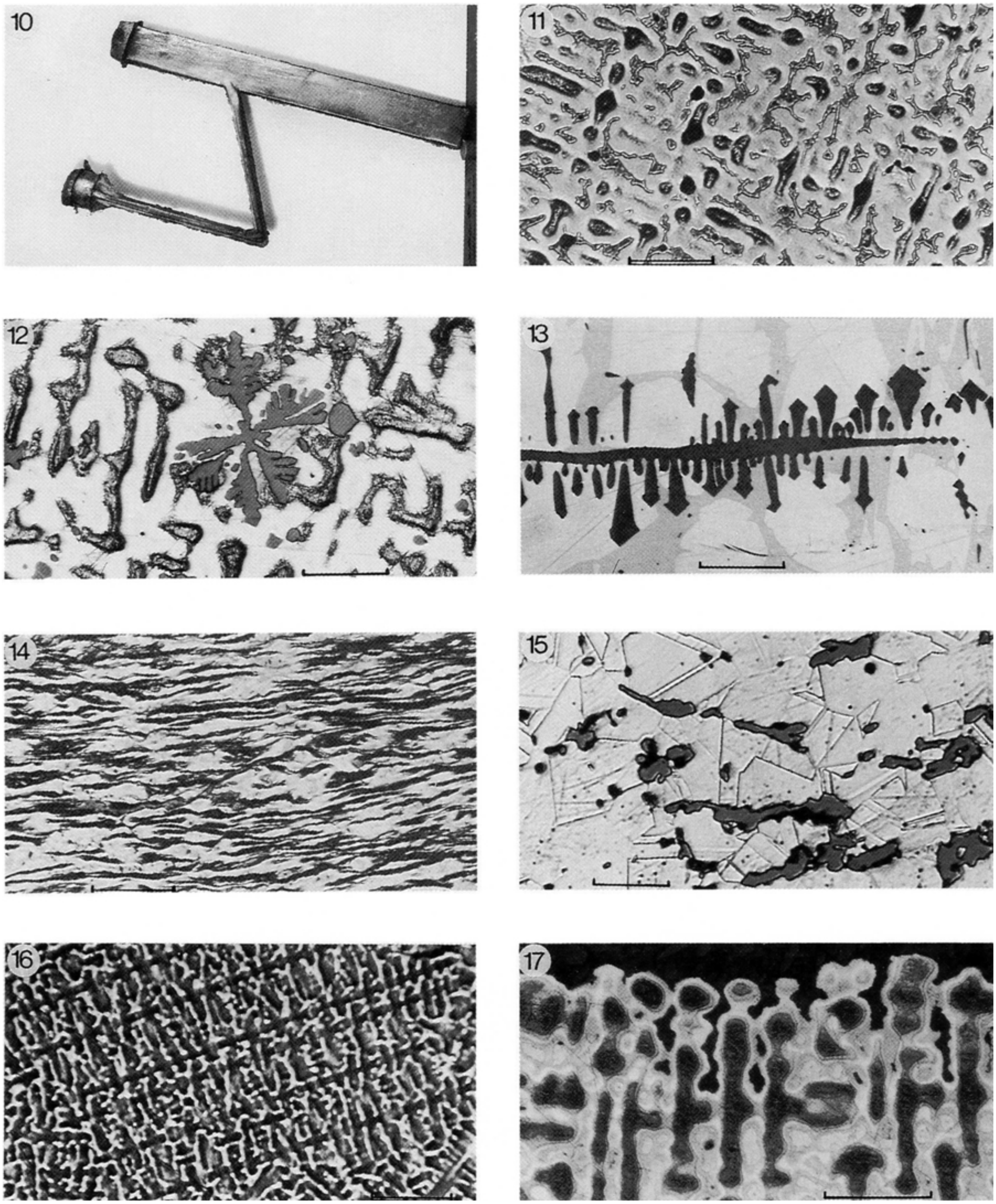
The bars were cold-worked and annealed, and one

Table 1

| | Cu | Sn | S | Pb | Charge weight, kg | Temp. at pouring | Vol.% δ-phase as cast | Vol.% δ-phase annealed 120 min /700 °C |
|---|---|---|---|---|---|---|---|---|
| A | 91.0 | 7.0 | 1.0 | 1.0 | 3.7 | 1300 °C | 1 | 0 |
| B | 85.5 | 14.0 | 0.5 | 0 | 3.9 | 1200 °C | 15 | 10 |
| C | 88.5 | 11.0 | 0.5 | 0 | 3.7 | 1160 °C | 11 | <0.5 |
| D | 92.5 | 7.0 | 0.5 | 0 | 3.6 | 1160 °C | 1 | 0 |




Figs. 2–9. The structure of a Cu-6Sn alloy in cast and worked conditions. Fig. 2. SEM picture of dendrites in the cast alloy. Scale bar 0.1 mm. Fig. 3. Polished and etched sections of a dendritic, cast structure. Scale bar 0.3 mm. Fig. 4. Cold-worked 44%: Slip lines in the segregated, cast structure. Scale bar 0.1 mm. Fig. 5. Cold-worked 81%: The cast structure has been severely deformed. Scale bar 0.3 mm. Fig. 6. Cold-worked 25% and recrystallized 50 min/550 °C. Scale bar 0.2 mm. Fig. 7. Cold-worked 63%, recrystallized 50 min/550 °C and again cold-worked 70%. Scale bar 0.1 mm. Fig. 8. Homogenized 120 min/620 °C, cold-worked 21%, and recrystallized 50 min/550 °C. Scale bar 0.2 mm. Fig. 9. Homogenized 120 min/620 °C, cold-worked 88%, and recrystallized 50 min/550 °C. Scale bar 0.2 mm.



Figs 10–17. Fig. 10. Experimental bronze sample, cast in a sand mould. The rectangular part is 50 cm long. Fig. 11. The segregated structure of a cast 14Sn-0.5S alloy (alloy B). Scale bar 0.3 mm. Fig. 12. Palmate $Cu_2S$-inclusions in a cast 10Sn-1S alloy. Scale bar 50 µm. Fig. 13. Faceted $Cu_2S$-inclusion in a cast 20Sn-1S alloy. Scale bar 50 µm. Fig. 14. Segregated 11Sn-0.5S alloy (alloy C), cold-worked 78%. Scale bar 0.3 mm. Fig. 15. Alloy A (7Sn-1S-1Pb) cold-worked 35%, then recrystallized 120 min/700 °C. Elongated sulphides, black lead globules, and recrystallized α-grains. Scale bar 0.2 mm. Fig. 16. Cu-1As alloy, as cast. Regular, segregated (=cored) dendrites. Scale bar 0.3 mm. Fig. 17. Cu-8Sn-1As alloy, as cast. Cored dendrites at the surface give the alloy a whiteblue luster. Scale bar 0.1 mm.

alloy was hot-forged. Typical structures are shown in figs. 11–15.

In fig. 18 are presented some of the results in terms of Vickers hardness at a load of 5 kg. The top curve gives the maximum hardness obtained on alloy D. The δ-rich alloy B could only be cold-worked to a reduction of 48% before it suffered cracking.

Comparing alloy A and D, which have the same tin content of 7%, it was evident that the sulphur and lead rich alloy A was less ductile than D. However, it was quite surprising to find that both copper sulphide-rich alloys could be substantially cold-worked without breaking. The copper sulphide is clearly sufficiently ductile to follow the deformation of the metal phases. In the cast alloys the sulphides are homogeneously distributed as palmate, subangular particles, fig. 12, but during cold-work they attain elongated shapes and become arranged along parallel lines. This is particularly easily seen when the alloys are reheated to recrystallization after cold-work, fig. 15.

Comparing alloys B, C, and D, which only differ in tin

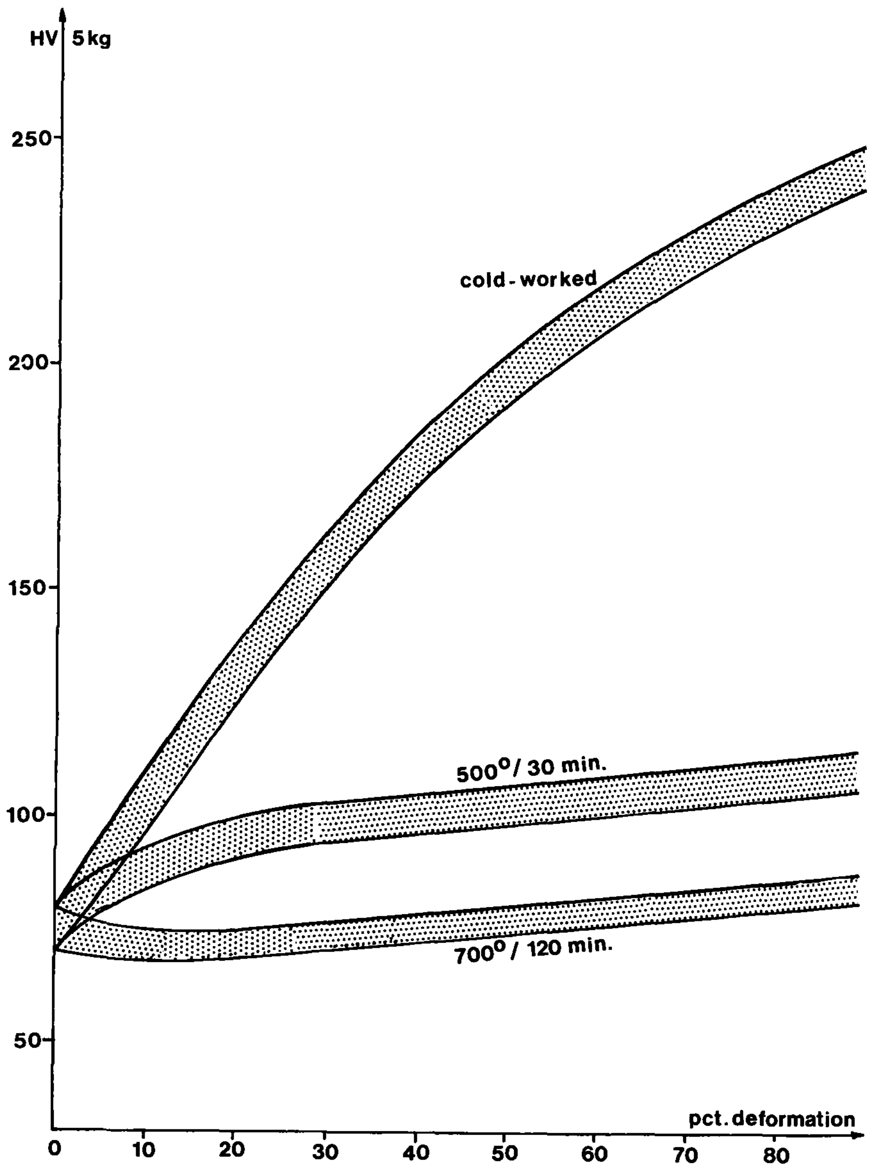



Fig. 18. Vickers hardness (5 kg) of a Cu-7Sn-0.5S alloy (alloy D). Cold-worked as shown, then recrystallized 30 min. at 500 °C. After thorough annealing for 2 hours at 700 °C, the hardness reaches its lowest level, the fully annealed state.

content, and thus in amount of δ-phase, it was observed that all can be cold-worked to hardnesses in the range 200–250 Vickers. This hardness range (and strength range) is the same as that found in low-carbon steels that have been worked or annealed, but not quenched in water. The properties of bronzes are, in general, not inferior to those of low-carbon steel. However, one weakness of the bronze alloys is their inherent porosity which stems from the shrinkage upon solidification. A bronze object hot- or cold-worked to final shape would be much superior to the equivalent cast object, because the subsequent reduction by working closes the numerous shrinkage cavities. Ancient iron and steel, on the other hand, has no shrinkage porosities, because the material was never melted but was produced by the direct process. Instead slag stringers occur, stretched in the forging direction and incurring fiber texture, which means that most iron objects have widely different mechanical properties in the longitudinal and transverse direction.

On annealing, i.e. reheating well above the recrystallization temperature of 300–400 °C for minutes or hours, the bronzes recover their basal hardness and strength, the material recrystallizes, and any heterogeneity resulting from casting is eliminated. Since this is a diffusional process, the final result depends very much upon the actual temperature and time applied. It will be noted that the hardness after annealing is almost independent of the foregoing cold-work, fig. 18. However the grain size of the recrystallized alloys decreases significantly, typically diminishing from about 200 μm to about 20 μm.

The lowest hardness of any bronze alloy is obtained by the following sequence: Casting, homogenization anneal, cold-work to a reduction by 10–20 %, followed by a thorough recrystallization anneal at about 700 °C for a few hours.

*Copper-arsenic and copper-arsenic-tin*

There are rather few data available on the properties of copper-arsenic alloys (Hanson & Marryat 1927; Maréchal 1958; Böhne 1965; McKerrell & Tylecote 1972; La Niece & Carradice 1989). Here we can present data referring to the synthetic alloys prepared during this project. The series covered the range 0–8 wt.% As, and other series within the ternary Cu-As-Sn system. The alloys were examined as cast and as homogenized, and in hot-forged, cold-worked and recrystallized conditions. Selected results are presented in figs. 16, 17, 19, 20.

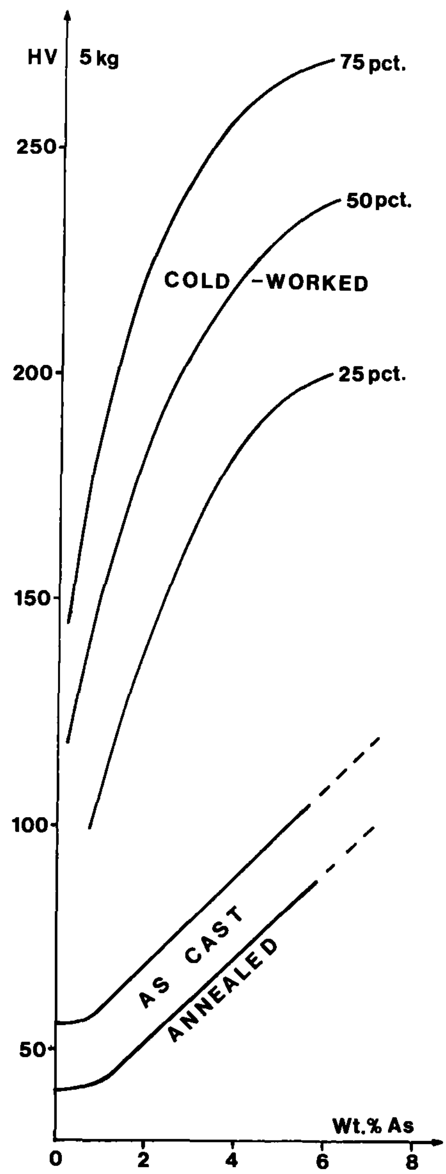



Fig. 19. Vickers hardness (5 kg) of Cu-As alloys. Below, the band for cast or annealed objects, compare Fig. 1. Above, the increasing hardness of cold-worked alloys. Arsenic is, on a weight percent basis, a far better hardening agent than tin.

Our results confirm the general opinion that copper is significantly strengthened by the addition of arsenic. The hardness of the annealed 4 wt.% As alloy is 70 ± 5 HV, while the annealed 4 wt.% Sn alloy is only 55 ± 5 HV. Evidently on a weight-percentage basis arsenic is a significantly better element than tin for hardening.

The difference becomes more pronounced when the alloys are cold-worked, compare the upper curves of figs.

19–20 with fig. 1. A Cu-2 wt.% As alloy is rather easily worked to a hardness of 225 HV (75% deformation), while a Cu-2 wt.% Sn alloy, even with the greatest deformation possible, will not increase above 190 HV. In order to confer a Cu-Sn alloy a hardness of 225 HV by 75% deformation, it is necessary to increase the tin content to 7 wt.%.

On annealing or recrystallizing, the hardnesses of Cu-As alloys fall back to the lower band, fig. 19. Prolonged maintenance of increased temperatures results in soft alloys close to the lower limit of the band, compare also fig. 18.

In one of our experimental series on the ternary Cu-As-Sn system, arsenic and tin were added in equal amounts, in consequence of which the abscissa in fig. 20 gives the sum of As + Sn as a wt.%. Thus, at 4 we have an alloy with 2 wt.% As and 2 wt.% Sn, and its hardness cold-worked to 50% is 200, while its hardness as fully recrystallized and/or annealed has decreased to 70.

It is evident that cold-work has most effect on the Cu-As alloys, somewhat less effect on the ternary Cu-As-Sn alloys, and least effect on the Cu-Sn alloys.

As more and more tin and arsenic are added to the alloys, new phases develop, such as $Cu_{31}Sn_8$ and $Cu_3As$. No ternary compounds exist, however, according to the equilibrium diagram by Maes & Strycker (1966). The new phases stiffen the alloys, which become harder and less ductile and thus difficult to shape by cold-working. Alloys with more than 4% of both Sn and As are rarely observed, and these "rich" alloys have not been further examined here.

The colour of arsenical bronzes changes to bluish-white by the time 2–4% As is added. Inverse segregation on casting is not uncommon, and the arsenic-rich dendrites at the surface convey a bluish-white lustre to the object, fig. 17.

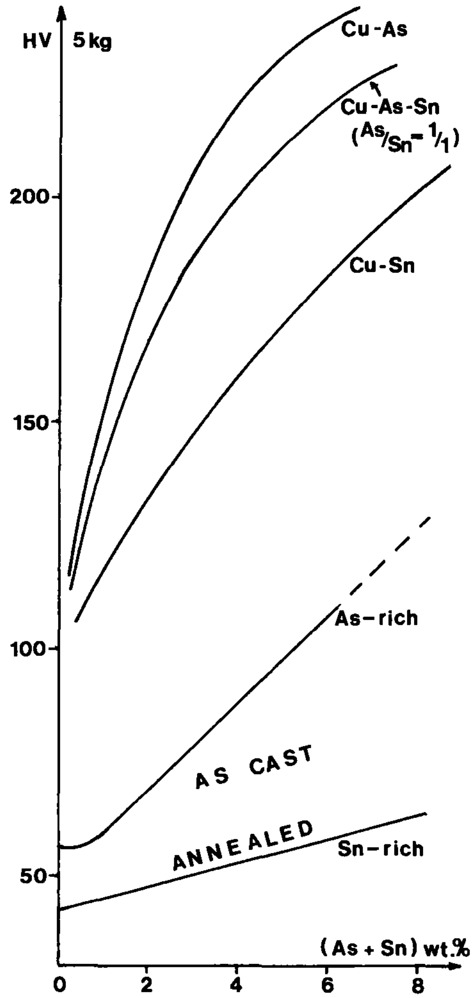



Fig. 20. Vickers hardness (5 kg) of Cu-Sn, Cu-As, and Cu-As-Sn alloys, annealed, and cold-worked 50% (the upper curves). Only one curve is shown for ternary Cu-As-Sn alloys, namely for those having the ratio 1:1 (weight) of arsenic and tin, and having been cold-worked 50%.

*Complex alloys*

Some of the ancient bronze objects are rather simple binary alloys, such as Cu-As and Cu-Sn, and the hardness diagrams presented here may then be used directly to estimate the degree of cold-work which has been applied to the cutting-edge of a knife or an axe. However, most bronzes are ternary or more complex alloys, and then the hardness diagrams may only serve as a guide. Usually the addition of extra alloying elements will increase the hardness, but there are no simple laws for prediction of the final hardness and strength. For example, while the annealed 7% Sn bronze has a hardness of 60, and the annealed 3% Sb bronze has a hardness of 60, the ternary annealed alloy 7% Sn – 3% Sb has a hardness of 95. Another example is that while the annealed 10% Sn bronze has a hardness of 70, and the annealed 2% As bronze has a hardness of 50, the annealed ternary 10% Sn – 2% As has a hardness of 90.

However the curves have turned out to be quite useful as a guideline for the minimum hardness in the annealed state and the maximum hardness in the cold-worked state, also for complex bronze alloys.

## THE ARTIFACTS

Ten axes and two lurs were examined. The axes had previously been analyzed by Junghans et al. (1968) and we give the serial number in their table. None of them had been examined metallurgically before. The objects are grouped in their expected order of archaeological age as estimated by D. Liversage (pers. comm.).

Two wedge-shaped samples were removed from each axe, one taken from the cutting-edge (A) and one taken from the side going as far in as the middle (B). Analytical work showed that the two places had the same chemical composition within the experimental error. However, as will be shown, their metallography and strength were usually quite different due to different working.

Generally, all etching was performed with standard copper-ammonium chloride solutions, although in some instances supplementary information was acquired by applying alcoholic ferric chloride.

*No. 1. B 2926. Tongue-shaped axe; Kirke Skensved Sogn; Tune Herred; Copenhagen Amt. Probably 4th millennium B.C. Weight: 135 g. Figs. 21–24. Table 2.*

The tongue-shaped object measures 100 × (25–35) × 8 mm, where the first figure in the parenthesis is the width at the neck and the second the width at the cutting-edge. The last figure is the maximum thickness. At section B one side is slightly convex, but rather smooth, the opposite is flat, but has a wrinkled and warty surface. We propose that the object was cast horizontally in an open mould, and that the slightly convex part was the underside. A linear, 24 mm long raised excrescence on this side apparently is the impression of a defect, a crack, in the mould, fig. 21 (Aner & Kersten 1973, No. 520).

Corrosion is slight, only thin 10–30 μm copper oxides of olive-brownish to black colors are present.

Analytically, the tongue-shaped axe is a copper-arsenic alloy. The spectrographic and the EDAX-analyses agree well. The composition falls in the Bygmet-group, proposed by Liversage & Liversage (1989):

Sn 0 or trace
As 0.1–2 %
Sb ≤ 0.15%
Ag ≤ 0.05%
Ni ≤ 0.04%
Pb, Bi and Co not defined.

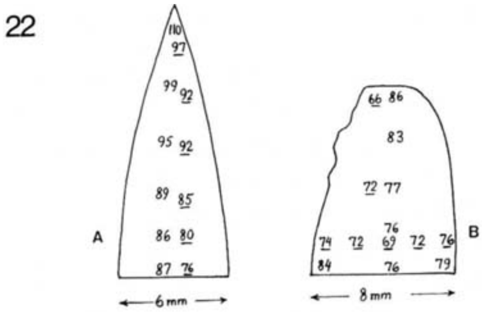
The polished sections show a red alloy with a number of fine, complex inclusions, 2–10 μm across. They consist, as in axe No. 2, of subangular copper oxides, $Cu_2O$, enveloped by lead- and copper-lead arsenates. Antimony and sulphur are not present. The inclusions date back from the smelting operations. In the cutting-edge they have acquired an elongate shape, suggesting some slight working, fig. 24. Junghans et al.'s spectral analysis was sensitive enough to reveal the bulk presence of 0.07 wt.% lead. Our energy dispersive method is not sensitive enough to catch the bulk value, but has, on the other hand, pinpointed the location of the lead to the slag minerals.

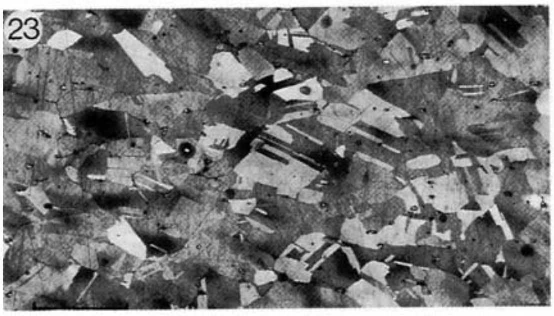
The etched sections show significant coring, overlapped by recrystallized, equiaxed α-grains with twins. The cutting-edge, A, displays a maximum hardness of 97, falling to 76 further inwards, with recrystallized grains 30–60 μm in diameter. The interior (B) displays hardnesses of 66–76, reflecting the segregated structure, and has recrystallized grains 100–200 μm in diameter, fig. 23.

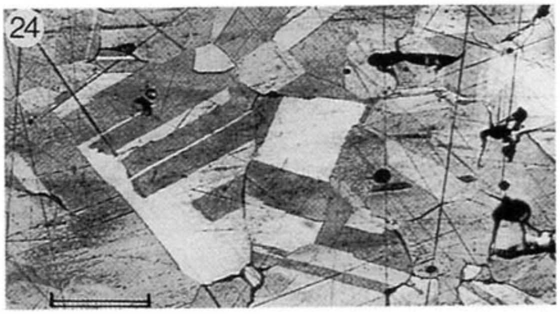
This axe is only very slightly worked. The microporosities remain, except in the edge which also is the hardest part. Annealing was not very thorough, since the coring was not eliminated, and the hardness remained on a comparatively high level of 66–97. This level is, in fact, very high for a Cu-1% As alloy in which only very minor traces of cold-work can be detected in the microscope. It may be speculated that some kind of age-hardening has occurred, but it will require a detailed electron-microscopic study for this problem to be solved. Concluding, it appears that B 2926 was produced from a sulphide-free, lead-arsenic-enriched gossan-type ore, which yielded

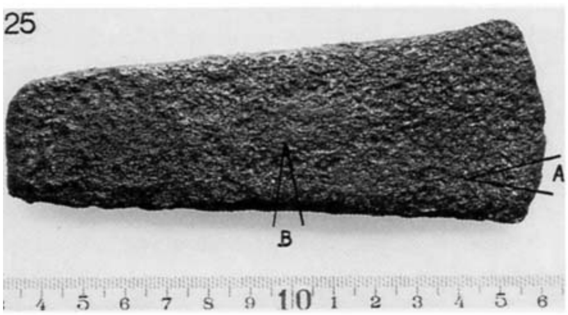
Table 2

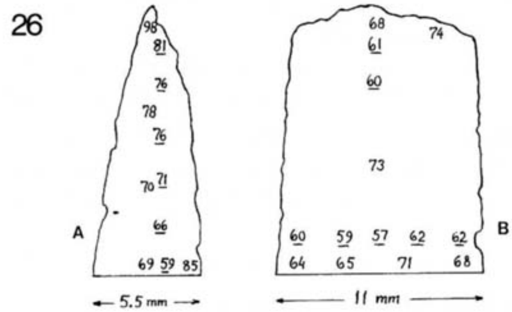
| | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Vol.% Sulph. | Vol.% Lead |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J.1968; no. 8163 | 0 | – | 0 | <0.01 | 0 | 1.05 | <0.01 | 0 | 0.07 | – | – | – |
| This work | <0.1 | <0.1 | <0.05 | <0.05 | <0.05 | 1.4 | <0.1 | <0.1 | <0.1 | (98.4) | 0 | 0 |

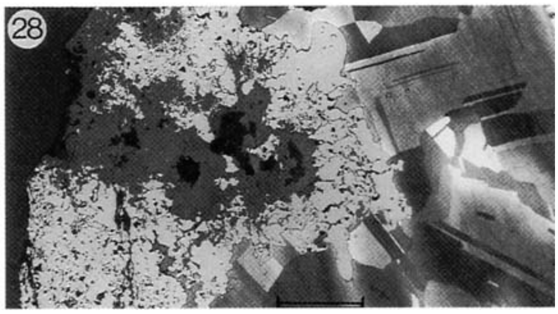








Figs. 21–28. Fig. 21. *No. 1. B 2926*. Tongue-shaped axe, 135 g. At D, a small ridge, suggesting a defect in the mould. Fig. 22. The Vickers hardness (5 kg) underlined, and the Microvickers hardness (100 g), sections A and B. Fig. 23. Slightly worked and recrystallized structure at B. Scale bar 0.3 mm. Fig. 24. Recrystallized and twinned grains at A. Elongated copper oxides with some lead-arsenates. Scale bar 20 µm. Fig. 25. *No. 2. B 5556.* Thin-butted flat axe. 311 g. Fig. 26. Vickers (5 kg) and Microvickers (100 g) of sections of A and B. Fig 27. Parallel ghost-lines on section A, suggesting forging. Scale bar 0.2 mm. Fig. 28. Two different corrosion products on the recrystallized Cu-As alloy: Red $Cu_2O$ (light grey), with a pocket of arsenic-enriched green carbonate (dark grey). Scale bar 0.1 mm.

metal of Bygmet-composition. The object was cast and never remelted, since repeated melting (under oxidizing conditions) would have removed all the complex arsenates as scum.

Considering the unsymmetrical shape, the raw finish and the very limited work applied to the object, it may be suggested that B 2926 was traded from Central Europe as a semi-manufacture suited for remelting and the production of other objects.

*No. 2. B 5556. Thin-butted flat axe. Denmark. Unknown locality. Probably 4th millennium B.C. Weight: 311 g. Figs. 25–28. Table 3.*

The axe measures 130 × (28–48) × 12 mm. The two "flat" sides are symmetrical and slightly convex. Corrosion is rather heavy, the surface being irregularly coated by an inner red $Cu_2O$-layer and an outer green patina, each about 50 µm thick. There are numerous corrosion pits, generally 1 mm across, but locally up to 3 mm in diameter. Comparison of the two corrosion products reveals that arsenic is enriched in the green patina, but absent in the red copper oxide, fig. 28.

Analytically, the flat axe is a copper-arsenic alloy. The spectrographic and EDAX-analysis agree well. The composition falls within the range defined by Liversage & Liversage (1989) as Bygmet alloy, a composition which is typical for a significant number of flat axes found in Denmark.

The polished sections show a red alloy with a number of fine inclusions, 5–15 µm across. They are complex, consisting of two different phases in varying proportions. The central, angular part is blue, but red under crossed polars; it consists of $Cu_2O$. The exterior envelope is blackish grey, and has internal reflections under crossed polars. Energy dispersive point analysis shows that these envelopes consist of lead arsenate, lead-copper arsenate, and lead antimonate. The inclusions are not caused by corrosion but date back to the smelting operations. No sulphides are present.

None of the bulk analyses revealed any lead or antimony. These two metals can however be estimated by planimetry of the inclusions to sum up to less than 0.1 wt.% in the bulk.

Sample A from the cutting edge shows equiaxial α-grains with distinct twin structure and grain size of about 60 µm. Towards the interior the grain size increases to 100 µm. There is a system of parallel "ghost" lines on the etched section, fig. 27, that suggests previous heavy cold-work, followed by annealing. Correspondingly, the hardness decreases from 81 at the edge to 59 in the interior, where the reduction by hammering was quite insignificant.

Sample B represents cast and slightly worked, then annealed metal, with hardnesses of about 60. The segregation from casting is not entirely eliminated. The α-grains are equiaxed with twins and display grain sizes of 80–250 µm.

The observations indicate that the axe was cast vertically in a bivalve form. Any ribs or casting flashes at the joins of the two valves have been removed by hammering and possibly by grinding. While the subsequent working of the massive part was small and superficial, the cutting edge was reduced significantly, probably to a hardness above 100. The final annealing was stopped at hardness levels of about 80, well before the low equilibrium values of 40–45 were reached (fig. 19). Recrystallization occurred but sufficient hardness and strength remained in the axe. It is not clear whether some age-hardening has occurred.

Although the lead and antimony content is very low, it appears that the ores were derived from the oxidized arsenic-lead-antimony enriched gossan of some sulphidic ore crop. Since the slags are still present in the final axe, it appears that this particular metal was melted no more than once, and thus probably cast in its area of production in Central Europe. The origin of No. 2 would thus be very similar to that of the tongue-shaped object, No. 1.

| Table 3 | | | | | | | | | | | Vol.% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Sulph. | Lead |
| J.1968; no. 8348 | 0 | – | 0 | <0.01 | 0 | 0.33 | tr. | 0 | 0 | – | – | – |
| This work | <0.1 | <0.1 | <0.1 | <0.05 | <0.05 | 0.47 | <0.1 | <0.1 | <0.1 | (99.3) | 0 | 0 |

*No. 3. B 1094. Low-flanged axe. Pederstrup, Ballerup Sogn, Smørum Herred, Copenhagen Amt. Early 2nd millennium B.C. Weight: 190 g. Figs. 29–32. Table 4.*

The axe measures 110 × (22–50) × 8 mm and was probably cast edge down, in a bivalve mould. Superficial hammering has sharpened the edge, removed casting flashes and enlarged the flanges by plastic deformation. The flanges are now up to 12 mm wide. The cutting edge is oblique, suggesting that the axe at some time has been sharpened. In antiquity the axe was severely bent so that two deep cracks developed, 7 mm deep from one side, and 15 mm deep from the opposite side (Aner & Kersten 1973, 99). Corrosion penetrates the cracks and has raised a number of blisters on the otherwise flat surfaces.

Analytically the axe is a sulphide-containing copper-silver-arsenic-antimony alloy, which corresponds with the Ösenring compositions proposed by Liversage & Liversage 1989 (p. 64). It belongs to the half of the Danish finds of this composition having less than 1% tin.

Ösenring composition: As ≥ 0.4%
Sb ≥ 0.6%
Ni ≤ 0.2%
Sn ranges from 0 to 8%

The polished sections show a red to yellow alloy; evidently, even the small silver, arsenic, and antimony content is sufficient to turn the red copper to yellowish shades. For the first time we have an alloy with sulphides, about 0.4 vol.%, suggesting that the ores from which the Ösenring metal was produced was partly sulphidic, partly oxidic. The sulphides, $Cu_2S$, occur as minute (2–10 μm) blue blebs, distributed at random, deformed, however, by the cold-work applied to the cutting-edge and flanges.

The etched sections show a cast structure in which coring is not fully eliminated, fig. 31, and in which a number of 0.1–0.3 mm micropores occur. The bulk of the sample shows equiaxed, recrystallized grains, 100–300 μm across, with a few twins and a hardness of 55 ± 3, fig. 32. The flanges and the edge have been severely cold-worked, so that minute cracks have developed. The recrystallized grains are slightly elongated from some final cold-work, and the hardness ranges up to 90 in the very edge. The exterior 4 mm of the flanges have been affected by the hammering, judging from the combined hardnesses and appearance of the grains.

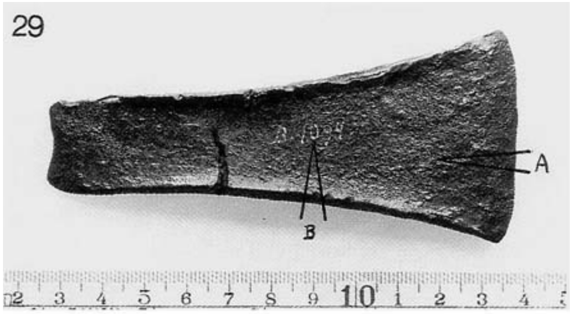
The axe has been cast as a flat object like No. 2, or with slight flanges. After casting, severe hammering, possibly both hot and cold, has raised the flanges, or at least the major part of them, and the edge has been sharpened. Under this action the material was exposed to the limits of its workability, as witnessed by the microcracks. After having been used, the axe suffered a violent bending which opened two large cracks, located almost at the transition from the exposed part of the axe to its mounting. It is difficult to explain these cracks, because the material is too strong and tough to break in this way under normal conditions, even given the number of large microporosities observed. The axe may indeed have been deposited after having been forcibly made useless.

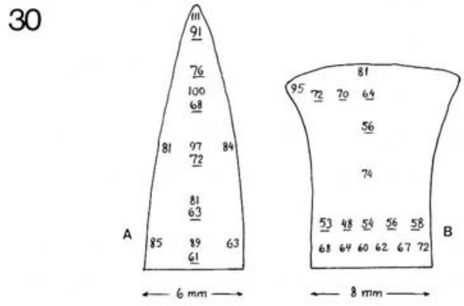
*No. 4. 11073. Low-flanged axe. Bygholm, Hatting Sogn, Hatting Herred, Vejle Amt. Early 2nd millennium B.C. Weight: 480 g. Figs. 33–36. Table 5.*

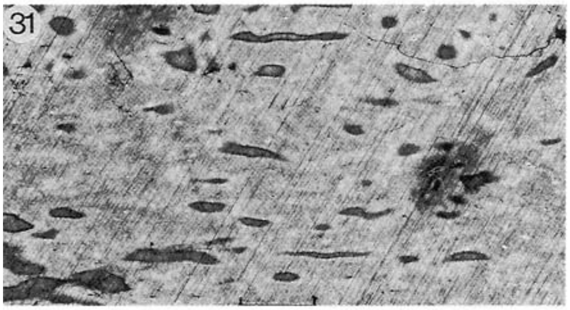
The dimensions of the axe are 155 × (22–70) × 13 mm. It is rather rough and uneven and has the poorest finish of the twelve objects examined. In the cutting-edge is a deep incision, probably damage from heavy blows. The flanges have been somewhat shaped by hammering to maximum widths of 15–16 mm. Corrosion is uneven, generally composed of a thin, inner green patina (≈ 30 μm) and a thick, outer reddish oxide (0.2–0.6 mm). Local irregularities, especially near the butt, may result from poor casting technique.

Table 4

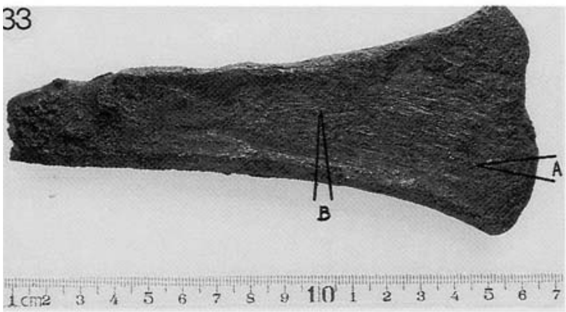
| | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Vol.% Sulph. | Vol.% Lead |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J.1968; no. 8271 | 0.01 | – | 0 | 0.08 | 0 | 0.6 | 0.4 | 0.69 | 0 | – | – | – |
| This work | <0.1 | 0.11 | <0.05 | 0.08 | <0.05 | 0.50 | 0.9 | 0.4 | <0.1 | (97.8) | 0.4 | 0 |

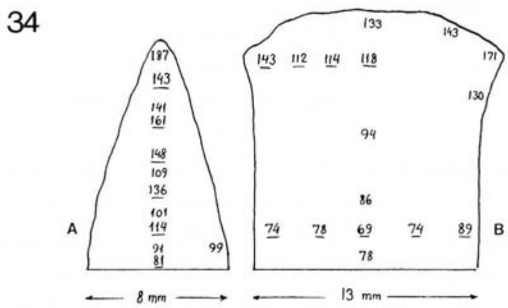


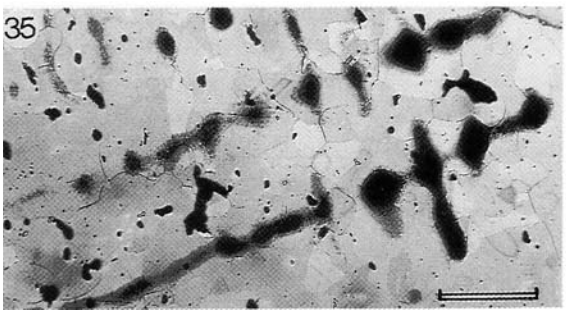



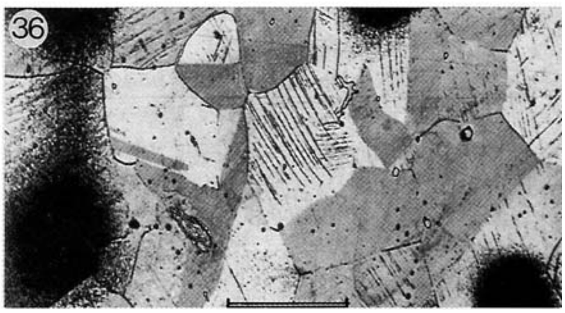








Figs. 29–36. Fig. 29. *No. 3. B 1094*. Low-flanged axe, 190 g. Fig 30. Vickers (5 kg) and Microvickers (100 g) hardness of sections A and B. Fig. 31. Segregated and worked structure at A with microcrack (above right). Scale bar 0.5 mm. Fig 32. Cored and recrystallized grains in the interior of B. Scale bar 0.1 mm. Fig. 33. *No. 4. 11073*. Low-flanged axe. 480 g. Fig. 34. Vickers (5 kg) and Microvickers (100 g) hardness of sections A and B. Fig 35. Cored and recrystallized grains in the interior of B. Scale bar 0.5 mm. Fig. 36. Recrystallized and cold-worked material in flanges of B. Scale bar 0.2 mm.

| Table 5 | | | | | | | | | | | Vol.% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Sulph. | Lead |
| J.1968; no. 8260 | 1.95 | – | tr. | 0.71 | 0 | 0.71 | 0.53 | 0.99 | 0 | – | – | – |
| This work | 2.1 | 0.15 | <0.05 | 0.74 | <0.05 | 0.36 | 0.74 | 0.82 | <0.1 | (95.0) | 0.5 | 0 |

The axe represents the first tin bronze metal appearing in Denmark about 2000 B.C., in the late Neolithic. The alloy is sulphide-rich and rather complex. It belongs in the Singen group as defined by Liversage & Liversage (1989:59):

Singen metal: As $\geq$ 0.1%
Sb $\geq$ 0.5%
Ag $\geq$ 0.3%
Ni $\geq$ 0.4%

The tin content in objects of this group varies between 0.01 and 10%, but 78% of the examined samples had like the present object less than 2% Sn. (Liversage 1989: graph 9).

Polished sections are yellow with a reddish tint. There are numerous tiny, blue copper sulphide inclusions, about 0.5 vol.%. They are softly rounded or palmate-lobed, and in the worked cutting-edge they are plastically deformed and rotated into the directions of forging. They are generally 5–10 μm across, but reach sizes of 25 μm. There are only a few microporosities from the casting, and they are rather small, $\approx$ 25 μm across.

The etched sections display a coarse, cast structure in which coring has not been entirely eliminated, fig. 35. The dendrite arm spacing is about 250 μm, suggesting rather slow cooling. Also the coarse sulphides point in this direction. The comparatively slow cooling is due to the rather large mass of the axe. It now weighs 480 g, but may easily have weighed 50% more before gates and risers were trimmed away.

The bulk of the material consists of large, equiaxed grains, 100–300 μm across, with a hardness of 75 $\pm$ 6. The cutting-edge has been cold-worked to a distance of about 5 mm and now displays equiaxed grains, 30–100 μm across, with a maximum hardness of 161. The flanges have acquired their basic shape by casting, improved locally however by mild hammering. Here the grains are elongated and rich in slip-lines from cold work, showing a maximum hardness of 143, fig. 36.

The axe should be of about the same age as the previous axe, No. 3. It has been cast in almost its final shape and only limited working of the edge and the flanges has occurred. It is a tin alloy and has not been very thoroughly annealed after working, and therefore is significantly harder than No. 3.

Before deposition the blade was destroyed by a heavy blow. Perhaps we here have another example, like No. 3, of deliberate destruction ?

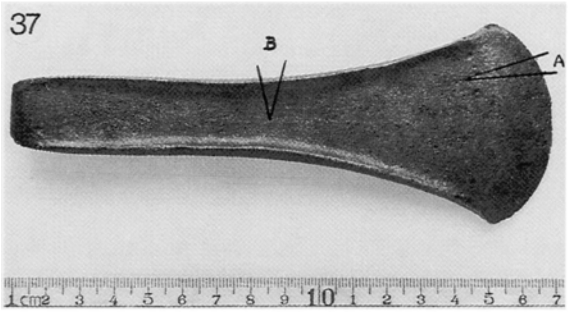
*No. 5. 26073. Flanged axe. Vicinity of Silkeborg, Gjern Herred, Skanderborg Amt. About 1750–1500 B.C. Weight: 250 g. Figs. 37–40. Table 6.*

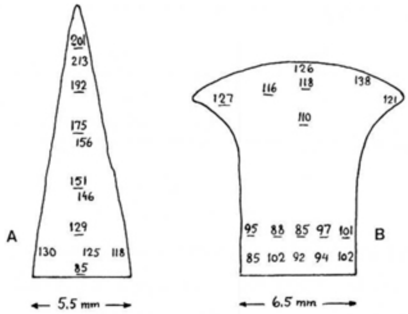
The axe measures 159 × (21–58) × 9 mm. It is of elegant shape and well-preserved, with less than 20 μm thick copper oxides on the surface. The flanges have been worked after the casting so that they attain maximum widths of 13 mm. The cutting-edge has been worked on at least the exterior 11–12 mm, and the neck has been hammered over after removal of the casting gate. Minor bruises mar the cutting-edge.

Analytically, the axe is a sulphide-rich tin bronze of the Faardmet group (Liversage & Liversage 1989,67):

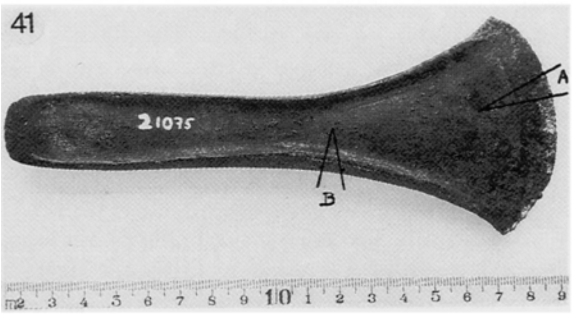
Faardmet As 0.25–1.8%
Sb 0.02–0.7%
Ag 0.01–0.16%
Ni 0.25–1.2%
4.3 < Sn < 13.3%

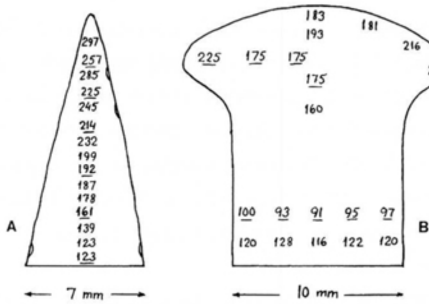
The axe belongs to the earliest part of the full Bronze Age in Denmark, and metallurgically represents the important change to full tin bronze alloys, whereby other elements decreased in importance. Unlike earlier, the tin is now systematically added. We agree with Liversage and Liversage (1989), who conclude from examination of the Danish artifacts with the Faardmet impurity pattern that "the consistency of the distribution suggests that the people who made the bronze knew exactly what tin content they wanted, even if they did not always hit it right". It is the general opinion that objects in this group are not

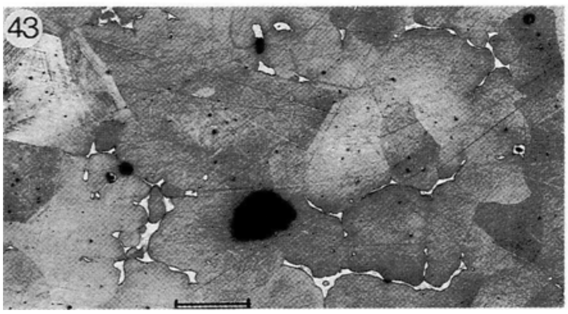


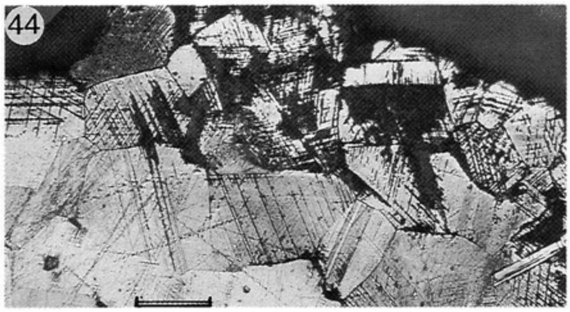






Figs. 37–44. Fig 37. *No. 5. 26073.* Flanged axe of elegant shape, 250 g. Fig. 38. Vickers (5 kg) and Microvickers (100 g) hardness of A and B. Fig. 39. Typical intercrystalline corrosion attack in medium-work-hardened tin bronze section B. Scale bar 0.1 mm. Fig. 40. Recrystallized and cold-worked grains with slip lines. Clusters of elongated sulphides. Scale bar 50 µm. Fig. 41. *No. 6. 21075.* Flanged axe, similar to No. 5, but larger. 354 g. Fig. 42. Vickers (5 kg) and Microvickers (100 g) hardness of A and B. Fig. 43. Interior of B, with significant remnants of δ-phase (white), probably stabilized by nickel. Scale bar 0.1 mm. Fig 44. Extremely cold-worked and hard edge, A, with slip line corrosion. Scale bar 0.1 mm.

| Table 6 | | | | | | | | | | Vol.% | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Sulph. | Lead |
| J.1968; no. 8434 | 6.4 | – | tr. | 0.3 | 0 | 1.1 | 0.08 | 0.22 | tr. | – | – | – |
| This work | 8.8 | 0.35 | 0.08 | 0.37 | <0.05 | >0.2 | 0.09 | 0.22 | <0.1 | (89.5) | 1.6 | 0 |

imports, but were cast in Denmark (Brøndsted 1939, vol. 2, Vandkilde 1989).

The polished sections show a yellow alloy with numerous fine, blue inclusions, amounting to 1.6 vol.%. These were identified as the copper sulphide, $Cu_2S$, often with minor amounts of iron (0.5–0.8 wt.%). The sulphides are free of As, Sb, Sn, and Ni. They are typically 3–30 μm in size, and often form palmate and lobed figures. In the worked parts of the axe they have been plastically deformed and turned into parallel streaks. The massive part of the casting is rich in micropores. These have been closed by working both along the cutting-edge and to a depth of about 3 mm under the flanges.

The etched sections show that the original coring has been almost eliminated by annealing. In places a little δ-phase, 3–15 μm across, remains as rounded blebs. Evidently the original casting was quite rich in δ-phase, which gives support to the 8.8% value for tin. Repeated hammering and annealing have left the axe with a variety of structures. The cutting-edge itself displays fine, 15–30 μm, recrystallized grains, which are elongated and striated by cold-work to a hardness of 201. Inwards the recrystallized grains grow to 50–75 μm and the hardness drops to 85.

Also the flanges have been severely hammered and shaped. The parts near the surface display elongated sulphides and small, work-hardened, recrystallized grains and have a hardness up to 127. Below a depth of 3 mm, the porosities from casting reappear, the recrystallized grains are 30–75 μm across, and the hardness about 85.

The axe has been produced from sulphide-rich ores. The final melting probably took place under reducing conditions in a crucible covered by charcoal and the axe was cast edge down in a bivalve form. The axe is unusually rich in $Cu_2S$ inclusions, which are sufficiently plastic to follow the displacement of the metallic matrix without breaking, during either hot or cold working. Repeated hammering and annealing have given the axe a cutting-edge with a maximum hardness of 200. 11 mm below the edge the hardness is that of the bulk material, 85. Similarly, the outer 3 mm of the flanges have been shaped by working after removal from the mould.

*No. 6. 21075. Flanged axe. Kragebæk, Merløse Herred, Holbæk Amt. About 1750 B.C. or a little earlier. Weight: 354 g. (According to Aner & Kersten 1976, 109 Hørby Sogn, Tuse Herred). Figs. 41–44. Table 7.*

The axe resembles the previous one, but it is heavier and larger, measuring 173 × (22–69) × 11 mm. The flanges have been worked and are up to 14–16 mm wide and somewhat unsymmetrical owing to differences in hot-working. The cutting edge is visibly sharpened on the last 12 mm by a combination of cold-working and grinding. The corrosion is not severe; however, locally pits 0.1–0.3 mm wide and deep, filled with green patina, are seen. The red copper oxide is almost absent. The slipbands from cold-working of the metal are still discernible as "fossil traces" in the green patina when examined in a polished section under the microscope.

Analytically, the axe is a sulphide-rich tin bronze belonging to the Singen group. Only silver is a little low. Except for the arsenic data, where we prefer the old determination, the analyses agree well.

The polished sections through the massive bulk show a yellow alloy with 0.1–0.3 mm wide micropores from casting. In the cutting-edge and flange parts all micropores have been closed by hammering. There are numerous sulphides, $Cu_2S$, but they are smaller than in No. 5 (2–20 μm) and fewer, adding up to about 0.6 vol.%. In the worked parts they have been rotated and become plastically elongated in the forging direction.

Etched sections display a cast structure in which coring has been almost eliminated by annealing. However, numerous δ-bodies appear everywhere, adding up to about 2 vol.%. In the interior which has only been little affected by the working, the recrystallized grains are equiaxial and 100–300 μm across, and the hardness is about 90, corresponding to an annealed tin-rich bronze (fig. 43). The cutting-edge and the flanges have been repeatedly worked and annealed. The last operation was a very heavy cold-working, leading to the extreme edge hardness of 257. The flanges have attained the somewhat lesser hardness of 225. The small recrystallized grains have here become flattened and display numerous slipbands, but no micro-

| Table 7 | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Vol.% Sulph. | Lead |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J.1968; no. 8235 | 8 | – | tr. | 0.7 | 0 | 1.2 | 0.31 | 0.5 | 0 | – | – | – |
| This work | 8.8 | 0.15 | <0.05 | 0.74 | <0.05 | >0.4 | 0.22 | 0.49 | <0.1 | (88.5) | 0.6 | 0 |

cracks have opened. Grains near the surface are corroded along the slipbands in a very characteristic way, the blue grid consisting of copper oxides, $Cu_2O$, fig. 44.

A qualitative test was run with the SEM-EDAX equipment on the three different corrosion products which could be identified on the surface. The major one is a 50 μm thick, grey, outer crust, which is slightly rusty-red under crossed polars. It turned out to consist of major tin, iron and copper, and minor silicon, arsenic, and phosphorus. Oxygen, carbonate, and hydroxyl ions are no doubt present at a significant level.

The minor one, a discontinuous greenish layer, green under crossed polars, and up to 40 μm thick, contained major tin, copper, and silicon, and minor arsenic and chlorine. It appears to be a silicate, related to chrysokol.

Finally there occur 10–50 μm blebs of a whitish-grey oxide phase, disseminated through the grey and green phases. It is complex, displaying tin, copper, arsenic, silicon, iron, nickel, and chlorine. It may be unequilibrated gels, and is perhaps not a stoichiometric mineral.

Common to all corrosion products is the depletement of copper. While the weight ratio Cu:Sn is about 10 in the metallic matrix, it varies between 0.3 and 1.0 in the corrosion products. Evidently copper has been selectively leached and has disappeared into the adjacent soil. On the other hand, substantial amounts of iron, phosphorus, chlorine, and silicon have been introduced from the surroundings. All the corrosion products were sulphide-free.

The axe has been cast, edge down, and while the flanges may already have been moulded in the raw product, they have attained their final shape by hammering. Intensive hammering and annealing has certainly been necessary in shaping an alloy of this type. The final coldwork brought the edge to the maximum hardness for this alloy and the flanges to a somewhat lower hardness. The edge acquired its final faceting by grinding. The axe is a fine example of the skill of the early Bronze Age craftsman, being of a very elegant shape and simultaneously displaying superior technological properties.

*No. 7. B 4077. Low-flanged axe. Moskjær, Virring Sogn, Sønderhald Herred, Randers Amt. About 1750–1500 B.C. Weight: 132 g. Figs. 45–50. Table 8.*

The axe measures 110 × (18–46) × 10 mm, with up to 12 mm wide flanges. While the shape is quite common for flanged axes of the early Bronze Age, the corrosion is unusual. The heavy layer consists of an inner, 1 mm thick, black layer and an outer, up to 2 mm thick, blistery, black layer. The border between the two layers is smooth, fig. 46.

The following information can be extracted from the data of acquisition: "The axe was discovered by Knud Petersen, Moskjær, in 1888. It was found together with two flint sickles and some other flint material. The depth was 6 feet, and there were thick layers of peat underneath. About 100 feet distant the turf terminated against a sloping field under culture". Although not stated directly it must be concluded that the axe was found during turf-cutting and that the overlying soil also was of a peaty nature.

The axe has the most tin of those we have examined. The impurities of arsenic, silver, antimony, and nickel place it in the Faardmet group of the early Bronze Age. It is rich in copper sulphide, ≈ 2 vol.%, and also is the first to contain appreciable quantities of lead.

Polished sections show a yellow alloy with very many and distinct pin holes 0.1–0.3 mm across, resulting from solidification shrinkage. The holes have been closed by forging on the cutting-edge and under the flanges to a depth of 3 mm. The sulphides are 3–10 μm across and consist of $Cu_2S$. They are rotated and significantly deformed in the forged areas. The δ-phase occupies about 2 vol.%. Lead appears as fluffy, dark blebs, usually 1–5 μm across, which are associated with the copper sulphide or included as discrete blebs in the δ-phase.

Etched sections through the bulk show that coring is well preserved. This part is apparently not recrystallized, but only somewhat homogenized, because deformation

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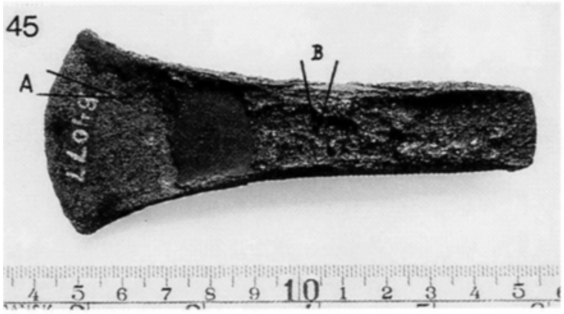


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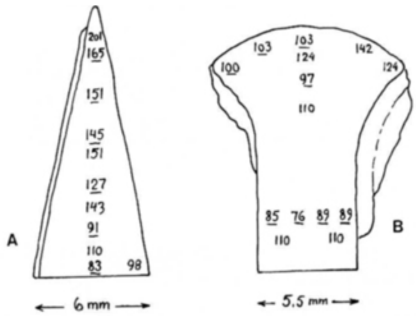


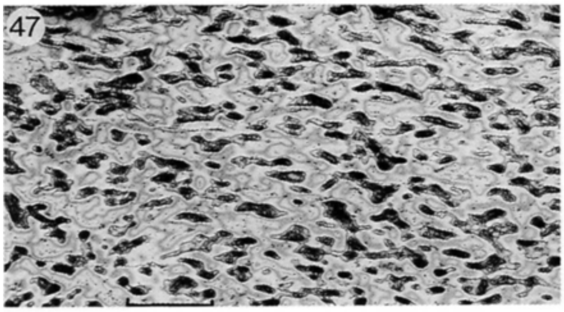

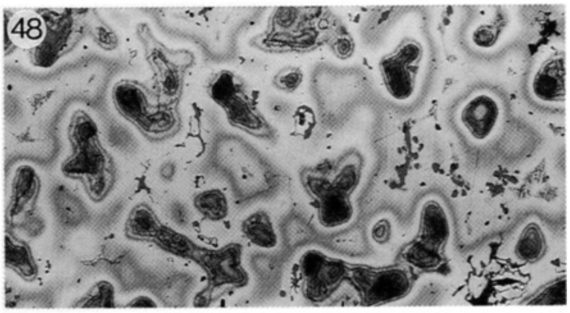

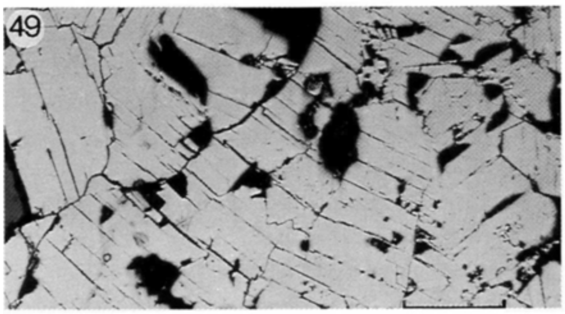

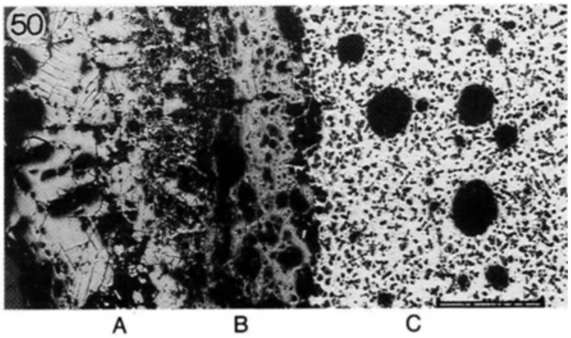


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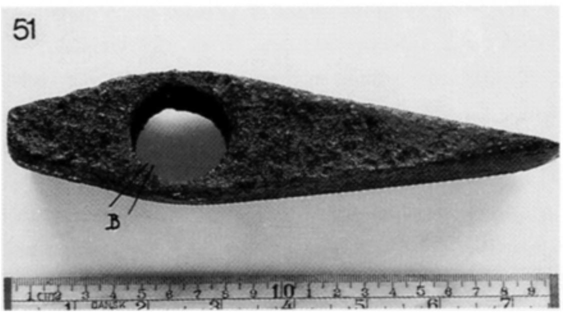


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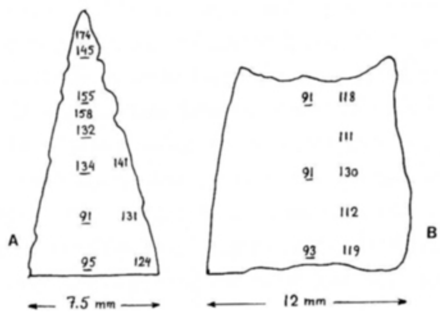



Figs. 45–52. Fig. 45. *No. 7. B 4077.* Low-flanged axe with thick layers of sulphides due to corrosion, 132 g. Fig. 46. Vickers (5 kg) and Microvickers (100 g) hardness of A and B. Fig. 47. Well-preserved coring, but somewhat deformed near the surface by working. Scale bar 0.3 mm. Fig. 48. The δ-phase and the sulphides are concentrated in the areas that solidified last. Interior of B. Scale bar 0.1 mm. Fig. 49. The exterior corrosion layer consists of $Cu_2S$ with impurities of arsenic. Scale bar 0.2 mm. Fig. 50. A: $Cu_2S$ corrosion layer. B: Complex corrosion layer. C: Dendritic bulk with major voids from the original casting process. Scale bar 1 mm. Fig. 51. *No. 8. B 5564.* Shaft-hole axe. 1470 g. Fig 52. Vickers (5 kg) and Microvickers (100 g) hardness of A and B.

| Table 8 | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Vol.% Sulph. | Vol.% Lead |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J.1968; no. 8191 | 10 | – | tr. | 0.32 | 0 | 1.15 | 0.05 | 0.17 | 0.68 | – | – | – |
| This work | 9.4 | 0.4 | <0.05 | 0.37 | <0.05 | >0.4 | <0.1 | 0.18 | 0.9 | (88) | 2.0 | 0.8 |

has been very minor, fig. 48. The hardness is correspondingly low and irregular, 84 ± 5.

The edge is worked to a distance of at least 20 mm. The recrystallized grains become finer and finer (10–20 μm across) the closer we come to the edge itself, where the maximum hardness is 165. Also the flanges are deformed, showing grains of about 50 μm and a maximum hardness of 103.

The exterior corrosion layer was probed by the EDAX-instrument and shown to be homogeneous copper sulphide, $Cu_2S$, with an impurity level below our detection limits except for 1–2 % As. The layer is well-developed, polycrystalline and anisotropic with a grain size of 0.2–0.5 mm and with distinct parting along crystallographic planes, fig. 49. It appears to be the low-temperature orthorhombic copper sulphide, $Cu_2S$, which is distinct from the high-temperature cubic digenite, $Cu_9S_5$ , which is so common in the matrix of most ancient copper objects and is derived from the smelting process.

The inner corrosion layer is a heterogeneous, porous material with major amounts of copper, tin, and sulphur, and minor amounts of arsenic, fig. 50. In this layer distinct δ-blebs, as yet undissolved, may be seen. The two corrosion products are different from those discussed on axe No. 6.

Summing up we meet here an axe which is not thoroughly mechanically worked and recrystallized. Only the cutting-edge and the flanges have been worked, as testified by oriented sulphides, closed micropores and fine recrystallization. The 9–10 % tin alloy has in itself sufficient strength and hardness and is also much less ductile than arsenic- and low-tin-copper alloys. The craftsman may have acquiesced with some local overworking and otherwise been satisfied with the properties as cast.

The axe was deposited in a lake or a peat bog and must have experienced about 3500 years under anaerobic conditions. Instead of the usual oxides, hydroxides, and carbonates, we here find an exterior solid $Cu_2S$ layer and an interior complex Cu-Sn-As-sulphide.

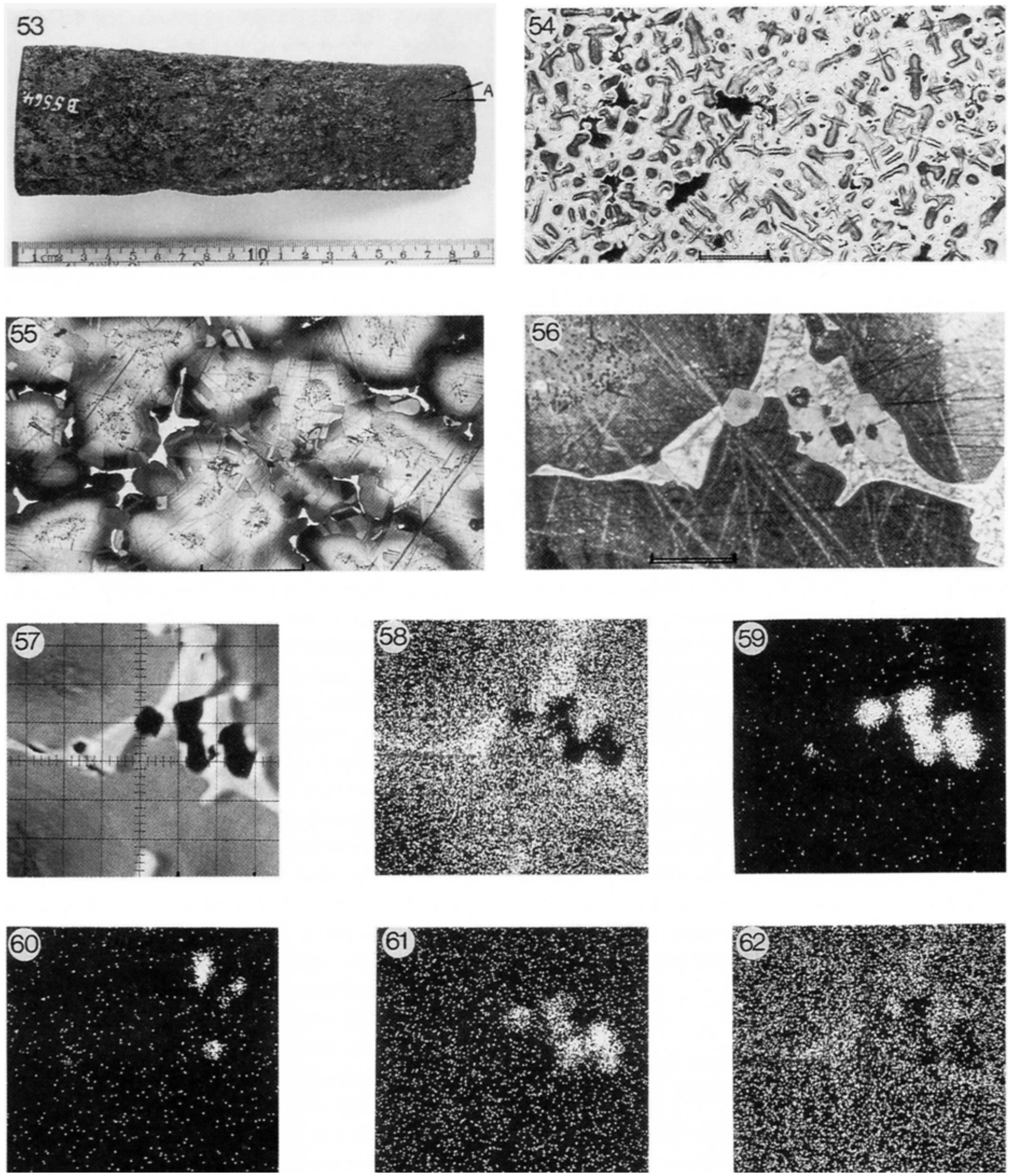
*No. 8. B 5564. Shaft-hole axe. Kragenæs, Birket Sogn, Lollands Herred, Maribo Amt. About 1750–1500 B.C. Weight: 1470 g. Figs. 51–62. Table 9.*

This is the only shaft-hole axe in our selection. It is big, but rather primitive and without decoration. It measures 185 × (51–55) × 38 mm and has a slightly elliptical hole measuring about 33 × 30 mm, fig. 51. When viewed edge-on the axe appears rhomboidal (instead of rectangular) in cross section, and also the shaft-hole is imprecise. While one side is pretty flat, the opposite is rough and undulating (Aner & Kersten 1977,76). There are no indications of hammering.

Analytically the axe is a full tin bronze with significant contents of As, Sb, Ag, and Ni, placing it in the Faardmet group (Liversage & Liversage 1989,67). It is further important to note the content of sulphur, present as copper sulphides, and of iron and lead.

Polished sections show a yellow alloy with many pinholes and microporosities from the casting. They are 0.05–0.2 mm across and interdendritic with concave outlines, fig. 54. Neither under the flange nor along the edge have they been closed by working. The sulphides are rather large, up to 30 μm across, and of the usual rounded, lobate-palmate forms. The microprobe shows that they are $Cu_2S$, sometimes with significant amounts of iron in solid solution, typically 0.3–0.5 wt.%.

| Table 9 | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Vol.% Sulph. | Vol.% Lead |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J.1968; no. 8378 | 7.6 | – | tr. | 0.35 | 0 | 1 | 0.06 | 0.29 | 1.15 | – | – | – |
| This work | 8.4 | 0.23 | 0.12 | 0.46 | <0.05 | >0.4 | 0.16 | 0.28 | 1.2 | (88.2) | 1.0 | 1.0 |



Figs. 53–62. Fig. 53. *No. 8. B 5564*. Shaft-hole axe, from the side. Fig. 54. Segregated, unequilibrated structure with short dendrites and interdendritic microporosities. Scale bar 0.3 mm. Fig. 55. Recrystallized α-phase and interdendritic δ-phase (white). Scale bar 0.2 mm. Fig. 56–62. Microprobe examination. Scale bar 20 μm. Fig. 56. δ-phase with inclusions. Fig 57. Back-scattered-electron (BSE) picture, showing the area under investigation. Fig. 58. Sn $L_\alpha$ radiation: Tin is concentrated in the δ-phase. Fig. 59. S $K_\alpha$ radiation: Sulphur is entirely located in the sulphides. Fig. 60. Pb $L_\alpha$ radiation: Small lead globules are associated with sulphides and δ-phase. Fig. 61. Fe $K_\alpha$ radiation: Iron is concentrated in the sulphide. Fig. 62. Ni $K_\alpha$ radiation: Nickel is concentrated in the δ-phase.

Etched sections display coring, showing a cast and unequilibrated structure. The δ-phase, the sulphides and the microporosities form interlacing networks which have not been modified by working, fig. 55. There is little recrystallization, but mainly the typical segregational structures, grading through various yellowish, brownish, and red colours. The lead occurs as discrete, fluffy blebs, 3–10 µm across and usually associated with the last melt to solidify, i.e. the present δ-phase and sulphides, fig. 60. The nickel is partitioned between the δ- and the α-phase, the ratio of nickel in the two phases being 3–4, fig 62. The hardness is 93 ± 5, somewhat irregular due to the coring. In general the etched sections appear "dirty", being rich in black filaments, that may derive from an improper casting process.

Only in the exterior 1 or 2 mm of the cutting edge can a little coldworking be identified. The material has recrystallized to 20–60 µm twinned grains, but the δ-phase and the sulphides are largely unaffected. The hardness increases to a maximum of about 150 at the very edge.

The patina is of a dark chocolate colour with green nuances. There are numerous corrosion pits, 1–5 mm across. In the complex, botryoidal corrosion crust, there are undissolved δ-phase and locally small blebs of copper, 2 µm or 25 × 2 µm, evidently re-cemented copper from seasonal variations in the corrosion process, the so-called destannification.

The axe with its oblique, lop-sided shape would probably have made poor service for an axe for heavy work. Considering the poor finish and the general absence of working one comes to speculate whether the object could be an unfinished axe of the Faardrup shaft hole type. The finish would have required plane grinding of the faces and subsequent engraving of the geometric patterns.

*No. 9. B 3971. High-flanged axe. Unknown location, Denmark. About 1500 B.C. Weight: 214 g. Figs. 63–68. Table 10.*

The axe has the dimensions 120 × (20–48) × 10 mm. The flanges are wide and somewhat irregular in width and thickness, figs. 63–65, due to substantial deformation by working. They reach widths of 17–18 mm. The butt appears unfinished and terminates in a rough break. In the middle of the axe a moderate stop-ridge appears, clearly a feature modelled in the mould. The edge has been sharpened for the outermost 13 mm, apparently by a combination of cold-working and grinding.

Analytically the axe belongs in the Faardmet group (Liversage & Liversage 1989), being a full tin bronze with substantial impurities of sulphur, nickel, arsenic, antimony, and lead.

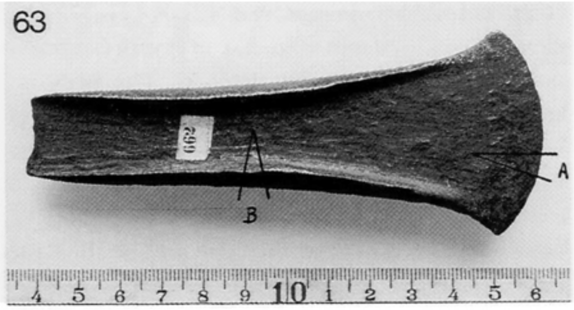
Polished sections display a yellow alloy with numerous small (3–15 µm across), blue sulphides, containing a little iron (about 0.1%). The sulphides cover about 1.0% by area. They are deformed to narrow, long veinlets in the cutting-edge and in the exterior 5 mm of the flanges, indicating very heavy deformation. This does not necessarily indicate hot work, since we have shown with our experimental sulphidic alloys, that the sulphides are sufficiently ductile to follow the metal also under heavy cold-working. The axe is pretty solid, displaying only a few micropores up to 100 µm across. No micropores remain in the heavily worked edge and flanges.

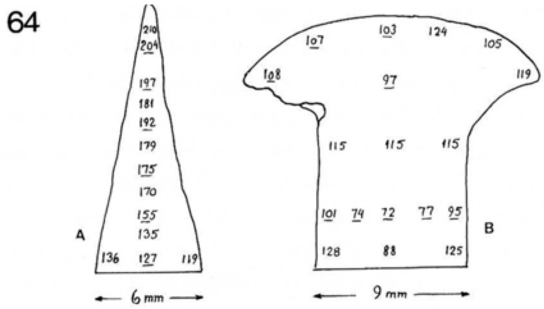
Etched sections show a rather homogeneous, recrystallized tin bronze. Almost all δ-phase and coring have disappeared, apparently due to repeated working and annealing. The recrystallized, twinned grains of the interior are 50–100 µm in diameter, and the hardness is 75 ± 3. In the edge and under the flanges the grain size gradually decreases to 10–20 µm, and the hardness increases to 200 ± 5. In these ultra-hard parts the recrystallized grains have visible traces of severe cold-work, such as numerous crossing slipband systems and elongation of grains near the surface, fig. 66.

The general corrosion development is the normal one for the Danish environment. An interior greenish patina covers the axe irregularly as up to 100 µm thick layers, filling micropits, 50–100 µm across with botryoidal, green patina. On top of this is a somewhat thicker gray layer, which is rusty-red in crossed polars, and very irregular.

On this axe destannification is particularly well-devel-

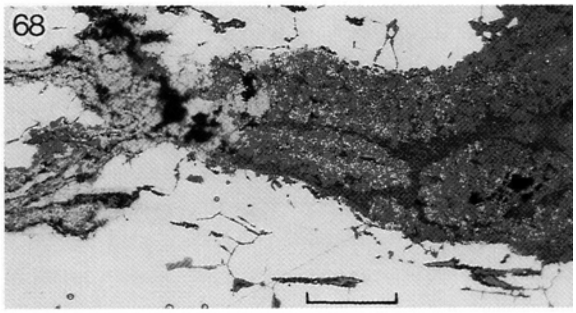
| Table 10 | | | | | | | | | | | Vol.% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Sulph. | Lead |
| J.1968; no. 8516 | 7.4 | – | tr. | 0.47 | – | 0.87 | 0.06 | 0.23 | 0.59 | – | – | – |
| This work | 8.0 | 0.25 | 0.05 | 0.49 | <0.05 | >0.3 | <0.1 | 0.28 | 0.5 | (89.5) | 1.0 | 0.4 |

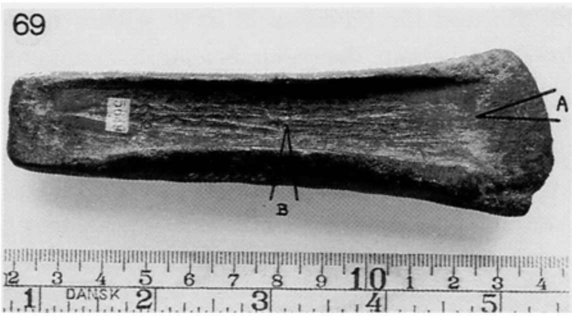


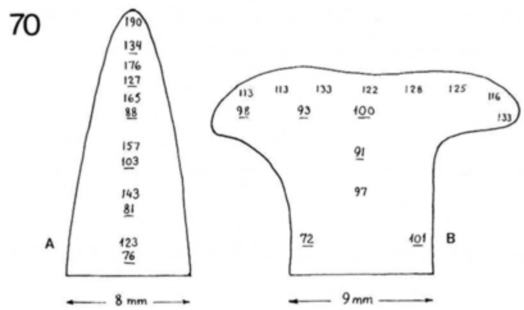










Figs. 63–70. Fig. 63. *No. 9. B3971*. High-flanged axe. 214 g. Fig. 64. Vickers (5 kg) and Microvickers (100 g) hardness af A and B. Fig. 65. The axe seen from above, the edge to the right. Fig. 66. Severely deformed edge with elongated coring due to hammering. Scale bar 0.3 mm. Fig. 67. Almost homogenized material with recrystallized α-grains and sulphides, from the interior. Scale bar 50 µm. Fig. 68. Corrosion pit. The fine, 1–2 µm, white spots in the corrosion products are copper particles from destannification. Scale bar 50 µm. Fig. 69. *No. 10. 26106*. High-flanged axe. 225 g. Fig. 70. Vickers (5 kg) and Microvickers (100 g) hardness of A and B.

oped. At the transition between flange and bulk is a 1 mm deep groove, figs. 64, 68. In this re-entrant part of the axe some "sand" from the casting mould has remained embedded in the surface material and on long exposure in the soil given easy access for moisture. The result is that tin has been selectively removed to form tin-enriched corrosion products while copper has been redeposited as a spongy mass, displaying grains 1–2 μm across. The "sand" particles are still firmly embedded in the corrosion products, on top of which the usual green and grey oxides/hydroxides are found.

SEM-EDAX on the corrosion products confirmed the destannification interpretation. The copper particles are re-precipitated tin-free copper, apparently with a little iron (0.5–1 wt.%), while the enveloping oxides are extremely variable. Some parts are tin-enriched to Cu-Sn ratios of 3 instead of 11 as in the alloy, some are copper-enriched to Cu-Sn ratios above 100, and all contain iron in varying quantities. In addition chlorine, calcium, and phosphorus are common minor impurities in the corrosion products. The surprisingly high iron content, often exceeding the copper content, must derive from the surrounding soil, as do the chlorine, calcium, and phosphorus.

B 3971 is an axe which has been subjected to heavy work, probably a combination of hot- and cold-work, so that the flanges could be raised as much as we now see. The severe deformation and the repeated annealing have removed all coring, dissolved all δ-phase, and closed a majority of the micropores. The grain size is fine, finest in the cold-worked cutting-edge, which reaches a hardness above 200. The axe provides a very fine example of the phenomenon of destannification, which otherwise has received little attention (Tylecote 1979).

*No. 10. 26106. High-flanged axe. Badstrup, Uggeløse Sogn, Lynge Herred, Frederiksborg Amt. About 1500 B.C. Weight: 225 g. Figs. 69–74. Table 11.*

This is a rather rough and clumsy looking tool (Aner & Kersten 1973,57). It measures 121 × (21–37) 11 mm. Its flanges are 17–20 mm wide due to severe hammering, and the cutting-edge is badly notched. The body is for unknown reasons heavily striated/grooved parallel to the long axis of the tool. Perhaps it is impressions of the mould, perhaps it is from severe scraping in order to remove moulding sand? The 2–3 cm nearest the edge have been hammered both *on* the edge and on the flanges near the edge. This has produced shallow, triangular depressions on the narrow sides near the corners of the blade.

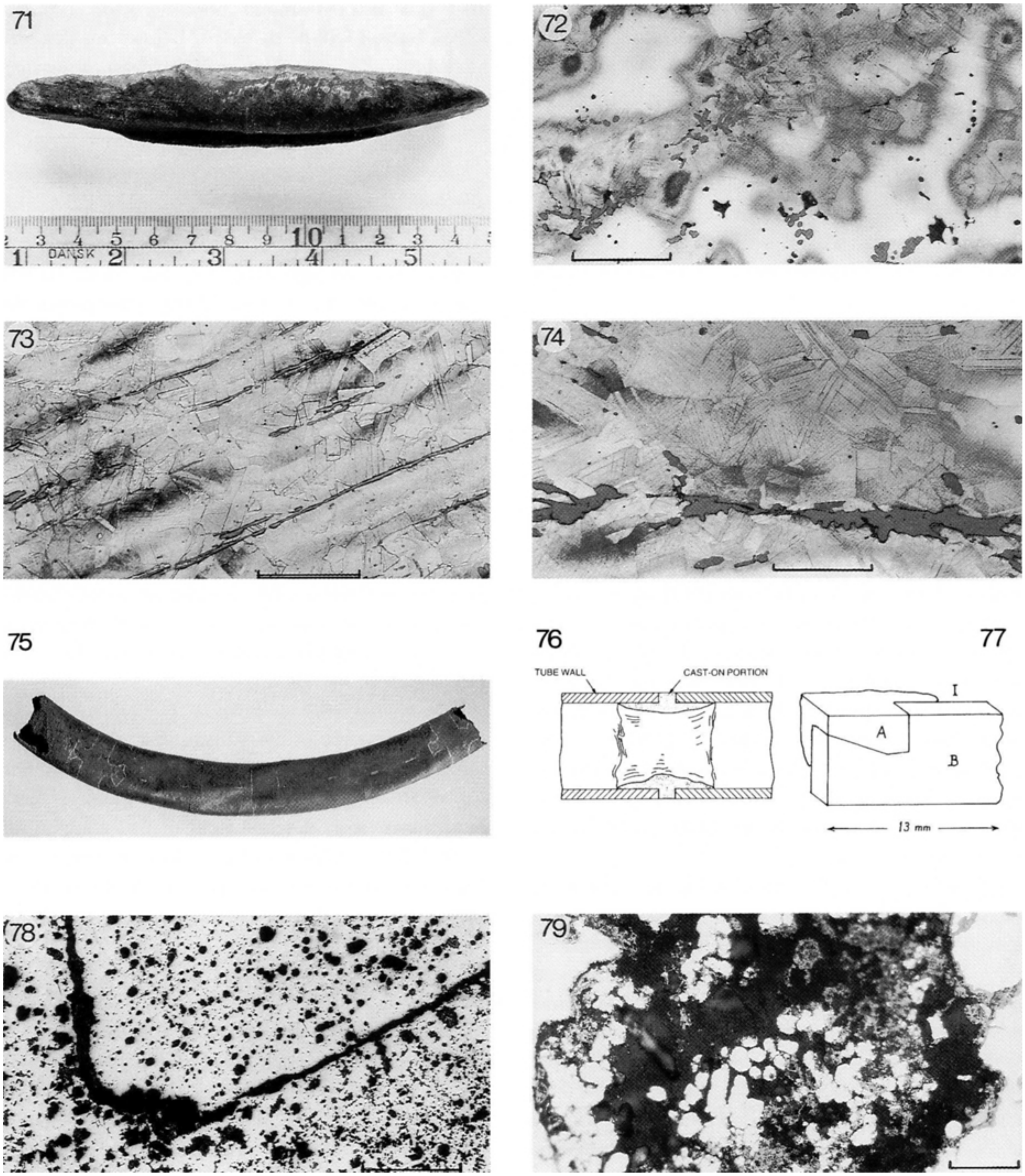
Analytically the axe is a little difficult to rubricate and has according to Liversage (pers. comm.) a deviant composition with unusually high antimony.

Polished sections show a yellow alloy with pin-holes in the interior. Many pin-holes are almost spherical, 0.1–0.2 mm across, others are interdendritic. They are often coated with blue sulphides, and many have during the long exposure in the soil become filled with corrosion products. The sulphides are palmate-lobate and attain dimensions of 30 μm from tip to tip. More normal are 3–10 μm blebs, all in all covering about 5.5% by area. The sulphides are blue, isotropic and of the digenite type, $Cu_9S_5$, with a little (0.1–0.3%) iron in solid solution.

In the edge and under the flanges to a depth of 4–5 mm the micropores have been closed and the sulphides severely deformed. They are typically stretched to narrow bands and filaments, e.g. 60 × 6 μm or 100 × 2 μm. They are not extensively broken but only plastically deformed, figs. 73–74.

The etched sections show a cored structure on which is superimposed a recrystallized, twinned structure. No δ-phase was identified. In the interior the grain size is about 80 μm and the hardness 79 ± 8, with a pretty large variation because the coring has not been eliminated. In the cutting-edge the grain-size decreases to 10–20 μm and the hardness increases to 134. Under the flanges the twinned, recrystallized grains are 20–40 μm across and the hardness increases to 100. On the whole there are few indications of final cold-work, so it appears that the present medium hardness level is due to repeated cold-work

| Table 11 | | | | | | | | | | | Vol.% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Sulph. | Lead |
| J.1968; no. 8289 | 5.5 | – | tr. | 0.21 | 0 | 0.73 | 0.04 | 2.6 | tr. | – | – | – |
| This work | 6.0 | 1.1 | <0.05 | 0.15 | <0.05 | >0.3 | 0.07 | 1.9 | <0.1 | (90.0) | 5.5 | 0 |




Figs. 71–79. Fig. 71. *No. 10. 26106*. The irregular flanges on the axe. The edge to the right. Fig. 72. Unequilibrated, slightly deformed interior with slip-lines in recrystallized α-grains. Palmate $Cu_2S$. Scale bar 0.1 mm. Fig. 73. Severely deformed sulphide crystals under the flange, B. Recrystallized grains with slip-lines. Scale bar 0.1 mm. Fig. 74. Detail of severely deformed, but unbroken sulphides, proving their ductility. Slip-lines in recrystallized α-grains. Scale bar 50 μm. Fig. 75. *No. 11. B 15505*. The Hallenslev Lur (from Hallenslev Sogn, Løve Herred, Holbæk Amt). Fig. 76. Reconstruction of the method for joining two tube parts (Holmes 1986:114). Fig 77. Sketch of the joining of tube B with cast-on A metal, compare Fig. 75–76. Fig. 78. The junction between A (top) and B (bottom) was never perfect. Note the numerous pin-holes from casting. Scale bar 0.5 mm. Fig. 79. Destannification of part B. Numerous micron-sized blebs of almost pure copper have been redeposited in voids. Scale bar 50 μm.

and annealing, and that the final process was a mild reheating that did not lead to equilibration.

The general patina consists of an inner 50–200 μm thick "red $Cu_2O$" layer, and an outer 50–200 μm thick green layer with botryoidal growth. The copper sulphides survive for a while in the corrosion products.

This chisel-like axe stands in shape and composition somewhat apart from the others examined here. It is a sulphide-rich tin bronze with heavy deformation-work on the flanges. The final treatment from the smith was a mild annealing.

*No. 11. B 15505C. The Hallenslev Lur. Hallenslev Sogn, Løve Herred, Holbæk Amt. About 1100–900 B.C. Figs. 75–79. Table 12.*

The Hallenslev lur was found in 1961–1962 in several fragments and was thoroughly described by Broholm (1962). Broholm paired it typologically with the four lur finds from Maltbæk, Lommelev, Nyrup, and Dauding, placing them in period IV of the Danish Bronze Age, or about 1100–900 B.C. Recently a fragment has been examined by X-ray fluorescence analysis (Gottlieb 1987), yielding qualitative information about the chemical composition. The small sample, which has here been examined by the kind co-operation of Poul Otto Nielsen, Jørgen Jensen, and Birthe Gottlieb, was carefully hacksawed from the lower part of the tube, figs. 6–7 in Broholm 1962. This tube is 1.2–1.5 mm thick, 50 mm in diameter, 50 mm long and weighs 702 g (fig. 75).

The specimen was cut so as to include both a part of the tube length (B) and a part of the meander-connection (A), figs. 76–77. When the lur was originally assembled two tubes, B and C, were cut to a meander shape and positioned firmly about 20 mm apart. Then a mould was constructed à cire perdu so that an annular connecting link, A, could be cast. The liquid metal flowed into the meander-cuts and also added about 1 mm of thickness on the interior of the tube. This reinforcement in thickness and the mechanical interlocking served well to fasten the tube parts securely. It has earlier been assumed that there also was metal-to-metal bonding from remelting the edges, but, as will be discussed below, this appears not to have been the case. The assembly was, however, strong and the later fragmentation of the lur happened outside the assembly regions.

*The tube, B.*

Analytically, the tube is a low-tin bronze with significant impurities of arsenic, antimony, and nickel. It somewhat resembles axe No. 4 of the Singen group, but the lur is very low in silver, and the two objects are separated in time by approximately 800 years.

The polished section shows a reddish-yellow alloy with a number of interdendritic micropores from casting, fig. 78. Sulphides occur as 5–15 μm blue subangular blebs, that are dead black in crossed Nicols. Many of the interdendritic cavities are filled with material of the same blue colour, but those that are *red* under crossed Nicols can be shown to be copper oxides produced by corrosion. In many of these pockets, and in the copper oxides on the surface, are numerous 1–2 μm copper blebs or up to 10 μm long copper filaments, all the result of corrosive destannification, fig. 79.

The etched section shows a cored casting with a dendrite armspacing of 30–40 μm. The coring is somewhat annealed, probably from reheating associated with casting of the assembly part A. No δ-phase is present, in accordance with the low total of tin, arsenic, and antimony. The hardness is 62 ± 4, in agreement with the annealed condition of a copper alloy low in alloying elements.

*The annular assembly part, A.*

Analytically, the alloy cannot be classified with the Faardmet group or any other of the groups proposed by Liversage & Liversage (1989), than which it is considerably younger. It differs from the alloy of the tube in its significantly higher tin, arsenic, and sulphur content. It appears that the smith purposefully has added these to

| Table 12 | | | | | | | | | | Vol.% | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Sulph. | Lead |
| Assembly, A | 4.0 | 0.4 | <0.1 | 0.70 | <0.05 | (1.2) | <0.05 | 1.4 | <0.1 | (92.2) | 2.0 | 0 |
| Tube, B | 2.4 | 0.1 | <0.1 | 0.47 | <0.05 | 0.8 | <0.1 | 1.5 | <0.1 | (94.5) | 0.5 | 0 |

the tube alloy base in order to create a lower-melting, free-running alloy, which would be well suited for the assembly process. The solidus line of alloy A may have been about 75 °C lower than that of B.

The polished section shows a reddish-yellow alloy, which cannot be distinguished from the colour of tube B. The material is unusually rich in interdendritic microporosities, so much so that a normal hardness determination at 5 kg load, giving the low range of 43 to 49, is misleading. Instead the hardness has been estimated by microhardness determination at 100 g load in massive material to 74 ± 5.

Sulphides are abundant, as 6 × 4, 15 × 5, or 3 μm subangular blebs, adding up to about 2.0 vol.%. In the boundary between A and B, a thin (2–3 μm), continuous $Cu_2S$ layer has formed on solidification, i.e. there has never been established a solid metal-to-metal contact. On the other hand, the geometry of the assembly has served to anchor the two parts securely. The reason for the formation of the $Cu_2S$ layer is, in somewhat simplified terms, that the sulphide nucleates and grows on the colder surface, i.e. the tube B, while the metal phase (copper enriched in tin, arsenic, and nickel) has a lower solidification range and therefore for a short while remains liquid. In addition, the tube B must at the time of pouring the A-metal have been covered by thin copper oxide coatings due to preheating of the mould assembly. This coating would assist in the nucleation of copper sulphide. In short, the finished assembly, although mechanically perfect, never acquired a remelted metal-to-metal bonding.

The etched section shows a cored alloy with sulphides, and a small amount (< 1 vol.%) of δ-phase, occurring as 3–6 μm blebs. The dendrite armspacing is about 30 μm, and the structure is unannealed. There are no indications of hammering or other forms of mechanical working, in contrast to the conclusion reached by Gottlieb (1987,193).

The minute δ-phase areas are located where the last melt solidified on casting. Since this was enriched in low-melting components we find these highly concentrated here. For example, one complex 10 μm area consisted of a lead nodule of which 25% was bismuth, associated with an area with 62% Cu, 20% Sb, 14% Sn, 3% Ni, and 1% As. Although bismuth is certainly present, it is a curiosity and cannot be traced in the bulk analysis.

Corrosion has attacked both parts. Especially the tube, B, has suffered, being covered by an interior, 20 μm thick copper oxide layer (red in crossed Nicols) and an exterior brownish-greenish layer, also very thin, 10–20 μm. The interdendritic cavities and the join between A and B are filled with copper oxides; some feldspar grains ($KAlSi_3O_8$) from the ancient moulding material may be found embedded here. Destannification, in the form of irregular 1–5 μm copper grains, is only observed in the $Cu_2O$ of the B part. It is not obvious, why the very similar, but more tin-rich A-alloy has not suffered destannification.

The lur has been cast by the cire-perdu technique as described by Broholm (1962), and individual tube parts have been assembled by casting on annular rings. This was done in one step; no signs of the two-step operation suggested by Gottlieb (1987, fig. 5) could be detected. All the metal of A, fig. 76, is coherent and of the same composition. No parts of the examined specimens have been worked after casting.

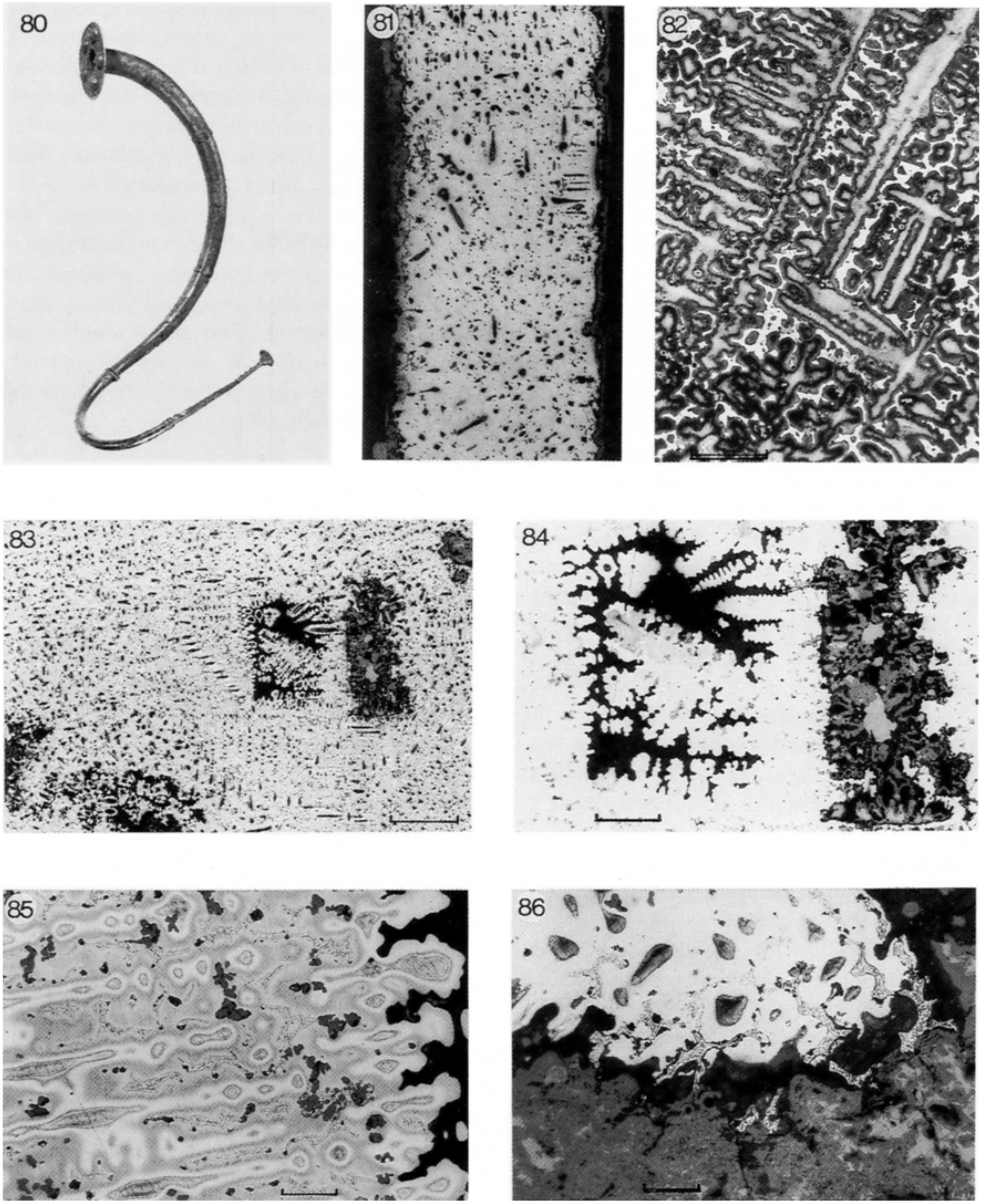
*No. 12. B 17482. The Ulvkær Lur No. 2. Near Tornby, Horne Sogn, Vennebjerg Herred, Hjørring Amt. About 700 B.C. Figs. 80–86. Table 13.*

Fragments of a lur were found in August 1988 by Orla Pedersen at Ulvkær, near Tornby, Vendsyssel (Lysdahl 1988, 1989). Further fieldwork revealed more fragments, and these could finally be restored as a pair of lurs, the first ever found in Vendsyssel. The instruments had been lying in a 3 m thick turf deposit overlain by blown sand, but the exact conditions will never be known, as the turf with the lurs had been removed in bulk during mechanical earth moving operations. The best preserved of the two lurs (No. 1) weighed almost 3 kg and measured 175 cm along the curved tube, fig. 80.

The material here examined is a 1.8 g fragment which comes from lur No. 2; it was not so well preserved, having been somewhat molested by a bulldozer. The fragment is from the inner part of the circular end-plate, which had broken along corroded, dendritic grain boundaries. The thickness of the plate now varies from 0.7 to 1.0 mm. Apparently the original thickness was about 1.0 mm while the present thinner parts mainly are due to general corrosion, fig. 81.

The surface is covered with black to blue and greenish-black corrosion products which in places are blistery. Below the 50–100 μm thick outer crust is a 50–100 μm, irregular, moss green patina which in most places is in direct contact with the dendritic metal.

The corroded fragment was broken in three pieces and mounted in coldsetting resin so as to show both a full cross-section and a view of the surface itself.




Figs. 80–86. Fig 80. *No. 12. B 17482*. The Ulvkær Lur No. 1. (Courtesy Nationalmuseet). Fig. 81. Full cross-section of a 1.0 mm thick fragment, broken from the circular end-plate of the Ulvkær Lur No. 2. Fig. 82. Cast, dendritic high-tin bronze with significant δ-phase. Scale bar 0.1 mm. Fig. 83. Because the lur was cast and never subsequently worked, all micropores are still well-defined voids. The void on the right is now partly filled with corrosion products. Scale bar 0.5 mm. Fig. 84. Detail of Fig. 83: Dendrites radiate into voids. Scale bar 0.2 mm. Fig. 85. Detail of Fig. 84: Cored α-phase, extensive δ-areas, and globular-palmate copper sulphides. Scale bar 50 μm. Fig. 86. Corroded surface. The α-phase adjacent to δ is the first to be attacked. The location of the δ-phase is still visible in the black corrosion products. Scale bar 50 μm.

| Table 13 | | | | | | | | | | | Vol.% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sn | S | Fe | Ni | Zn | As | Ag | Sb | Pb | Cu | Sulph. | Lead |
| This work | 13.1 | 1.0 | 0.10 | 0.11 | <0.05 | 0.5 | <0.1 | <0.1 | 3.0 | (82.1) | 5.0 | 2.5 |

Analytically, the lur is a high-tin bronze, rich in lead and sulphur. Its composition is entirely different from that of the Hallenslev Lur, and it is the object with the most tin of any examined in this study. In addition to the elements reported below, we found 0.25% Co. Ni and Co were enriched in the δ-phase relative to the α-phase by factors of respectively 3 and 1.5.

Polished sections show a yellow, cast alloy with many microporosities. The blue sulphides are conspicuous as blebs or palmate inclusions, 5–20 μm across, constituting about 5 vol.%. The micropores are interdendritic empty voids, or are filled with complex corrosion products, figs. 83–84.

Etched sections show a beautiful cored casting with substantial amounts, about 20 vol.%, of bluish-grey δ-phase, fig. 82. Lead occurs as 3-25 μm rounded blebs associated with the δ-phase and the sulphides. The morphology of the δ-phase, the sulphides, and the lead all show the object was neither hot nor cold-worked after casting and was not reheated for annealing. The hardness is 120 ± 12, displaying a rather large spread due to segregation and microporosities. SEM-EDAX work on the individual phases showed that the copper sulphide was as usual of the $Cu_2S$-type and had from 1.2 to 3.6 wt.% Fe in solid solution. The iron content of the adjacent metal phase is below the detection limit of 0.05 wt.%.

The lead segregates are pure lead and do not display the dirty appearance of the A-part of the Hallenslev lur. The δ-phase is similarly a rather pure phase, primarily consisting of $Cu_{31}Sn_8$, in which are minor impurities of arsenic (about 0.4%), nickel (about 0.2%) and cobalt (about 0.16%), fig. 85.

The corrosion products are complex grey-blue (black in crossed Nicols) and black (black in crossed Nicols) layers, often developed in botryoidal forms. Nearest the metal are discontinuous greenish films, that are green in crossed Nicols. The copper part of the δ-areas and the copper zone around the sulphides are the first to be attacked by the corrosion. No simple, red copper oxides and no destannification was observed. The cohesion of the lur is weakened considerably by the interdendritic corrosion, fig. 86.

A preliminary examination of the corrosion products showed that they are extremely variable, with Cu-Sn ratios varying from 0.7 to 2, compared with 6 for the bulk alloy, and with significant amounts of iron, sulphur, phosphorus, silicon, and chlorine, introduced from the adjacent soil and peat. Some of the corrosion products are similar in structure and composition to those reported on axe No. 7 (B 4077) which was also found in peat.

The Ulvkær lur is the youngest of our bronze objects and represents a new alloy type which is rich in tin, lead, and sulphur, and poor in nickel and antimony. Cobalt is present at the low level of 0.25%. The casting succeeded very well, and no further hammering or annealing has taken place on this part of the lur, which is the circular end-plate.

## DISCUSSION

### *The analytical data.*

Ten of the twelve objects have already been analyzed by the spectrographic method (Junghans et al. 1968). Inspection shows that the material for spectrography was obtained by drilling 1 mm holes, generally in the middle of the axes. Presumably the drillings from the outermost, corroded layers were discarded before analyzing. However our metallographic studies have shown that many of these ancient objects are rich in corrosion products also in the interior, especially along grain boundaries and in interdendritic micropores that originated during casting. Much of the corrosion is selective, removing either copper, tin, or arsenic, depending on alloy type and environment, so the presence of corrosion products in the drillings may have influenced the results.

Nevertheless, the differences between our results and Junghans et al's spectrographic data are small. In general, our values for iron, nickel, silver, antimony, zinc, and lead agree very well with the old data sets, and so do our tin values for low-tin alloys. For the full tin bronzes there are small discrepancies, but we believe our tin data to be the better, because they are well supported by the metallographic structure. With respect to arsenic the spectrographic data are apparently better than ours, mainly because our instrument has difficulty in the quantitative separation of the As $K_\alpha$ line (10,530 eV) from the Pb $L_\alpha$ line (10,550 eV).

With respect to bismuth, cobalt, and gold, which were reported as nil in the spectrographic data sets, we can support this by stating that they are certainly below 0.05% in the bulk samples, and were not detected either as discrete blebs or as inclusions when searched for under the scanning electron microscope. However, traces of bismuth were found in lur No. 11, and traces of cobalt in lur No. 12.

Sulphur is an important element, which cannot be measured by the spectrographic method. On the other hand it is easily detected by metallographic examination, when it appears as blue sulphides which are dead black in crossed Nicols and have the general composition, $Cu_2S$. The bulk sulphur value may then be calculated using planimetry, as we have done here in the last columns of the analytical tables. Also sulphur is easily detected and measured using SEM-EDAX equipment, and the two results generally agree very well. When discrepancies occurred we preferred the planimetric results because the instrument had problems with separating the signals from S $K_\alpha$ (2.307 eV) and Pb $M_\alpha$ (2.342 eV), generally leading to too high sulphur concentrations. These conclusions were supported by analyzing synthetic series of copper-tin-lead-sulphur alloys.

Turning now to the composition of the ancient objects several interesting points are revealed by inspection of table 14.

First, the two oldest objects are almost pure copper-arsenic alloys. No sulphur is present; instead a host of copper oxide and copper-lead arsenate inclusions are found, proving that the two axes were produced by casting and not, for example, by hammering some native copper. That native copper can be excluded as a source of metal is supported by the observations of Maddin et al. (1980) and Matteoli & Storti (1982) who find that native copper is extremely pure, similar to or better than modern electrolytic copper for electric cables. We therefore conclude that the axes have been produced by smelting of oxidised minerals from the gossan. Minerals in question could be cuprite ($Cu_2O$), malachite ($Cu_2(OH)_2CO_3$), azurite ($Cu_3(OH,CO_3)_2$), brochantite ($Cu_4(OH)_6SO_4$), atacamite ($Cu_2(OH)_3Cl$), and antlerite ($Cu_3(OH)_4SO_4$). Since the last three are characteristic of weathering under arid conditions, such as in the Chilean Atacama Desert, it is probable that the ores with which we are concerned were a mixture of the first three, possibly with cuprite as the dominant mineral. Arsenic, antimony, and lead are usually enriched in the gossan as oxides, carbonates, and sulphates and must have been included in small proportions in the ore. Also a number of copper arsenates are known from the gossan, for example olivenite ($Cu_2(OH,AsO_4)$), cornwallite ($Cu_5[(OH)_2AsO_4]_2$), clinoclase ($Cu_3$

| Object | | Sn | S | Fe | Ni | As | Ag | Sb | Pb | Cu* | Hardness range HV5 | Approx. date B.C. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | B2926 | <0.1 | <0.1 | <0.05 | <0.05 | 1.4 | <0.1 | <0.1 | <0.1 | 98.4 | 66– 97 | 3500 |
| 2 | B5556 | <0.1 | <0.1 | <0.1 | <0.05 | 0.47 | <0.1 | <0.1 | <0.1 | 99.3 | 57– 81 | 3500 |
| 3 | B1094 | <0.1 | 0.11 | <0.05 | 0.08 | 0.50 | 0.9 | 0.4 | <0.1 | 97.8 | 53– 91 | 2000 |
| 4 | 11073 | 2.1 | 0.15 | <0.05 | 0.74 | 0.36 | 0.7 | 0.8 | <0.1 | 95.0 | 69–161 | 2000 |
| 5 | 26073 | 8.8 | 0.35 | 0.08 | 0.37 | ca.1 | 0.09 | 0.22 | <0.1 | 89.5 | 85–201 | 1700 |
| 6 | 21075 | 8.8 | 0.15 | <0.05 | 0.74 | ca.1 | 0.22 | 0.5 | <0.1 | 88.5 | 91–257 | 1800 |
| 7 | B4077 | 9.4 | 0.40 | <0.05 | 0.37 | ca.1 | <0.1 | 0.18 | 0.9 | 88.0 | 76–165 | 1700 |
| 8 | B5564 | 8.4 | 0.23 | 0.12 | 0.46 | ca.1 | 0.16 | 0.28 | 1.2 | 88.2 | 91–155 | 1700 |
| 9 | B3971 | 8.0 | 0.25 | 0.05 | 0.49 | ca.0.8 | <0.1 | 0.28 | 0.5 | 89.5 | 72–204 | 1500 |
| 10 | 26106 | 6.0 | 1.1 | <0.05 | 0.15 | ca.0.7 | 0.07 | 1.9 | <0.1 | 90.0 | 72–134 | 1500 |
| 11A | B15505A | 4.0 | 0.4 | <0.1 | 0.70 | 1.2 | <0.05 | 1.4 | <0.1 | 92.2 | 70– 78+ | 1000 |
| 11B | B15505B | 2.4 | 0.1 | <0.1 | 0.47 | 0.8 | <0.1 | 1.5 | <0.1 | 94.5 | 58– 66 | 1000 |
| 12 | B17482 | 13.1 | 1.0 | 0.10 | 0.11° | 0.5 | <0.1 | <0.1 | 3.0 | 82.1 | 106–134 | 700 |

* estimated
+ estimated from the hardness at 100 g load
° in addition 0.25% Co

Table 14. Composition and hardness of ten axes and two lurs (the three last lines). Zinc, cobalt, bismuth, and gold searched for, but present at levels below 0.05%, except for no. 12, see the text.

$(OH)_3AsO_4)$, cornubite $(Cu_5[(OH)_2AsO_4]_2)$, euchroite $(Cu_2(OH, AsO_4), 3H_2O)$, and tirolite $(Ca_2Cu_9[(OH)_{10}(AsO_4)_4], 10H_2O)$ (Ramdohr & Strunz 1967; Strunz 1970). It is not known to what extent the natural minerals at this ancient date were sorted before smelting, but we believe that it would have been possible even then to mix them to give a specific alloy if the desire were there. Charles (1985) has some interesting viewpoints on this early development.

The two old axes were probably cast in Central Europe, the present Austria-Hungary, exported to Denmark and never remelted, for reasons given p. 76. Analytically, they belong in the Bygmet group, which comprises many other early flat axes (Liversage & Liversage 1989).

The next two axes are typologically younger and represent analytically a significant change since a number of other elements are now present, first of all sulphur. In our opinion the presence of sulphur reflects the first utilization of sulphidic copper ores. In Central Europe there is a host of these ores, ranging from simple copper sulphides (chalcosite, covellite) to complex ones containing also arsenic (e.g. enargite), antimony (e.g. tetrahedrite), iron (e.g. chalcopyrite), silver (e.g. stromeyerite), bismuth (e.g. emplektite), and the very complex ones, containing both iron and tin (e.g. stannite), both lead and antimony (e.g. bournonite), or silver, arsenic, antimony, iron, zinc, and tin together (the Fahlerze).

Nickel does not occur as a component of complex copper hydroxides or sulphides, but it may be present mixed with the other minerals as arsenides (e.g. niccolite, NiAs), antimonides (e.g. breithauptite, NiSb) or complex sulphides (e.g. pentlandite $(Fe,Ni)_9S_8$). The thorough examination of an early Bronze Age hoard of copper ingots from Obereching at Salzach, North of Salzburg, demonstrated that the Austrian mixed ores could produce a semifabricate which was rather variable, but generally rich in nickel, sulphur, iron, arsenic, and silver (Moosleitner & Moesta 1988). On further processing and remelting, the iron, nickel, and sulphur in particular must have been reduced to the lower values which are known in the finished objects.

When the sulphide ores are roasted and smelted part of the impurities (arsenic, antimony, nickel, iron, silver, sulphur, lead) follows the copper metal, while another part is removed as volatiles or is eliminated in the slag. The partition coefficients may be known for individual components under laboratory conditions, but it is almost impossible to predict the result of smelting complex ores under the rather unknown conditions of ancient times. Tylecote (1980) has reported some valuable observations on the experimental smelting of nine different ores; he studied the effect of fluxing and the distribution of main impurities after melting under oxidizing or reducing conditions. He found that most of the iron and other impurities can be reduced in amount by controlled remelting in a crucible, and that the degree of refining will depend on the time and care given to the refining operation. Much discussion has revolved around these early smelting processes, and the interested reader should consult, e.g. Percy (1861), Tylecote (1976), Jovanovic (1980), Moesta et al. (1984), Hauptmann (1985), and Riederer (1987) and references therein.

The situation is very complex. Suffice it to say that the analytical evidence from the present examination seems able to show groups of objects that were produced from similar ores by similar methods during distinct periods, and the groups were to some extent related to the groupings proposed by Liversage & Liversage (1989).

Thus axe No. 3 would have been smelted from an ore type from which tin is absent (Ösenring composition), while No. 4 would have been smelted from a different ore type (Singen composition) contaminated by one or more tinminerals such as stannite $(Cu_2FeSnS_4)$ or cassiterite $(SnO_2)$. Such mineral associations are known to occur in Saxony, Bohemia, and Austria, or generally speaking in the Fichtelgebirge and the Erzgebirge. It is unlikely that copper occurrences in Sweden, Norway, or Finland, although rich today, were exploited in the Bronze Age. Similarly the Helgoland copper occurrence has another fingerprint with respect to the associated elements (Schulz 1984) and can hardly be associated with these tools. The axe No. 4 is apparently from a period when separate tin ores were first being used. Otherwise it would be difficult to understand graph 9 in Liversage & Liversage (1989), where 78% of all objects have tin contents less than 2%, while the remainder show variable additions, deliberate we take it, of up to and over 10%.

The next six axes, Nos. 5–10, are full tin bronzes with 6.0–9.4% Sn. No naturally occurring mineral mixture will by smelting yield such a rich tin bronze. It may be assumed that by this time the craftsman had learned to appreciate the new tin bronze and had a continuous supply of the proper ore or metal. He may even have experienced the toxicity associated with the smelting of copper-arsenic alloys and alone for this reason preferred the copper-tin alloy. However arsenic followed him for a long time, as witnessed by this suite of ten axes. Charles (1985) in an interesting paper discusses the sequential steps from copper-arsenic to copper-tin bronzes and speculates that Hephaistos, the only Greek god who was imperfect, acquired his lame leg from arsenic poisoning.

By judicious mixing of tin or tin ore with the copper alloy in fixed ratios the smith could obtain a full tin bronze with the desired properties. An addition of metallic tin is apparently the simplest way to make the new alloy, since tin melts at 232 °C and will start coating and diffusion into the copper long before this has melted. Since, however, we rarely if ever find the raw tin on archaeological smelting sites, it is speculated that the alloying material was cassiterite, $SnO_2$, which when heated under charcoal with a molten copper alloy will be reduced to metallic tin and enter the alloy to form the desired bronze. From the high sulphur content of the finished objects we conclude that the copper ores were for a major part sulphidic, and they still carried some arsenic.

While copper ores are widespread, it has long been a problem where the tin ores came from. It is certain that cassiterite from Cornwall and Devon was used as early as 2200 B.C. for the production of early British bronze axes (McKerrell 1978), and it is also plausible that the extent of the Cornish deposits was sufficient to cover all the needs of civilization from the beginning of the full Bronze Age onwards; but whether this was actually done is another matter (Tylecote 1978). Small deposits are known to have existed in the Erzgebirge, for example at Zinnwald, and in Bohemia at Schlackenwald (Riederer 1987). Very recently, cassiterite deposits and ancient mines have been documented at Bolkardag in Anatolia (Yener & Özbal 1987; Yener et al. 1989) from where the tin ores may have been traded around the Mediterranean Sea and further inland. Possibly the tin ores reached the smelter as concentrates of tin-rich minerals, perhaps as mineral sand. This material is rather inconspicuous and may have been overlooked when excavating ancient smelting sites (Charles 1985). However, it is equally possible that tin at an early date was traded in the shape of metal ingots. Thus, an ancient trading ship from about 500 B.C. was recently discovered in the Mediterranean Sea near Haifa, and several brick-shaped tin ingots, each weighing from 11 to 22 kg, were recovered (Rothenberg 1980).

Denmark has absolutely no copper or tin ores and must have received everything from abroad. However it is a mystery in what form the metal was imported, as ingots are almost or entirely unknown. No doubt part of the demand was met by recycling of metal already in the country, but the results presented by Liversage and Liversage (1989) show that the largest factor affecting impurity pattern was import of new metal – especially in the case of the sudden change-over at the beginning of the full Bronze Age (at about 1750 B.C.) to a full tin bronze, usually of Faardmet pattern.

The last two objects are lurs, i.e. musical instruments, cast in the cire perdu technique with a very thin (1–1.5 mm) wall thickness and never subjected to hammer-work. They are substantially younger and the alloy compositions are different from those of the axes with respect to both tin and accessory elements. In No. 12 we meet a tin-lead-sulphur-copper alloy, where the alloying components are at an extremely high level. Arsenic is still present, but the other common accessory elements, nickel, silver, and antimony have almost disappeared. Instead, cobalt for once appears at the low level of 0.25%. The alloy corresponds in many respects to the Etrurian bronzes used for the casting of vessels and statuettes (e.g. Riederer 1987). No doubt the alloy was chosen because well suited for the purpose.

The Hallenslev lur appears to have been made of bronze of two compositions, which were selected with a knowledge of their melting ranges, the one with the lower melting point having been made as a "solder" to join the tubes. That this did not succeed in terms of metal-to-metal bonding, but only in terms of mechanical interlocking, was probably never realized. The low-tin alloys have resulted in relatively poor castings with very many internal holes and interdendritic microporosities.

A final point concerning the analyses: our twelve objects are low in iron. We shall see (paper in preparation), that Danish bronze objects from the Iron Age and the Viking Age have significantly higher iron content, usually in the range 0.2–0.3%. This may be attributed to other ores, but it may also have been caused by the extensive use of iron in smelting practice, i.e. for ladles and stirring poles. This practice would have introduced significant portions of iron into the copper alloy melt. Apparently most of the iron present in the ancient objects studied here is in solid solution in the copper sulphides.

*The structure and the mechanical properties.*

Most of the axes have been worked to different degrees after casting. Only the tongue-shaped axe and the shaft-hole axe are still largely in the as-cast state.

It appears that all axes, except the oldest one, were cast in symmetrical bivalve moulds, edge-down. However, the finishing by grinding and hammering has entirely removed all casting flashes and possible indications of the positions of gates and risers. The oldest, tongue-shaped object preserves a ridge which may be interpreted as an impression of a crack in the flat mould in which it was cast.

Copper alloys are even today difficult to cast so that they are entirely solid. Very often voids and microporosities are found and these are generally located were the dimensions change abruptly. However all our axes have more or less the same simple, wedge-shaped form and evenly dispersed voids. The microporosities make the bronze sensitive to bending and breaking strains, so that their transverse strength is significantly decreased. This is demonstrated by the low-flanged axe, No. 3, that has failed in bending, cracking in two places.

Hammering closes the microporosities and improves the mechanical properties of the alloy. The cutting-edges have all been hammered and generally no voids remain for a distance of 10 mm from the edge. The flanges have also been hammered, and the voids have disappeared to a depth of 3–5 mm. Hammering has deformed the sulphide inclusions and they have been altered from their original palmate to subangular shape to irregular filaments. We have shown that the sulphides are sufficiently ductile to deform even under cold-work, so the presence of these elongated inclusions is not alone a valid indication of hot-work.

On cold-working, the hardness and strength increase ever more until maximum values of about 3.5 times that of annealed material are reached. If the desired shape has not yet been reached, a recrystallization anneal can be performed, i.e. the object can be reheated to 600–700° C for anything from 10 minutes to an hour. Thereby the hardness decreases substantially, and the ductility improves so that the object can be shaped further by renewed cold-work. In addition, the coring slowly becomes eliminated by diffusion, and the copper-rich α-phase recrystallizes as equiaxed, twinned grains. The value to us of the sulphide inclusions lies in the fact that on annealing they retain their elongated shapes, and thus document previous deformation, while the metal grains around them recrystallize to equiaxial shapes.

The softest state is reached on repeated working and annealing, ending with slight deformation (10–20 %) followed by a full anneal. Such material has not been identified in this study.

It is instructive to compare the hardness of the lurs, which have been cast and never worked, with the axes, which after casting have been exposed to different combinations of working and annealing, fig. 87. Here the hardness ranges of all objects have been plotted against the composition. The abscissa is the sum of tin, nickel, arsenic, antimony, and silver, which all are known to increase the hardness. This is a rough procedure, but may nevertheless help to explain the phenomena.

The lurs, Nos. 11 A, 11 B, and 12, have the small hardness range appropriate for cast objects. They fall entirely within the band of variability for cast or annealed objects. The tube, No. 11 B, is the softest because it was annealed when preheated during the casting-on of component 11 A. This, and the tube, No. 12, are located in the relatively hard, upper part of the band, because they are thin-walled castings with a high cooling-rate and fine dendritic microstructures.

The axes show a wide range in hardness. Axe No. 6 has as the final production step been cold-worked to a reduction of over 60% on the edge and has not been annealed. The ratio of edge-hardness to bulk-hardness is 2.85, which suggests severe cold-working. Also axes Nos. 4, 5, and 9 have as the final step been heavily cold-worked to reductions of about 40%. The recrystallized grains are elongated and with many internal striations, proving that the final step was cold-working. or perhaps cold-working followed by some mild annealing.

In contrast, axes Nos. 2, 3, 7, and 10 have been severely worked with the purpose of shaping the flanges and edges, and have at one time during production had the high hardnesses corresponding to 50 or 60% reduction. However the final step was an anneal, not very thorough, but sufficient to reduce the hardness substantially.

Finally, objects Nos. 1 and 2, based upon copper and arsenic alone, are surprisingly hard in relation to their composition, whether they are judged by fig. 87 or by fig. 19. Perhaps the long exposure time, over 5000 years, has resulted in the separation of a submicroscopic, arsenic-rich, intermetallic phase, giving rise to age-hardening. For this to occur it is required that the copper-arsenic diagram have a reclining solvus line similar to what is known to exist in the related Cu-P, Cu-Sb, and Cu-Be systems. However, the Cu-As diagram has not been well studied at low temperatures, and the question has so far recieved no attention.

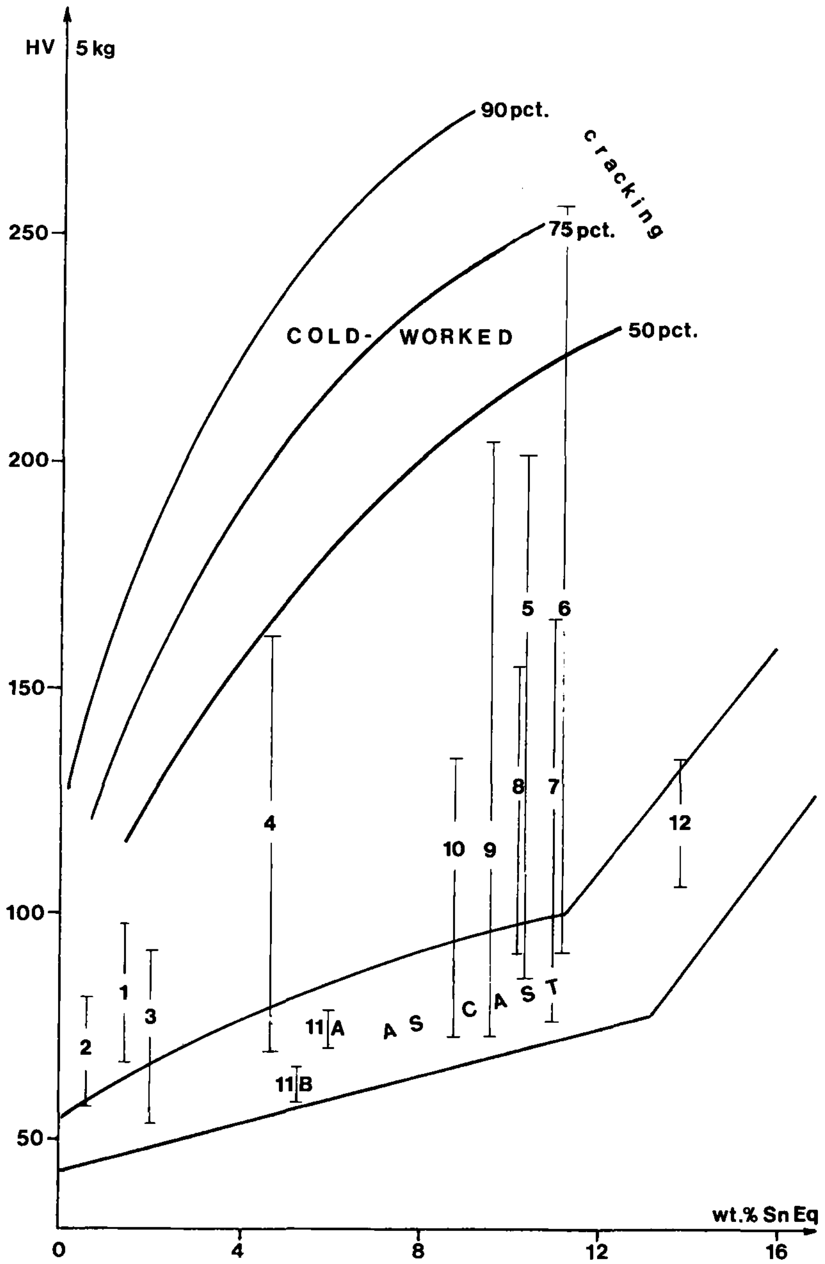



Fig. 87. Vickers hardness (5 kg) of all 12 examined objects superimposed on fig. 1. The abscissa is % Sn Eq., i.e. the sum of Sn, Ni, As, Ag, and Sb. Since the lurs (11, 12) have been finished by casting, their hardness must fall within the lower band. All the other objects show varying combinations of cold-work, hot-work and annealing.

The casting structure, microporosities, and segregation are fully preserved in the lur components, Nos. 11 A, 11 B, and 12. Modern copies of the lurs have been made from rolled brass or tin-bronze, and have completely solid metal walls. In view of the fact that sound waves are significantly attenuated by phase boundaries and particularly by internal voids, it may be speculated that the quality of the sound from a modern replica would be somewhat different from that of the ancient, pore-filled instruments.

*Corrosion.*

It has not been a purpose of this study to examine the corrosion products, but we have a few observations.

On the copper-arsenic alloys, No. 1 and No. 2, the inner corrosive layer is red copper oxide ($Cu_2O$), while the outer one is a greenish patina. In contrast, on most of the other objects, which have more alloying elements, the inner layer is a greenish patina, followed by greyish-brownish layers of a complex nature. These layers are significantly depleted in copper content, the copper having been removed in solution.

On axe No. 7 we observed two sulphidic layers of which the exterior layer, 1 mm thick was orthorhombic $Cu_2S$, while the inner was a complex tin-copper-arsenic sulphide. The axe had lain in anaerobic conditions in a peat bog. A similar, less well-developed layer was detected on the Ulvkær lur, which also was discovered in turf.

Destannification was very well developed on the lur component No. 11 B and on the axes No. 8 and No. 9. The fine, irregular or filamentary copper particles were generally below 10 µm in size. They consist of copper, apparently with up to 1% Fe in solid solution, and are located in red copper oxide. Tylecote (1979) was of the opinion that arsenic inhibits destannification, but our data, on full tin bronzes with about 1 wt.% arsenic, show that arsenic had little effect under the conditions observed.

Grain boundary corrosion is common in those axes which were annealed as a final step, e.g. axe No. 10, while corrosion along slip lines of the cold-worked metal is well developed in axe No. 6, the one which had been severely hammered. The corroded slip line grid is otherwise absent or only present as a minor feature, probably because of the slight annealing to which the other objects had been subjected.

A final observation relates to the microporosities of the cast objects. These were voids, almost under vacuum, immediately after casting, and many of them were interconnected. If open to the surroundings they easily corrode, generally giving rise to red copper oxides. The lur parts Nos. 11 A and 11 B are good examples of this behaviour.

## CONCLUSIONS

1. The spectrographic data of Junghans et al. (1968) are supported by our results.
2. The two oldest objects are copper-arsenic alloys, without sulphides. They are interpreted as produced from a sulphide-free gossan in Central Europe, possibly in the present Austria-Hungarian region.
3. The later objects are rich in sulphides and are interpreted as having been produced from a sulphide-containing gossan, or from sulphides proper.
4. The presence of sulphur is very close to a guarantee that an object is ancient and not a 20th century replica. Replicas will have been made from modern alloys, and these are all sulphide-free.
5. Axes Nos. 5–10 and the lurs have tin at levels which suggest a deliberate addition of tin metal or tin ore to obtain specific properties.
6. Even after the introduction of tin arsenic remains present in all the examined objects at levels of 0.4–1.0 wt.%.
7. The objects are poor in zinc, cobalt, gold, and bismuth, i.e. these elements occur at levels below 0.05 wt.%, our equipment's limit of detection. Only the LBA lur No. 12 shows some cobalt, 0.25%.
8. Lead is present in four objects, the axes No. 7, No. 8, and No. 9 from the early Bronze Age and the Ulvkær lur from the late Bronze Age, which has no less than 3.0 wt.% lead.
9. Iron in prehistoric bronzes is very low. Although it has been proposed, based upon the rusty appearance of some corrosion products, that iron might be a significant alloying element, this is not so. When iron is present in very small quantities it is not evenly distributed throughout the metal, but is found in solid solution in the copper sulphide inclusions.
10. Samples taken from different positions show that individual objects are of the same composition everywhere, within analytical error. Inverse segregation was not observed.
11. The tongue-shaped "axe" (No. 1) and the shaft-hole axe (No. 8) are unsymmetrical, unfinished, and made with impure alloys. It is suggested that they represent semi-fabricates.
12. The presence of sulphides ($Cu_2S$ or $Cu_9S_5$) is helpful, because they preserve evidence of the ore type, tech-

nology (such as the composition of the furnace atmosphere), the solidification by preferential nucleation (No. 11 A), and the degree of working.

13. Eight of the ten axes have been worked on both the cutting-edges and the flanges. Four of them were left in the cold-worked hard condition, four others were annealed to somewhat lower hardnesses.
14. The working of the edges and the flanges served a) to improve the shape, b) to close the microporosities, c) to add substantial hardness.
15. The hardness of the cutting-edge is above 150 on six axes, and above 200 on three of these. The hardness of cold-worked, low-carbon wrought iron is in the same region.
16. The addition of arsenic hardens copper significantly more than the same weight % tin addition. On cold-working the differences become still more pronounced (figs. 19–20). Early Bronze Age axes from Denmark usually contain as little as 0.5–2.0 wt.% As, but they are seen from this point of view legitimate arsenic bronzes.
17. When cold-working these alloys, the hardness increases easily by a factor of 3. Cold-working beyond 70–80 % introduces risks of cracking, ruining the edges or the flanges. A proper anneal before this degree of reduction is reached serves to soften the metal, so that it can be further worked without the risk of cracking. The softest state of any alloy will be reached by thorough annealing after slight reduction (10–20 %).
18. The hardness of complex copper alloys is not simply additive. Nevertheless, in fig. 87 an attempt is presented to display the range of cast, cold-worked, and annealed alloys. Phosphorus which is present in many modern bronzes as a deoxidizing agent and known to add substantially to the hardness, was not present in our synthetic series of alloys.
19. The lurs are unworked. A lower-melting alloy, No. 11 A, has been selected by the ancient smith to prepare the assembly of individual tube segments. The lurs have abundant microporosities and owing to corrosion are much more fragile today than in the Bronze Age.
20. The corrosion products range from simple red copper oxide, $Cu_2O$, to complex, copper-depleted, greenish, brownish, or blueish oxy-hydroxycarbonates, which were not further examined. Iron and chlorine are common components of the corrosion products and must have been introduced from the environment during the long exposure to ground-water. It is therefore important that no corrosion products should be included in the analysis.
21. Destannification is well-developed on three objects, No. 8, No. 9, and No. 11 B, in spite of the presence of almost 1 wt.% arsenic. The re-precipitated metal is almost pure copper, but apparently has up to 1 wt.% iron in solid solution.
22. The axe No. 7 has lain in an anaerobic, peaty environment and acquired a millimetre-thick covering of $Cu_2S$ and of complex copper sulphides. The sulphur is derived from the environment.
23. Corrosion of annealed alloys is generally intercrystalline. Corrosion of severely cold-worked alloys generally follows the deformation grid of the metallic grains, suggesting stress-corrosion.
24. The chronological arrangement of objects 1–12 was suggested before the start of this project. The analytical data and the structural observations let us vaguely distinguish five groups, more or less overlapping in time: a) Cu-As-O, b) Cu-As-S, c) Cu-As-low Sn-S, d) Cu-As-high Sn-S, and e) Cu-high Sn-S-Pb. This development occurs over about 2800 years in our area, from about 3500 to 700 B.C.
25. The combination of spectrographic analysis and microprobe analysis with scanning electron microscopy and classical metallography, including hardness determination, is the best way to examine ancient bronze objects and their technology.

Vagn F. Buchwald and Peter Leisner, Institute of Metallurgy, *Danmarks Tekniske Højskole,* DK-2800 Lyngby.

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# A Late Neolithic Hoard from Vigerslev, North Sealand

## – An Archaeological and Metal Analytical Classification

by HELLE VANDKILDE

In 1975 a metal-hilted dagger and a flanged axe of copper or bronze were found during construction work in a garden, situated c. 100 ms east of Harrestrup brook and c. 760 ms to the south of the Damhus lake in Vigerslev in the Parish of Copenhagen (sb 68), District of Sokkelund, County of Copenhagen (1). For the find circumstances we have to rely largely on a report made by the finder a year after the discovery: The dagger and the axe lay close together, "within two spits", in sand c. 2 ms below the present surface; however, some 0.7 m fill have been added in recent times. During the construction work the finder noted two layers of sand separated by a peat-like layer, but he did not observe whether the objects were connected with the upper or lower layer of sand. An area of approximately 5 × 3.5 m was searched, but other objects did not appear.

The find circumstances indicate that the dagger and the axe make up a hoard or part of a hoard. In the corroded surface of the metal there are impressions of plants, which have been examined by Claus Malmros of the Scientific Department of the National Museum: The remains are identified as plant roots, possibly rhizomes and leaves, perhaps from grasses. The presence of leaves together with roots can be explained by the fact that the growth of grass leaves may start below the soil surface. The phenomenon is interpreted by Malmros as herbs, that grew on the site where the objects were deposited, rather than material wrapped around the objects. The remains of leaves are too few to justify the latter explanation. Moreover, the nature of the plant remains indicates that the metal objects derive from a moist layer of peat, mud or perhaps sand, that has been penetrated by moor plants. Such an environment is found at the shores of lakes and streams that are in the process of being overgrown, and Malmros points out that it is in good agreement with the immediate topography of the site and with the stratigraphical observations of the finder.

In conclusion, the objects were presumably deposited in wet terrain as a ritual action or part of such action. In that respect the Vigerslev hoard joins the majority of contemporary metal find.

## DESCRIPTION AND CLASSIFICATION

*The metal-hilted dagger* (fig. 1)
The thick corrosion layer with plant remains covers most of the surface, but was partially removed on one side of the hafting-plate, so that the decoration and the casting technique could be studied. The blade point is missing, and the fracture is covered by corrosion. It is thus likely that the point was already missing, when the dagger was hoarded. The preserved length is 20.9 cms; the original length was around 28–29 cms.

The pommel has an approximately circular outline, and it is flat with a slight concavity on top. The transition to the hilt itself is convex and not quite regular. The latter, which has an irregularly oval transverse section, narrows towards the hafting-plate, the shoulders of which are distinctly and evenly rounded. The indentation is mushroom-shaped and closed towards the blade. The terminations of the hafting-plate are oblique with an upwards tilt. The edges of the triangular blade are much damaged, but preserved parts show that the edge outline was slightly concave.

The hilt itself is divided into undecorated and decorated zones. Each decorated zone consists of three, somewhat irregular, horizontal grooves, except the lowest zone, which has four grooves. The distance between the grooves is not quite regular. The lower edge of the hafting-plate is decorated with closely, not very carefully set, shallow strokes. A row of originally around sixteen, small "false" rivets decorates the shoulder. The rib of the blade is tripartite, divided by a relatively broad, straight central rib, flanked by narrower, slightly curved ribs. There are no traces of wear. The decoration appears distinct, and

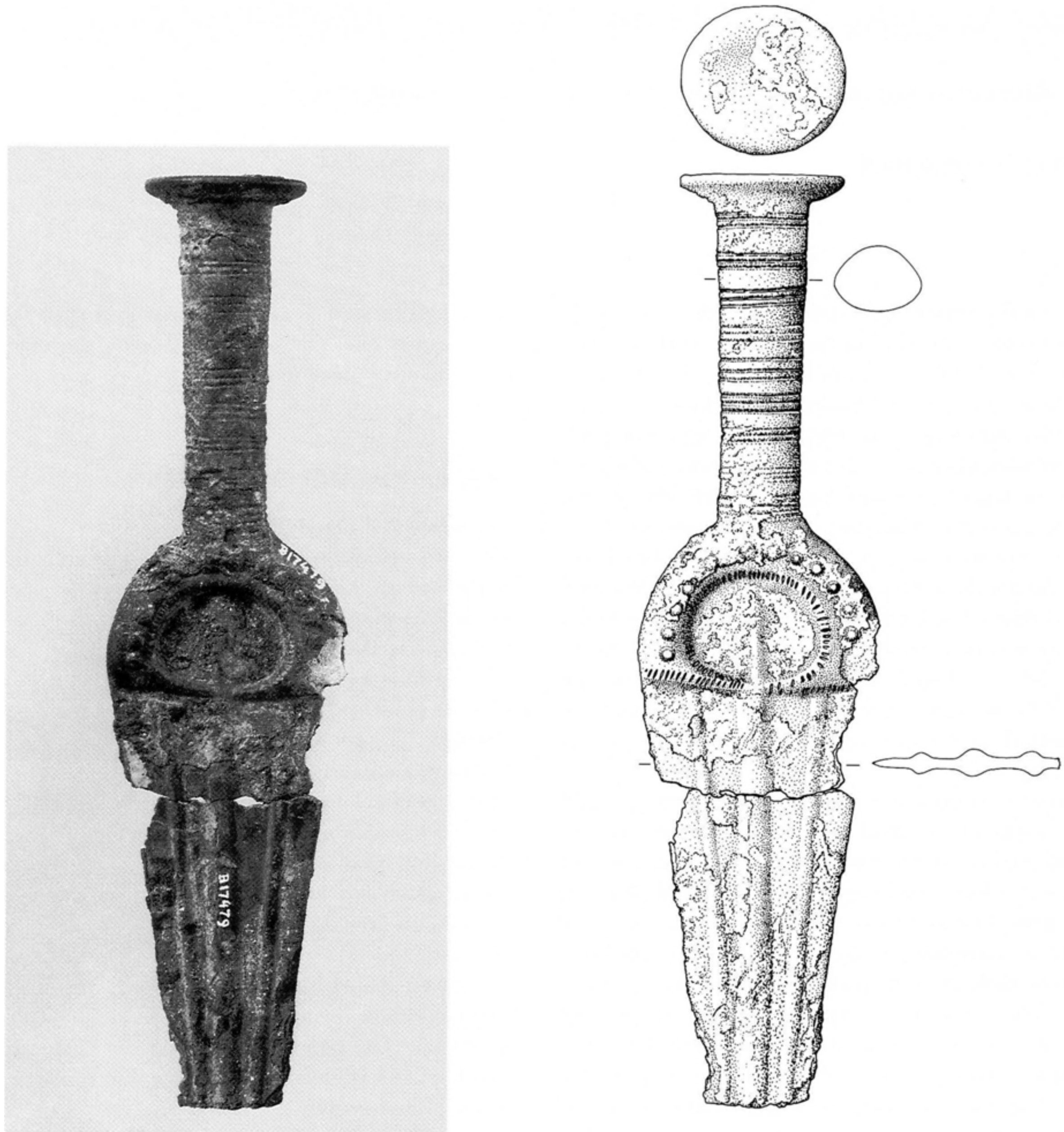


Fig. 1. The Vigerslev metal-hilted dagger, scale 2:3 (P.Delholm photo, E.Morville del.).

preserved parts of the cutting edge are sharp. The weight is 258 grammes.

The Vigerslev dagger belongs typologically to the metal-hilted daggers with triangular blade of the central European Early Bronze Age. Such daggers are normally produced according to one of three methods: 1. Cast in one piece during a single process. 2. Cast in two pieces, joined with rivets. 3. Cast apparently in one piece, but during two phases, *Überfangsguss*. Casting a metal-hilted dagger in one piece during a single process gives a strong product. Technically, however, it must be difficult to deal with such heterogeneous elements as blade and hilt in one process, and this may thus result in variability in regard to the quality of the products. Casting the blade and hilt separately makes the casting easier and more efficient. It gives the opportunity to insert a clay core in the hilt, thus saving metal, but the joint constitutes the weak point of such a dagger. The method of *Überfangsguss* has the advantages of both these methods. Although *Überfangsguss* is known in the late part of the EBA, for instance in the casting of metal-hafted halberds, few of the metal-hilted daggers with triangular blade seem to have been made by this technique (Drescher 1958, 30). They are usually either cast in one piece, or in two pieces, that are joined by rivets.

In the Vigerslev case the second method can be ruled out. All rivets are false, and the transition between hilt and blade is smooth. Several elements suggest the first method. In the indentation the central rib is distinctly narrower than on the blade, and an X-ray photograph (fig. 2) demonstrates that inside the indentation the blade is considerably thinner than outside, which would not be the case if the dagger had been cast by the second or the third technique. This can only be explained by supposing that the dagger was cast during a single process in one piece. The X-ray photo also shows, that the hilt is solid, which is unlikely if blade and hilt had been cast separately or by *Überfangsguss*.

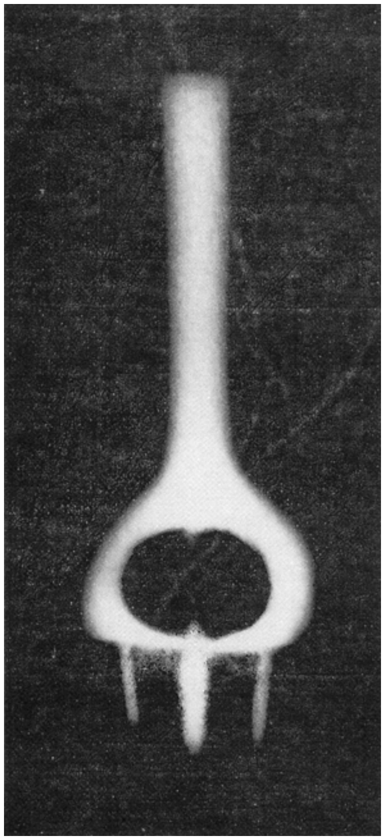

Fig. 2. X-ray photo of the dagger 2:3 (H.Strehle photo).

Uenze (1938) has divided metal-hilted daggers with triangular blade into seven types, that have different geographical centres of gravity and also somewhat different chronological positions, as the Úněticean daggers belong to Br.A1b, whereas the southern daggers tend to cover also Br.A2. The Vigerslev dagger does not fit particularly well into any of these types, although it has features in common with all of them (table 1).

The table shows that the Vigerslev dagger has more elements in common with type Aunjetitz than with any of the other types, but there are also important differences. None of the metal-hilted daggers of type Aunjetitz have a tripartite midrib. Tripartite and bipartite midribs are more frequent on Úněticean halberd blades (Otto & Witter 1952, Z729, AZ811, Z919; Ke 367). The daggers of type Aunjetitz are, moreover, usually cast in two or three separate pieces that are joined with rivets (Uenze 1938, 31ff). Type Aunjetitz is most frequent in the central areas of the Únětice culture, in north Bohemia and central Germany, and occurs more sporadically north of this region, as imports (Schubart 1972, Taf. 60N and 101.1) or local copies (Gedl 1980, Taf. 1). A few daggers of type Aunjetitz found in northern Poland and Mecklenburg are actually cast in one piece during a single process (Gedl 1980, Taf. 1.3–1.6) or by *Überfangsguss* (Schubart 1972, 125, Taf. 101.1).

The Vigerslev dagger was most likely manufactured in the Baltic periphery of the Únětice culture as a local imitation of the metal-hilted dagger of type Aunjetitz. This is in harmony with the casting technique, inasmuch as the simple, one-piece casting is very often used in the manufacture of daggers in this region. It is also in accordance with the mixture of elements present in this dagger. In the Baltic region peculiar daggers that cannot easily be classified into Uenze's typology are sometimes encountered (Schubart 1972, Taf. 1D, 50I, 90A; Kersten 1958, Taf. 84: 767, Taf. 99: 879; Gedl 1980, Taf. 5: 28–29). As an example of such syncretistic specimens may be mentioned the dagger from Alt-Schönau, Kr. Waren in Mecklenburg (fig. 3). Its tripartite midrib and its zones of grooves and strokes on the hilt makes it a close parallel to the Vigerslev dagger.

| ELEMENTS OF THE VIGERSLEV DAGGER | DAGGER TYPES: Rhône | Italian | Swiss | Aunjetitz | Oder-Elbe | Malchin | Saxon |
|---|---|---|---|---|---|---|---|
| 1. flat pommel | X | X | | X | X | | |
| 2. hilt widest towards pommel | | | | X | (X) | X | X |
| 3. distinctly rounded shoulders | X | X | X | X | | X | X |
| 4. many, small rivets (false?) | | X | | | X | | |
| 5. mushrum-shaped indentation | X | (X) | (X) | X | | X | |
| 6. closed indentation | | | | (X) | | (X) | |
| 7. oblique hilt terminations | (X) | (X) | | (X) | | | (X) |
| 8. broad, slightly curved blade | | X | X | X | X | | |
| 9. tripartite midrib on blade | | (X) | | | | | |
| 10. zones of grooves on the hilt | (X) | | | X | (X) | (X) | (X) |
| 11. strokes on hafting-plate | | | | X | (X) | (X) | (X) |
| 12. cast in one piece | | | | OO | X | X | |
| 13. high tin bronze (class 6) | X | X | X | (X) | | | |
| total number of elements min. | 4 | 5 | 3 | 7 | 4 | 4 | 2 |
| max. | 6 | 8 | 4 | 11 | 7 | 7 | 5 |

Table 1. Comparison of the Vigerslev dagger to Uenze's dagger types. X = commonly occurring. (X) = occasionally present. OO = seems to occur sometimes, although not mentioned by Uenze (1938).

| TIN CLASS | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|
| ÚNĚTICEAN REGION: | | | | | | | |
| 1. Baltic | 9 | 8 | 8 | 2 | 2 | | 29 |
| 2. Berlin-Brandenburg | 3 | | 6 | | 1 | | 10 |
| 3. Spree-Neisse | | | 25 | 3 | | | 28 |
| 4. Riesa-Dresden-Bautzen | | 1 | | | | 1 | 2 |
| 5. Unstrutt-Saale | | 2 | | 2 | | | 4 |
| 6. North Bohemia | 3 | 5 | 2 | 3 | 2 | 1 | 16 |
| total number of analyses | 15 | 16 | 41 | 11 | 5 | 2 | 89 |

Table 2. Geographical comparison of tin content in Únêticean metal-hilted daggers. Tin class 1: tin free copper; class 2: tin present as an impurity, trace-0.126%; class 3: tin copper, 0.127–2.0%; class 4: low tin bronze, 2.01–4.0%; class 5: medium tin bronze, 4.01–7.95%; class 6: high tin bronze, 7.96–>10%. (Data from Junghans *et al.* 1968–74, SAM 2:3 and 2:4; Otto & Witter 1952).

Whereas Únĕticean halberds, irrespective of the various local styles, are very often manufactured in high tin bronze, the high tin percent of the Vigerslev dagger, 15–16% (class 6), is rarely found among Únĕticean metal-hilted daggers. In a sample of 89 analyses of metal-hilted daggers only two analyses exhibited such high tin percentages, and they come from central Germany and north Bohemia (table 2). Such an origin for the dagger can, however, probably be ruled out with reference to the archaeological evidence.

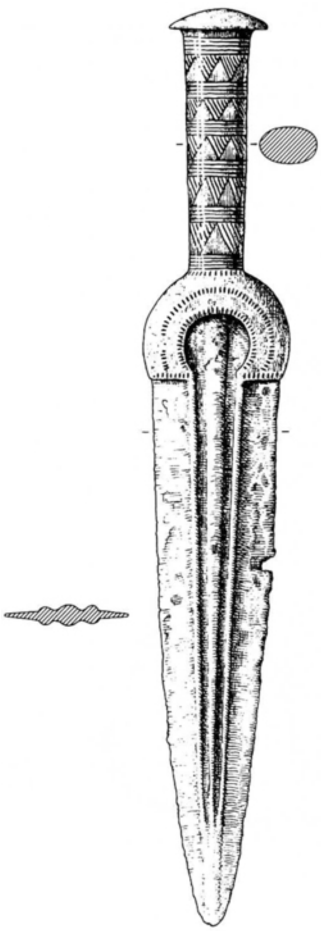

Fig. 3. Metal-hilted dagger from Alt-Schönau, Kr. Waren in Mecklenburg, scale 2:3 (Schubart 1972, Taf. 1D). The dagger has no tin (SAM 2:3, no. 9630).

The Vigerslev dagger is the sixth metal-hilted dagger with triangular blade found in Scandinavia. The daggers from Emb, Brøndum, Säter, and Pile (two specimens) have been treated by Lomborg (1969, 219ff). Apart from the very simple and atypical Emb dagger, which is considered to be local, these daggers belong to Uenze's Saxon type (Brøndum and Pile) and to his Malchin type (Säter). Metal-hilted daggers of Saxon and Malchin type were manufactured in the Baltic region of Mecklenburg and Pomerania (Lomborg 1969, 222; Uenze 1938, 60f, 85, Karte 13; Gedl 1980, 15, 21ff, Taf. 23). Hence, in regard to the place of manufacture the Vigerslev dagger joins the other Úněticean metal-hilted daggers found in south Scandinavia.

*The flanged axe* (fig. 4)
A thick layer of corrosion covers most of the surface of the axe. Because of the plant remains a removal of the corrosion was not attempted during conservation. The original surface is dark green and slightly uneven. In places near the edge the shining pink colour of the copper is visible.

The axe is 15.5 cms long and seen from the face the sides are parallel from the butt as far as almost midway, whereupon they begin to flare quite widely and concavely towards the cutting edge. Thus, the basic shape of the axe is parallelsided-curved.

The butt-end is 2.9 cms wide and convexly curved. The edge is 6.9 cms wide and quite expanding with a depth of 1.7 cms. The flanges are rounded, and their height does not exceed 0.2 cm; the axe can thus be classified as low-flanged. On the better preserved of the faces (fig. 4: drawing) there is no transverse bevel. The narrow sides are decorated with two longitudinal facets forming a pointed oval, that matches the contour of the profile itself. Decoration is only visible on one face where several, indistinct facets are placed with regular intervals on the lower half of the axe, parallel to the cutting edge. There is also a faint edge bevel. The weight is 431 grammes.

The cutting edge is sharp and does not seem damaged or much resharpened. The faintness of the ornamental facets on the face may suggest wear; on the other hand, the facets of the narrow sides appear rather distinct.

The Vigerslev axe belongs to type Værslev, a group of c. 30 low-flanged, parallelsided-curved axes with Pile style of decoration, named after a hoard in northwest Sealand (Vandkilde 1989, 32, fig. 5; 1990b, 182f, Abb. 5). Type Værslev makes up the essence of Forssander's "Pile Axe" (1936, 169ff). Flanged axes of type Værslev are particularly frequent in east Jutland and northwest Sealand; the type is also found in southern Sweden. The Vigerslev axe has a broader butt in relation to the width than most of the Værslev axes, and it belongs to the variant with hammered facets instead of lines parallel to the cutting edge.

## CHRONOLOGY

On the basis of a seriation of 35 hoards of early metal objects a late phase of the Late Neolithic Period (LN II) and two phases of the first period of the Bronze Age (Period IA and Period IB) were distinguished (Vandkilde

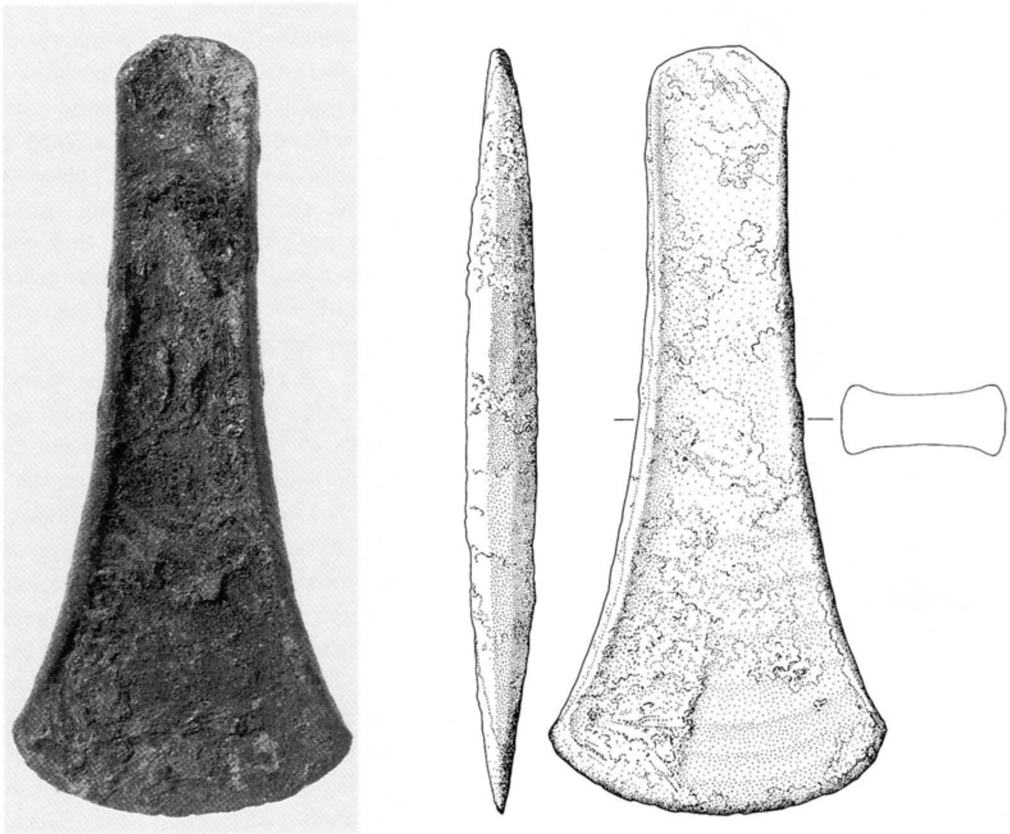

Fig. 4. The Vigerslev low-flanged axe, scale 2:3 (P.Delholm photo, E.Morville del.).

1989, 29f, figs. 2–3; 1990a, 128ff, figs. 13–14; 1990b, 177ff, Abb. 2–3). The Vigerslev hoard is clearly attached to the LN II hoards.

Axes of type Værslev occur mainly as singly deposited pieces, but the type is also known from six hoards: Gallemose (Ke. 5492), Egå (Ke. 5554), Vrold Østergård (Ke. 4554I), Værslev (Ke. 1017), and the Scanian hoards of Pile (Ol. 832) and Balkråka (Ol. 15). All six hoards date to the LN II Period.

Of the five metal-hilted daggers with triangular blade previously found in Scandinavia two have been found in a hoard, Pile, and this hoard is safely dated to the LN II Period. In the Úněticean region metal-hilted daggers with triangular blade are found in hoards of the classical phase, and this period has elsewhere been shown to be synchronous with the LN II Period (Lomborg 1973, 142; Vandkilde 1989, fig. 1; 1990b, 176ff, Abb. 1). Thus, the Vigerslev dagger emphasizes this synchronism.

By far the majority of the LN II metal objects are singly hoarded objects. Less frequent are hoards, containing two or more flanged axes. A small number of hoards, Gallemose, Pile, and Skeldal, contain several different types and characteristically combine locally manufactured flanged axes with foreign imports, just like the Vigerslev hoard. Metal objects in burials are infrequent. A specific pattern for ritual depositions of metal objects thus exists, reflecting aspects of ideology and social organization.

In regard to geographical position the Vigerslev hoard is situated periphercally to the distributional centre of gravity of the Danish LN II metal finds in east Jutland, north Funen and northwest Sealand (Vandkilde 1989, 40, fig. 17; 1990a, fig. 15; 1990b, 192ff).

## METAL ANALYSIS

Metal analysis was carried out on the Vigerslev objects as part of an analysis programme, that also included the Skeldal hoard (Vandkilde, this volume). To facilitate comparison with the SAM programme (Junghans *et al.*

1960, 1968, 1974) the objects were analysed quantitatively for the same eleven elements, other than copper (Cu): tin (Sn), arsenic (As), lead (Pb), antimony (Sb), silver (Ag), nickel (Ni), bismuth (Bi), cobalt (Co), gold (Au), zinc (Zn), and iron (Fe).

The analyses were made by two laboratories, and three different methods were used: The Department of Metallurgy and Science of Materials, University of Oxford, used electron probe microanalysis (EPM), and *Risø National Laboratory* used energy dispersive X-ray fluorescence (EDXRF) and induction-coupled plasma-mass spectroscopy (ICP-MS). A sample from the axe was analysed twice by EDXRF and once by EPM and once by ICP-MS. A sample from the blade of the dagger was analysed twice by EDXRF and once by ICP-MS; a sample from the pommel was analysed once by EPM, a total of eight raw analyses (Appendix). This gives a rare opportunity to compare and evaluate different metal analytical

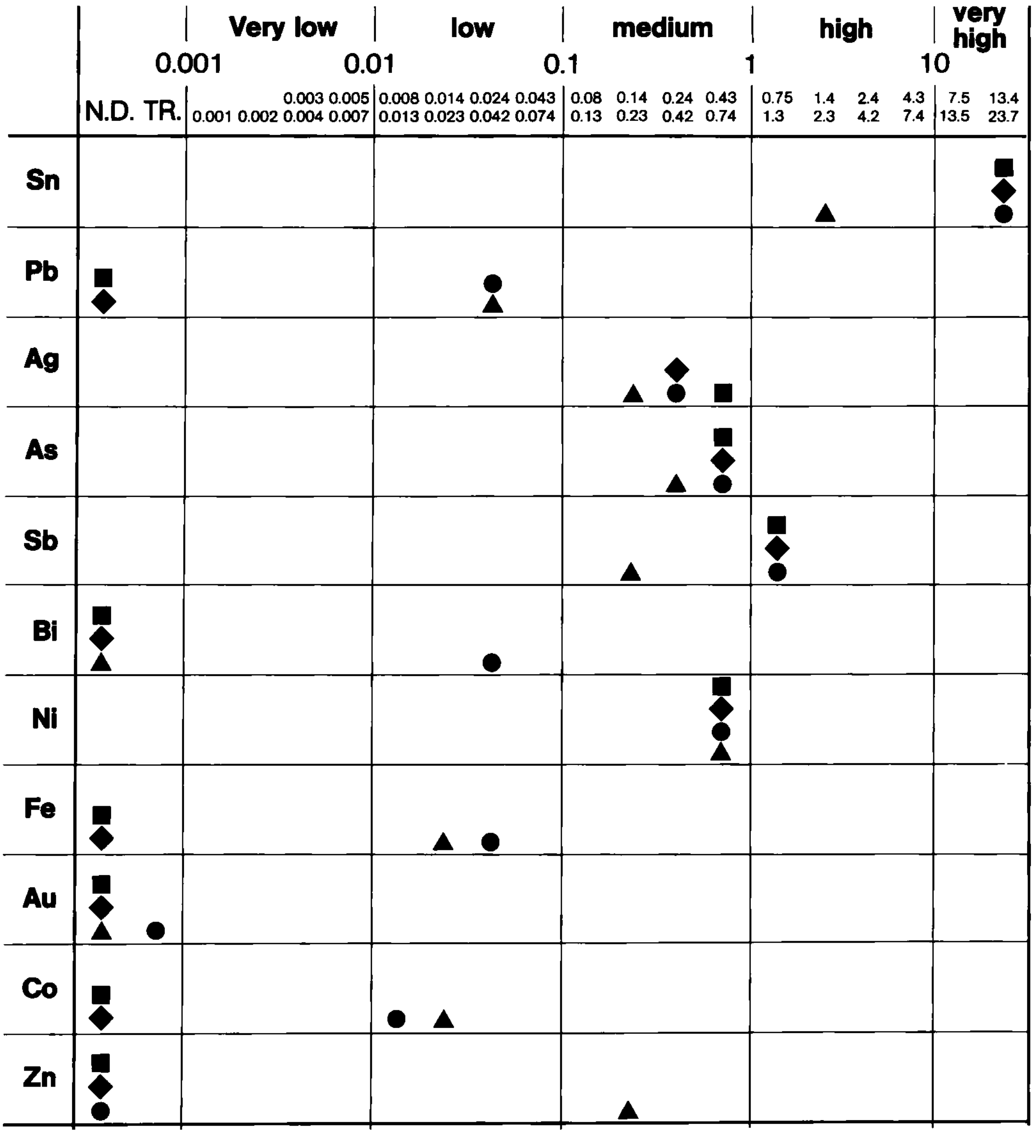


Fig. 5. Waterbolk-Butler diagram presenting the four metal analyses of the Vigerslev dagger by different methods and laboratories. Symbols: ICP-MS = triangle, EPM = circle, EDXRF 1 = rhomb, EDXRF 2 = quadrangle. (J.Kirkeby del.).

methods (2). A brief survey of the comparability and an archaeological evaluation of the analyses are presented below.

The analyses were entered into Waterbolk-Butler worksheet graphs (Waterbolk & Butler 1965) (figs. 5–6). In regard to the most important grouping indicators Ag, As, Sb, and Ni (3) there is a general agreement between the results of the three methods. In regard to Bi, which is also fairly important, there is only a little variability within the lowest ranges. The values of Pb, Fe, Co, and to some degree Zn show dissimilarities, which may be serious, if included in a statistical description. In regard to Pb, Fe, and Co the results of the ICP-MS method are in accordance with the EPM method, whereas they are undetected by the EDXRF method. The Sn values are fairly similar, apart from the ICP-MS analysis of the dagger, which misjudges the tin content completely.

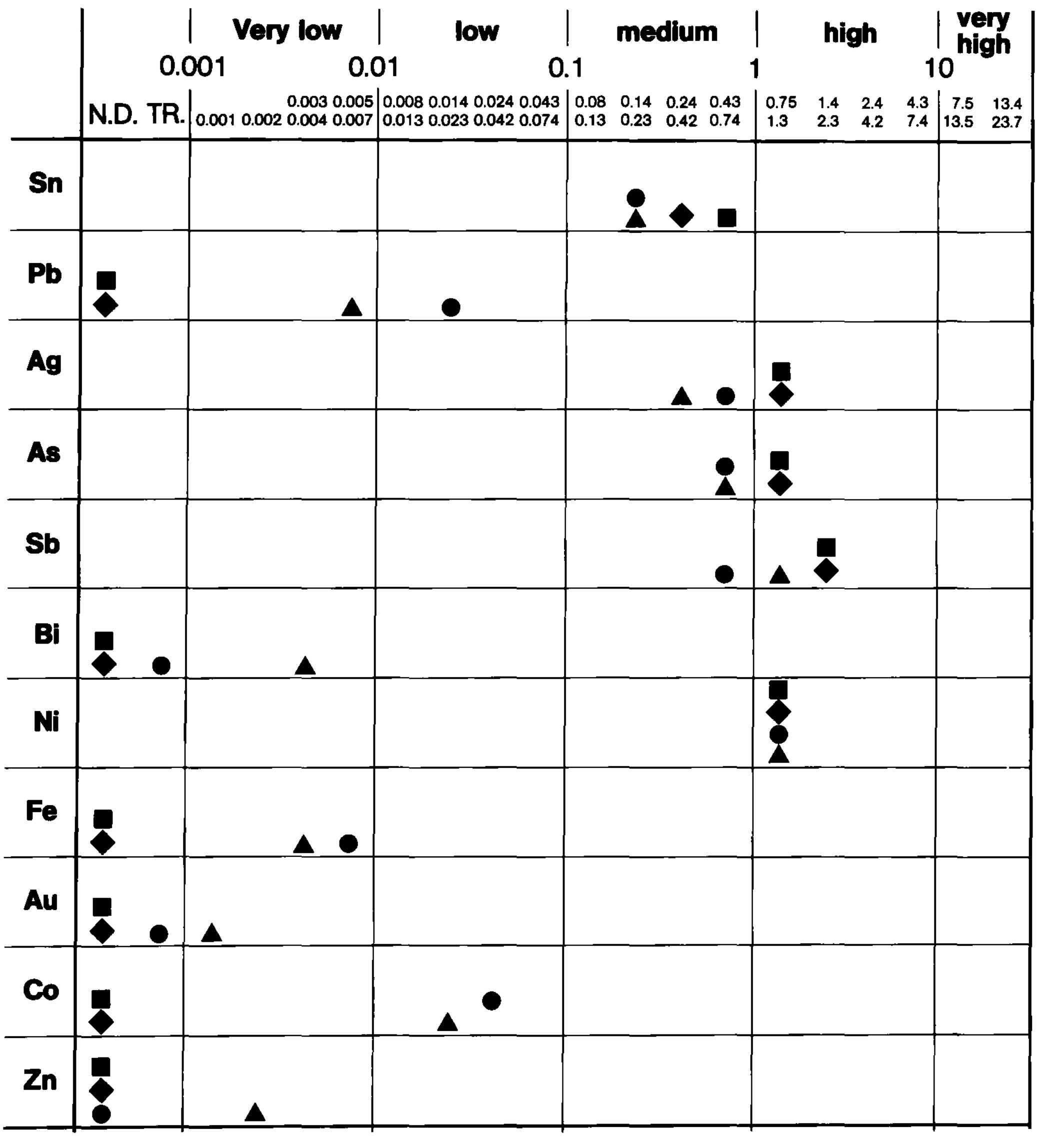


Fig. 6. Waterbolk-Butler diagram presenting the four metal analyses of the Vigerslev axe by different methods and laboratories. Symbols: ICP-MS = triangle, EPM = circle, EDXRF 1 = rhomb, EDXRF 2 = quadrangle. (J.Kirkeby del.).

In conclusion, the results from the three methods show an acceptable agreement in regard to the major impurities of copper. The ICP-MS method has difficulties in measuring larger quantities of tin. Taken the importance of tin as alloying material, such inaccuracy is of course serious. There is good agreement between the two EDXRF analyses; this method, however, appeared to be unable to detect elements occurring in small quantities, which is usually the case with Pb, Bi, Fe, Au, Co, and Zn. This leaves the EPM method as the most accurate of the three methods.

A classification of the eight raw metal analyses into the SAM *Materialgruppen* (fig. 7), based on variability in the content of Ag, As, Sb, Ni, and Bi (cf. Junghans *et al.* 1968, SAM 2,2: Tabelle 1), confirms the homogeneous distribution of these major elements. The results of all three methods refer the dagger to *Materialgruppe* B2 and the axe to *Materialgruppe* A. *Materialgruppe* A and B2 are both high impurity coppers with Ag, As, Sb, and Ni as the principal impurities. The two copper types only differ in the contents of Ni, which is lower in the B2 type; they correspond approximately to the "Singen metal" of Waterbolk and Butler (1965, Graphs 8–9) and Liversage (1989, 59f).

*Materialgruppe* A and B2 are very common copper types in the LN II Period in Denmark and contemporary central Europe (Vandkilde 1992 (this volume), fig. 7A, figs. 8A-B). They are still frequent in Period IA and Br.A2 (*op. cit.*, fig. 7B and 8C-D), but the tin levels of the Vigerslev objects do not make such a date likely. The dagger has 15–16% tin and the axe 0.2–0.6% tin, tin class 6 and 3 respectively (cf. table 2 and *op. cit.*, 123). In Period IA the tin value is seldom below 4% and rarely above 10%. A combination of highly variable tin values is very characteristic of the classical Úněticean phase and of the contemporary LN II Period (*op. cit.*, fig. 9A, 10A-B), contrary to the standardization of the succeeding period (*op. cit.*, fig. 9C). The metal groups and the tin content of the Vigerslev objects thus confirm the archaeological determination of chronology and intercultural relations.

According to Spindler (1971, 250f) a low percentage of tin as found in the Vigerslev axe was most likely not added to the copper during the process of manufacture of the axe, but is on the other hand probably too high to be a naturally occurring element of the copper. Tin class 3, (0.127–2.0%) or tin copper is very common in low-flanged axes of the LN II Period, and is probably a result of remelting and mixing copper belonging to various tin classes.

| Method of analysis | | Dagger | Axe |
|---|---|---|---|
| EPM | | B2 | A |
| EDXRF | 1 | B2 | A |
| EDXRF | 2 | B2 | A |
| ICP-MS | | B2 | A |

Fig. 7. Table presenting the classification into the SAM 2 *Materialgruppen* of the eigth metal analyses of the Vigerslev hoard by different methods and laboratories (J.Kirkeby del.).

Tin class 6 (7.96–>10%) is high tin bronze, and the dagger is in the upper end of this range, the golden colour visually distinguishing it from the axe. Such high tin bronzes are manufactured in central Europe for the first time in this period, i.e. around 1950–1700 B.C. They are most frequent in the centre of the Únětice culture in Thuringia, closest to the tin deposits of the Erzgebirge, the frequency generally decreasing with the distance from the centre (Vandkilde 1992, this volume figs. 10A-B). It may be argued (Vandkilde in press) that the emergence of the Úněticean centre is closely related to the discovery and exploitation of the Erzgebirge tin and the development of a tin-bronze technology. Distribution of tin, or tin bronze, appears to have been controlled by the centre, and we can be fairly certain that the tin in the dagger and in the axe from Vigerslev originated in the Erzgebirge, and therefore passed the centre at some point in time. In the Danish resource dependent periphery the Vigerslev metal-hilted dagger must have been very valuable, not only because of its prestige value, but also as potential raw material in the local production of flanged axes, the strength and efficacy of which depended on the quality of the metal.

Helle Vandkilde, Institute of Prehistoric Archaeology, University of Aarhus, Moesgård, DK-8270 Højbjerg.

NOTES

1. I wish to thank the 1. Department of the National Museum for permission to publish the Vigerslev hoard, conservator H.Strehle, Moesgård for discussions regarding the casting technique of the

dagger, and D.Liversage for revision of the English text. The Danish Research Council for the Humanities financed the metal analyses; the EPM analyses were made by P.Northover, the EDXRF and ICP-MS analyses by L.Højslet Christensen and K.Haydorn. The accession numbers in the register of the National Museum are B17479 (dagger) and B17480 (axe). "Ke." refers to numbers in Aner and Kersten 1973ff. "Ol" refers to numbers in Oldeberg 1974. The manuscript was finished august 1989.

2. This material is included in an extensive interlaboratory research programme organised by P. Northover of the Department of Metallurgy and Science of Materials, University of Oxford.
3. Elements that are not alloying additions and are suitable for classification purposes inasmuch as they show some relationship to the metal sources (Northover 1982, 229).

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## APPENDIX

The Raw Metal Analyses of the Vigerslev Hoard

| NM B17479 *dagger* | Sn | As | Sb | Pb | Co | Ni | Fe | Ag | Au | Zn | Bi | group |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EPM | 15.24 | 0.61 | 0.75 | 0.025 | 0.01 | 0.47 | 0.025 | 0.33 | tr. | – | 0.025 | B2 |
| EDXRF1 | 16.00 | 0.54 | 0.76 | | | 0.61 | | 0.34 | | | | B2 |
| EDXRF2 | 20.60 | 0.48 | 0.94 | | | 0.57 | | 0.44 | | | | B2 |
| ICP-MS | 1.60 | 0.365 | 0.22 | 0.03 | 0.015 | 0.46 | 0.021 | 0.19 | – | 0.196 | – | B2 |
| NM B17480 *axe* | | | | | | | | | | | | |
| EPM | 0.19 | 0.61 | 0.66 | 0.015 | 0.035 | 0.92 | 0.005 | 0.43 | tr. | – | tr. | A |
| EDXRF1 | 0.34 | 0.83 | 1.37 | | | 1.07 | | 0.78 | | | | A |
| EDXRF2 | 0.59 | 0.81 | 1.94 | | | 1.06 | | 1.05 | | | | A |
| ICP-MS | 0.19 | 0.72 | 0.756 | 0.005 | 0.017 | 0.76 | 0.003 | 0.33 | 0.001 | 0.002 | 0.003 | A |

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# Metal Analyses of the Skeldal Hoard and Aspects of Early Danish Metal Use

by HELLE VANDKILDE

An archaeological assessment of the Skeldal hoard has recently been published in this journal (Vandkilde 1990a). The hoard was found by Salten Langsø in the middle of Jutland, and it consisted of three low-flanged axes, the butt part of a fourth low-flanged axe, a nick-flanged double-edged chisel, a beehive-shaped box with lid, an open solid-cast ring, a spiral armring, a spiral bead, and two *Noppenringe*, all in copper or bronze; and a pair of golden *Noppenringe*. The objects were dated to the late part of the Late Neolithic Period (LN II) or c. 1950–1700 B.C. (cf. Vandkilde 1989, 29ff; 1990b, 175ff). It was argued that the flanged axes were produced in Denmark, with the possible exception of a trapezoidal axe in west European style, whereas the bronze ornaments and the chisel most probably came from the northern Únětice culture or its Baltic periphery, and it was suggested that the golden *Noppenringe* originated somewhere between the Erzgebirge and the Alps. The dating and the determination of the provenance was based purely on archaeological criteria. Already at this stage a metal analysis of the objects had been initiated in order to evaluate and supplement the archaeological evidence, and it is the results of this analysis that shall be reported on here (1).

The raw analysis data (appendix) will be classified according to different statistical procedures, and the results will be compared. The metal analyses of the Skeldal hoard will then be discussed in a local Danish and a wider European perspective. The analyses of the two golden *Noppenringe* will be treated in a separate chapter. The point of departure for the examination is a new chronological framework based largely on metal objects (Vandkilde 1986, 1989, 1990a, 1990b) (fig. 1).

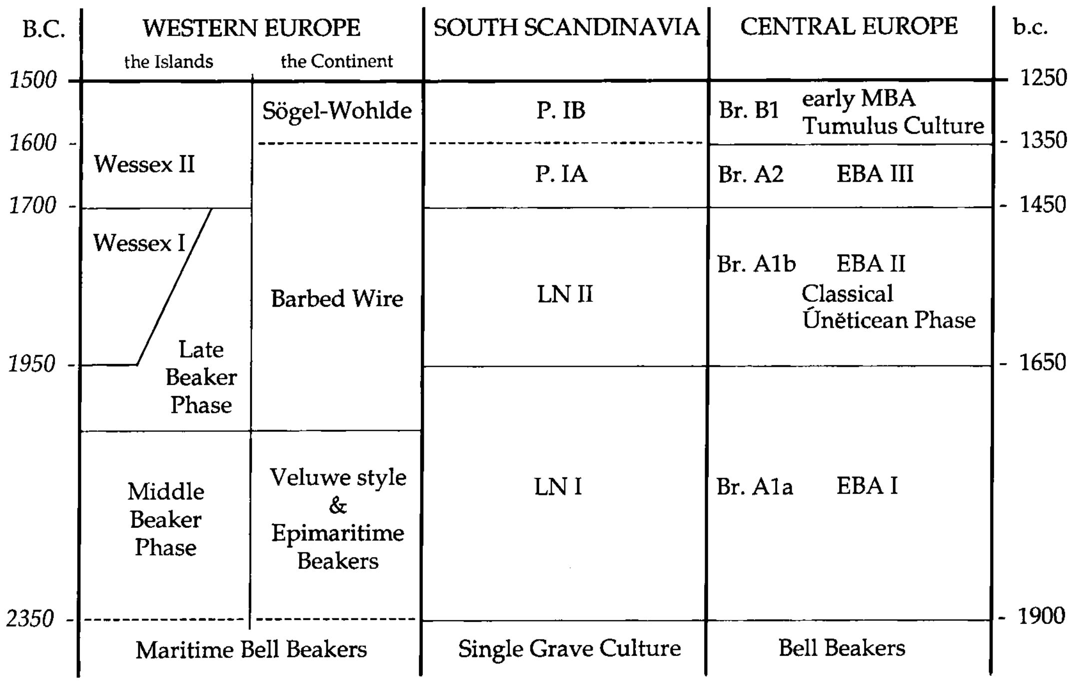



Fig. 1. Chronological table for the Danish Late Neolithic and earliest Bronze Age synchronized with central and west Europe.

## STATISTICAL CLASSIFICATION OF THE SKELDAL METAL ANALYTICAL DATA

Most Danish copper and bronze objects prior to Period II of the south Scandinavian Bronze Age have been analysed quantitatively for the most important elements other than copper (Cu): tin (Sn), arsenic (As), lead (Pb), antimony (Sb), silver (Ag), nickel (Ni), bismuth (Bi), cobalt (Co), gold (Au), zinc (Zn), and iron (Fe) by the *Arbeitsgemeinschaft für Metallurgie des Altertums* based in Stuttgart/Mainz during the 1950's and 1960's. The results of this project have appeared in a series of publications abbreviated SAM. The analyses of the Danish material have been published in SAM 2 (Junghans, Sangmeister, and Schröder 1968–1974, SAM 2:3 and 2:4; cf. Cullberg 1968, 170ff). The appearance of the Skeldal hoard gave the opportunity to continue the metal analyses with regard to objects, which had been overlooked or which have appeared after the termination of the SAM analysis program (2).

The Skeldal metal objects were analysed by electron probe microanalysis (EPM), which requires only very small samples (3–4 mg); it is non-destructive, i.e. the samples are preserved for future analysis, and it is in general suitable for the analysis of ancient metal work (Northover 1980, 1982; Härke 1978, 249). All objects in the hoard, with the exception of the small spiral bead, which was too damaged and corroded, were analysed quantitatively for the same elements as in the SAM program, to facilitate comparison. Thirteen samples were examined, including two samples from the beehive-shaped box (appendix).

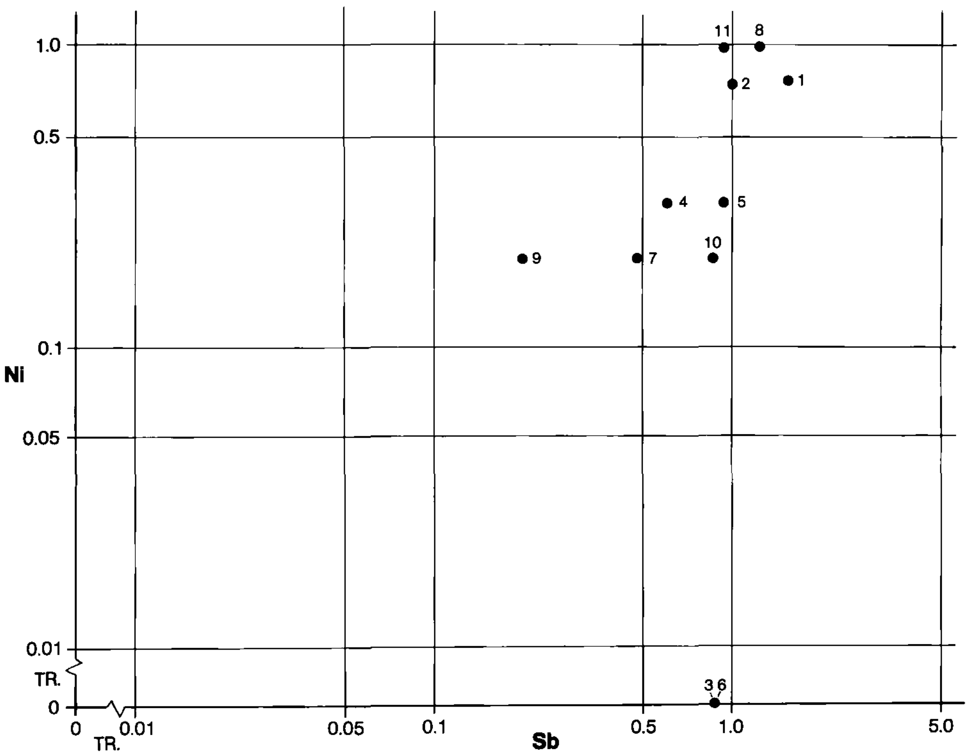
Cluster analysis has recently been much used for grouping metal analyses (Hodson 1969, 97ff; Ottaway 1974; Boomert 1975; Butler 1979; Pernicka 1984; Ryckner 1987, 22ff; Krause 1988, 192ff). Dealing with a limited number of objects, like the Skeldal hoard, there is, however, no need of multivariate methods. The Skeldal analyses will be classified according to three simple procedures: The Waterbolk-Butler graph method, a plot in a system of co-ordinates and the *Materialgruppen* of SAM 2.

The Waterbolk-Butler graph method was originally developed as an alternative to the SAM *Materialgruppen* (Waterbolk and Butler 1965, 234ff). Initially the grouping of the data was done by hand, the "impressionist way", using a so-called work-sheet graph, and the result was then illustrated in a corresponding histogram. Later, the work-sheet classification was partly replaced by an aver-

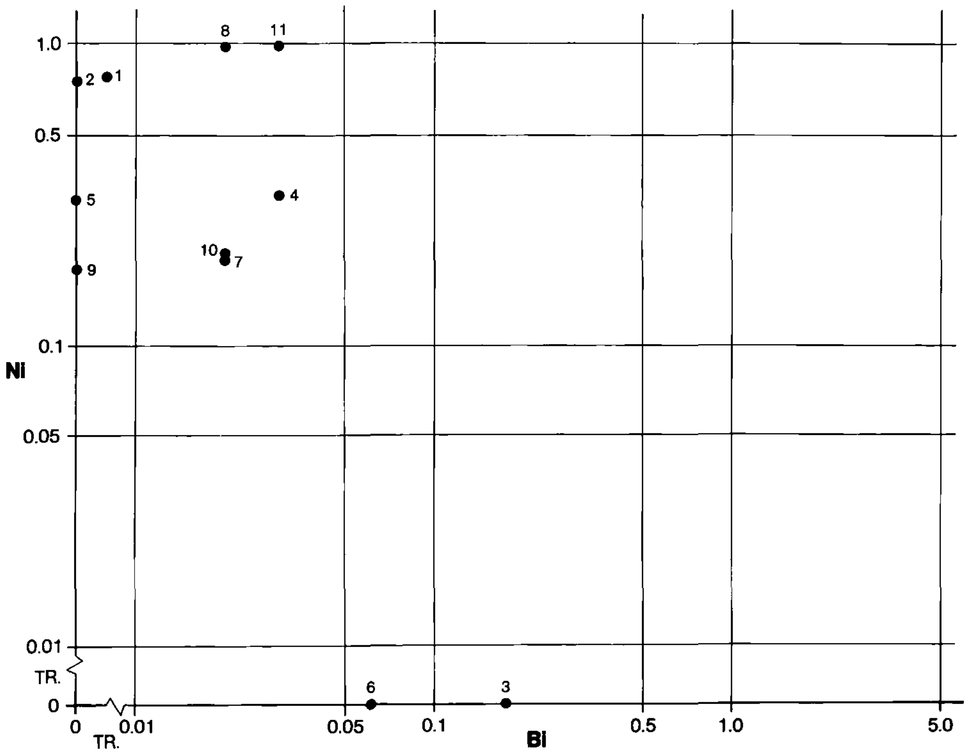
| | N.D. TR. | low | medium | high | very high |
|---|---|---|---|---|---|
| | 0.01 | 0.1 | 1 | 10 | |
| **Sn** | 3 | 7 6 | | 10 11 5 8 2 4 1 | 9 |
| **Pb** | 10 8 9 6 2 5 | 7 4 1 | 11 3 | | |
| **Ag** | | | 9 10 | 11 8 7 6 5 4 3 2 1 | |
| **As** | | 9 | 8 7 11 4 1 2 | 10 5 3 6 | |
| **Sb** | | | 9 7 4 | 11 10 8 6 5 3 2 1 | |
| **Bi** | 9 5 2 1 | 10 8 11 7 4 6 | 3 | | |
| **Ni** | 6 3 | | 10 9 5 7 4 2 | 11 8 1 | |
| **Fe** | 9 8 11 6 3 | 10 7 5 4 1 2 | | | |
| **Au** | 11 9 8 7 6 5 4 3 1 2 | 10 | | | |
| **Co** | 11 10 9 7 6 4 5 1 3 | 8 2 | | | |
| **Zn** | 9 8 7 6 4 3 11 2 10 1 5 | | | | |

Fig. 2. Waterbolk-Butler work-sheet graph of the Skeldal hoard. Numbers of objects with deviating metal composition have been accentuated. See fig. 5 for the logarithmic scale of each range.

A


Ni
1.0
0.5
0.1
0.05
0.01
TR.
0
0
TR.
0.01
0.05
0.1
0.5
1.0
5.0
Sb
1
2
3
4
5
6
7
8
9
10
11

B


Ni
1.0
0.5
0.1
0.05
0.01
TR.
0
0
TR.
0.01
0.05
0.1
0.5
1.0
5.0
Bi
1
2
3
4
5
6
7
8
9
10
11

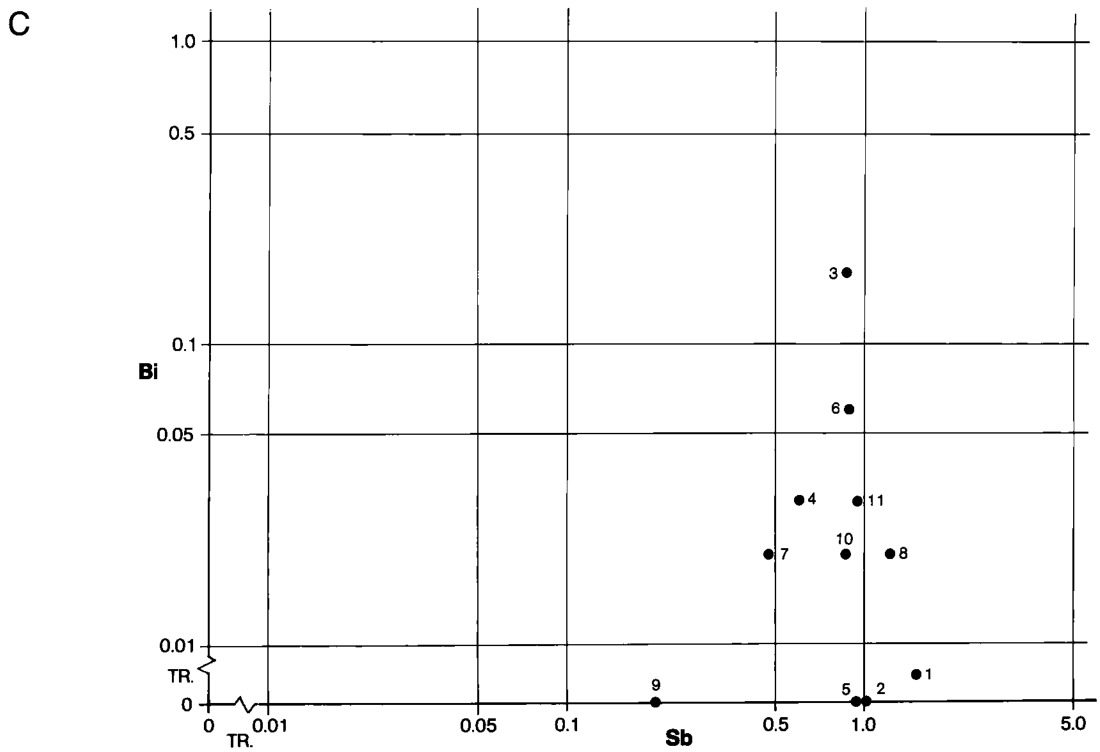



Fig. 3A–C. Bivariate plots of the relationship between selected elements: Sb, Ni, and Bi. A: The relationship between Ni and Sb. B: The relationship between Ni and Bi. C: The relationship between Bi and Sb.

age linkage cluster analysis by computer (Boomert 1975; Butler 1979), probably because it proved difficult to process large amounts of data on the basis of the work-sheet sorting. The representation of the results in histograms was, however, maintained.

Plotting the eleven Skeldal analyses into a Waterbolk-Butler work-sheet graph discloses a rather homogeneous impurity pattern with Ag, As, and Sb as the principal impurities in all objects (fig. 2). The metal of the Skeldal objects can be described as high impurity copper with a variable percentage of tin. Tin is an alloying addition in most of these objects (see below) and is therefore left out of consideration in this analysis. Pb, Bi, Ni, and Fe have differing values, while Au, Co, and Zn are, as is normally the case, present at a very low level or not present. It is immediately noticed that no. 9 falls outside the main distribution, but also no. 3 and no. 6 deviate from the main group, especially regarding the lack of Ni. This coincides with slightly higher contents of Bi and As than are found in the main group. Neither the Pb nor the Fe value seems to be of any significance.

This sorting procedure results in the following three groups:

| | |
|---|---|
| Group I | Medium to high Ag, As, Sb, and Ni: nos. 1, 2, 4, 5, 7, 8, 10, and 11. |
| Group II | High Ag, Sb, and As; As higher than in group I; Ni not present: nos. 3 and 6. |
| Group III | Medium Ag and Sb; rather low As: no. 9. |

Liversage has recently advocated a computer-based use of the Waterbolk-Butler work-sheet sorting, on the basis of which he numerically defines four metal types in the Danish material (Liversage *et al.* 1989; Liversage 1989). His metal types agree quite well with the above metal groups. Group I corresponds roughly to the "Singen metal" of Liversage, however, with nos. 4, 5, and 7 at the border line between "Singen metal" and "*Ösenring* metal" (Liversage et al. 1989, 59, 64). Group II corresponds to Liversage's "Ösenring-metal", whereas Group III falls outside the system of Liversage.

The second statistical procedure is an attempt to classify the material by plotting impurity values of the main grouping indicators (cf. Northover 1982, 229) into a system of co-ordinates using logarithmic scales, thus illustrating the relationship between the elements. On the

| Waterbolk-Butler work-sheet graph | System of co-ordinates | SAM-"Materialgruppe" classification |
|---|---|---|
| **GROUP I:** no. 1, 2, 4, 5, 7, 8, 11 → | **GROUP IA:** no. 1, 2, 8, 11 → | **A:** no. 1, 2 |
| | | **A1:** no. 8, 11 |
| | **GROUP IB:** no. 4, 5, 7, 10 → | **B2:** no. 4, 5, 7, 10 |
| **GROUP II:** no. 3, 6 → | **GROUP II:** no. 3, 6 → | **C2c:** no. 3, 6 |
| **GROUP III:** no. 9 → | **GROUP III:** no. 9 → | **FG:** no. 9 |

Fig. 4. Comparative table with the metal groups achieved when using three different, bivariate statistical procedures.

basis of the work-sheet graph (fig. 2) only Ag, As, Sb, Ni, and possibly Bi are considered significant, and because of the nearly identical distribution of Sb, Ag and As, Sb was selected as representative of all three elements. Consequently, only the relationship between Sb, Ni, and Bi are examined (figs. 3A–C).

In all three logarithmic plots nos. 3 and 6 (Group II) deviate from the rest of the analyses. In the plots that relate Ni to Sb (fig. 3A) and Bi to Sb (fig. 3C), no. 9 (Group III) clearly falls outside the main distribution. A subdivision of Group I is indicated by the distribution of Ni (figs. 3A–B):

Group IA  Medium to high Ag, Sb, and As; high Ni: nos. 1, 2, 8, and 11.

Group IB  Medium to high Ag, Sb, and As; medium Ni: nos. 4, 5, 7, and 10.

Further subdivision cannot be inferred from this analysis (3).

The last procedure is the SAM *Materialgruppen* (Junghans *et al.* 1968, SAM 2:2, Tabelle 1, modified in Sangmeister 1973, 215). The SAM project has been the subject of much criticism (Butler & van der Waals 1964; Waterbolk & Butler 1965; Boomert 1975), with some recent attempts to rehabilitate aspects of this ambitious analysis programme (Härke 1978; Pernicka 1984) (4). Apart from being criticized for having a non-archaeological point of departure for the statistical classification of the raw analysis data (5), SAM is criticized for the statistical procedures, that resulted in no less than twenty-nine *Materialgruppen* and four residual groups. As admitted by Sangmeister (1973, 215) and further demonstrated by Boomert (1975, figs. 1–5) some of the *Materialgruppen* are so closely related that there is hardly any point in keeping them separate. This may particularly be the case where separation is due solely to differences in the content of Bi. The dispersion of Bi is, apparently, not constant within an object of copper or bronze (Slater & Charles 1970; Härke 1978, 194, but contradicted by Sangmeister & Otto 1973, 217ff; cf. Pernicka 1984, 522–524). Another problem appears to be some ten, less distinctly defined, mainly minor classes of copper (Boomert 1975, 137). On this background the classification of the Skeldal metal analyses into the *Materialgruppen* of SAM could be anticipated with scepticism.

However, the outcome (6) is quite in accordance with the results of the two preceding procedures. The only difference is that Group IA is subdivided into two groups, *Materialgruppe* A and A1 on the basis of a slight difference in the Bi value. As mentioned above the significance of minor variations in Bi has been questioned, and we shall therefore ignore this subdivision as recommended by Sangmeister (1973, 215).

It might have been expected that the use of three different statistical procedures would expose somewhat different metal groups, but the results have proved to be concordant to a very high degree (7) (fig. 4). There can, thus, be no doubt that the principal groups I, II, and III, and probably also the subgroups IA and IB, are significant. The result of the classification is displayed in a Waterbolk-Butler histogram (fig. 5).

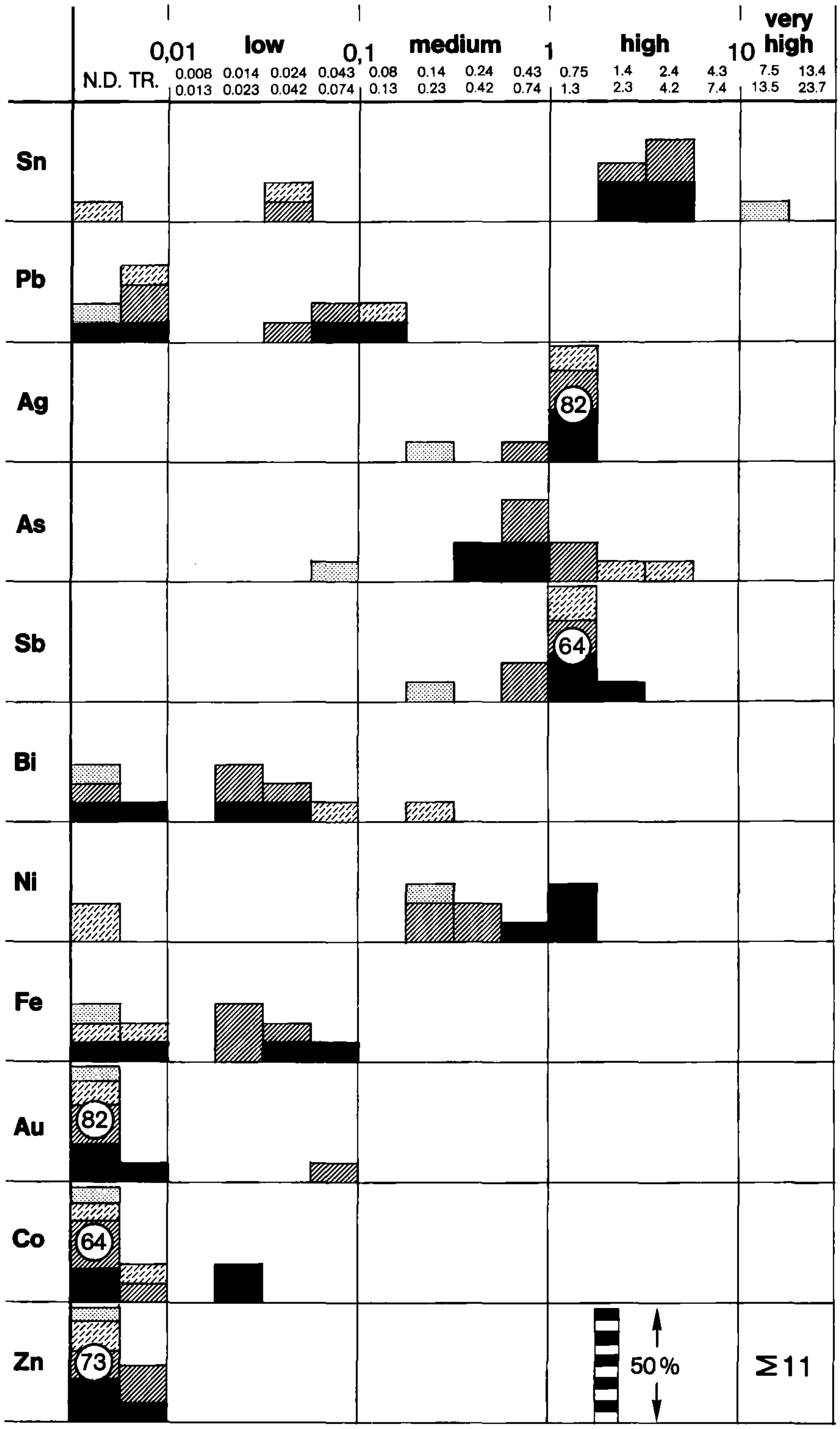



Fig. 5. The final four metal groups of the Skeldal hoard, illustrated in a Waterbolk-Butler histogram. Columns above 50% are marked. Symbols: black = Group IA, obliquely hatched = Group IB, oblique strokes = Group II, dots = Group III.

A modified version of the *Materialgruppen* of SAM 2 (cf. Sangmeister 1973, 215; Boomert 1975, figs. 1–5) will be employed in the remainder of this study, as they can be considered sufficiently reliable and accurate for a general survey. Besides, when comparing many different copper types in time and space the SAM *Materialgruppen* are extremely useful, due to their conciseness and brevity.

## THE SKELDAL METAL ANALYSES IN A WIDER PERSPECTIVE

Even a superficial examination of the relationship between morphological types, metal types, and tin content in the Skeldal hoard demonstrates a high degree of correlation (fig. 6): The two *Noppenringe* fall into the same group, IA. The box and its lid have been made from the same type of metal, Group IB. The spiral armring and the open solid-cast ring are morphologically and functionally related, Úněticean imports, and they both belong to metal group II and contain little or no tin. The trapezoidal flanged axe, the only object of west European affinity in the hoard, falls in Group III and is the only medium tin bronze. These observations will now be discussed in a wider context, particularly in terms of chronology and intercultural relations, treating the copper types and the tin content separately.

### *1. Copper types*

The composition of early copper objects undergoes a general development from almost pure or relatively pure copper in the Neolithic periods to highly impure copper in the early Bronze Age (Butler & van der Waals 1967, 56, 57ff; Junghans *et al.* 1968, SAM 2:1, 32, SAM 2:2, Diagram 2). This most likely reflects a transition from native, oxide, and carbonate ores to sulphide ores, including the grey ores or *Fahlerz* (Sherratt 1976, 570, 577ff). In the central European *Materialgruppen* of SAM 2 (SAM 2:2, Diagram 2), there are systematic shifts through time, which are of obvious relevance for the study of the chronological development of copper and bronze objects. At the transition to Br.A1 the purer copper types like E00, E01a/E01, and E10 have been replaced by medium to high impurity copper like A/A1/A2, B2, C2D/C5, E11A–B, and C2/C2A–C, and these coppers give way to the medium impurity coppers FA and especially FB1–2 at the end of the early Bronze Age. A similar change in coppers

| analysis no. | type of object | group IA (Materialgruppe A) | group IB (Materialgruppe B2) | group II (Materialgruppe C2c) | group III (Materialgruppe FG) | tin class |
|---|---|---|---|---|---|---|
| 1 | Noppenring | ● | | | | 4 |
| 2 | Noppenring | ● | | | | 4 |
| 8 | small parallelsided-curved flanged axe | ● | | | | 3 |
| 11 | butt part of a flanged axe | ● | | | | 3 |
| 4 | beehive-shaped box | | ● | | | 4 |
| 5 | lid of the box | | ● | | | 4 |
| 7 | double-edged chisel | | ● | | | 2 |
| 10 | large parallelsided-curved flanged axe | | ● | | | 4 |
| 3 | spiral armring | | | ● | | 1 |
| 6 | open solid-cast ring | | | ● | | 2 |
| 9 | trapeze-shaped flanged axe | | | | ● | 5 |

Fig. 6. The relationship between object types, metal groups, and tin content in the Skeldal hoard.

occurs in the Danish material, a fact that has not been systematically exploited.

A brief description of the development of Danish metal types follows, based on the new chronology of early Danish metal objects (fig. 1).

In the Early and Middle Neolithic Periods (EN–MN) metal objects were manufactured in low impurity coppers, first and foremost E01/E01A, secondarily E00 and E10. In the early part of the Late Neolithic Period (LN I) the preferred metal types are medium to high impurity coppers like FA, FB1–2, A/A1/A2, and C2D/C5, relating the manufacture of metal objects to the succeeding periods rather than the preceding ones (Vandkilde 1989, 34ff; 1990b, 186ff). Whereas the separation between Periods EN–MN and LN I is due to a metal-analytical-typological classification of especially flat axes (Vandkilde 1989, 34ff), later periods have been separated on purely archaeological criteria. Thus, the metal analytical transition between the EN–MN and the LN I is possible not quite as clear-cut as indicated above.

In the LN II Period the local production is characterized by the high impurity coppers A/A1/A2, B2, and

C2D/C5, which constitute the three dominating *Materialgruppen* (fig. 7A).

In Period IA of the early Bronze Age the B2 group is still the most frequent, and the A groups are only reduced a little, whereas C2D/C5 has almost disappeared (fig. 7B). The mutually related medium impurity copper types FA, FC, and especially FB1–2 constitute a new and prominent group of coppers (8).

In Period IB of the early Bronze Age the FB1–2 copper has become absolutely dominant, and the only other metal of some importance is the FA group (fig. 7C). It is a general tendency that the use of copper types becomes increasingly standardized through time, particularly from Period IA to Period IB (figs. 7A–C). A similar development characterizes the alloying practices (see below).

Liversage arrives at a quite different picture of the changes in metal supply from the Late Neolithic Period to Period I of the Bronze Age (Liversage 1989, 52ff; Liversage *et al.*, 1989, 56ff). In the younger part of the Late Neolithic Period he defines two types of metals, "Singen metal", which approximately corresponds to *Materialgruppe* A/A1/A2 and B2 of the SAM system, and "Ösenring metal", which approximately corresponds to *Materialgruppe* C2/C2A–C and C2D/C5. According to Liversage, the "Singen-metal" and the "Ösenring-metal" are completely replaced by a new copper type, FAARDMET, approximately corresponding to *Materialgruppe* FB1–2, at the beginning of Period I. Liversage is, thus, in favour of a very clear-cut change instead of the gradual change, which is proposed here.

The gradual change with Period IA as a transitional, metallurgical phase is, however, supported by the evidence of all the metal analysed, closed finds, Virring, Tinsdahl, and Torsted (8a), and by the many singly found objects attached typologically to these key finds of Period IA. Whereas the coexistence of the two *Materialgruppen*, B2 and FB1–2, during Period IA can be considered certain, it is interesting to note that the Period IB hoard of Bagterp (cf. Vandkilde 1990b, 180) belongs exclusively to *Materialgruppe* FB1–2 (SAM 2:3, 8496–8499). The two analysed

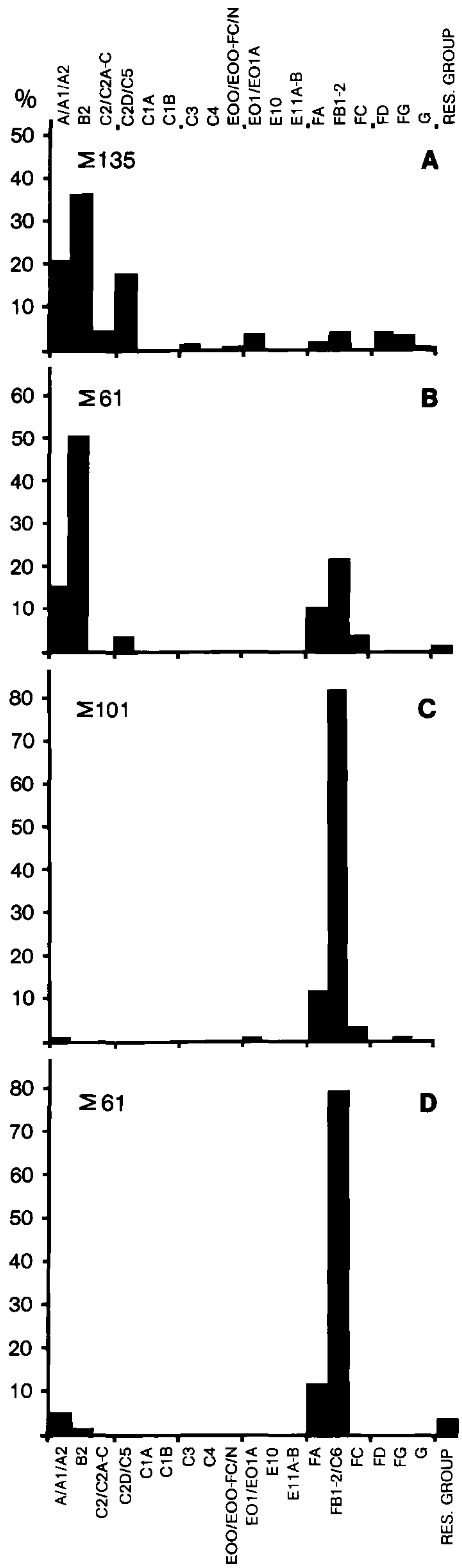



Fig. 7. The frequency of SAM 2 *Materialgruppen* within archaeologically defined periods and groups in Denmark. (Data primarily from Cullberg 1968, catalogue). A. Locally made metal objects (mainly flanged axes and halberds of south Scandinavian type) of the LN II Period. B. Locally made metal objects (mainly flanged axes) of Period IA. C. Locally made metal objects (mainly flanged axes) of Period IB. D. Locally made shafthole axes of type Fårdrup.

axes from Virring both belong to *Materialgruppe* B2 (SAM 2:3, 8500–8501), and three of the four recently analysed axes from Torsted belong to *Materialgruppe* B2, whereas the fourth belong to *Materialgruppe* FB1–2. The axe from Tinsdahl belong to *Materialgruppe* FB1–2 (Otto-Witter 1952: z1137).

A sample of 37 of the most typical of the flanged axes of type Torsted-Tinsdahl and Virring, which characterize Period IA, gives a similar result: 59% are assigned to *Materialgruppe* B2, 22% to FB1–2, and 19% to A/A1/A2 and FA. Moreover, it must be stressed that these Period IA objects are all full tin bronzes (see below), so that a typological and chronological mixture with LN II objects in the analysis is unlikely to have taken place.

If the closed finds and the singly found objects of Period IA are classified according to the metal groups of Liversage as first defined (Liversage 1989, 53), the results are identical. If his later definition is applied (Liversage *et al.* 1989, 67), the FAARDMET is a little more prominent than indicated above. One analysis from Virring and one from Torsted belong to "Singen metal", one analysis from Virring and three from Torsted and the one from Tinsdahl belong to FAARDMET. In the sample of 37 flanged axes of type Torsted-Tinsdahl and Virring, 51% join the "Singen metal", 43% FAARDMET, and the rest is ungrouped.

It is evident that the Danish development in metal types runs parallel to that of central Europe (compare fig. 7A to fig. 8A and 8B, fig. 7B to fig. 8C and 8D, and fig. 7C to fig. 8E).

This observation supports the recently published comparative chronology, which was based alone on archaeological data (fig. 1). Moreover, the parallel development indicates that the copper and bronze used in Denmark during these periods predominantly originated in central Europe. This suggestion is not contradicted by the Danish early metal objects, which are in general typologically tied to the current central European style.

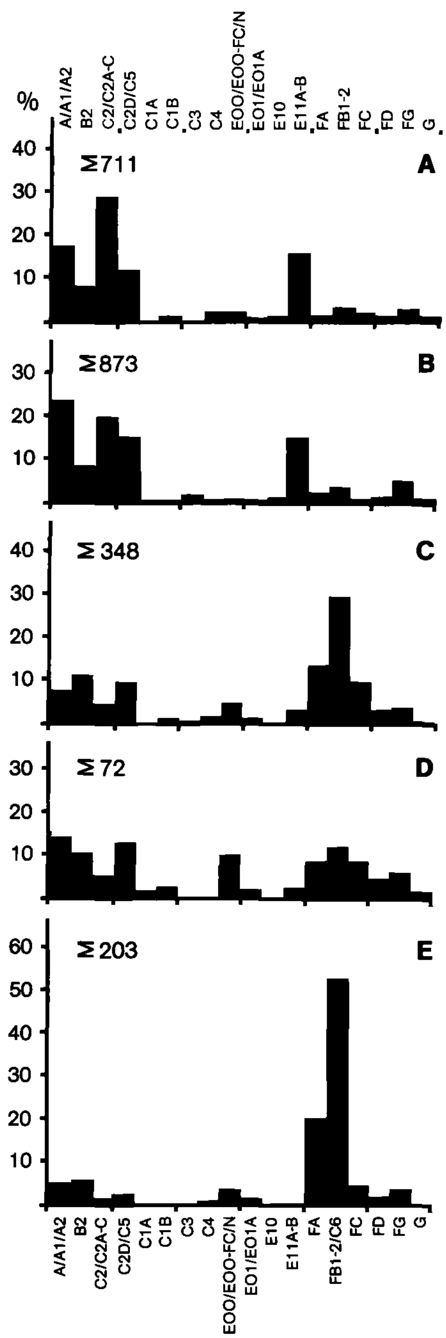



Fig. 8. The frequency of SAM 2 *Materialgruppen* within archaeologically defined periods and regions of central Europe. (Data from SAM 2,2: Tabelle 2, row no. 9a–b (excl. possible Úněticean objects), row no. 10b, 13, 14, and 17; Sangmeister 1966, Abb. 2, Tab. 2: phase 4). A. Southeast central Europe in the early and middle part of the early Bronze Age, Br.A1 (= approximately the LN Period in Denmark). B. The north Únětice culture and its Baltic periphery (north Bohemia, central Germany, Silesia, Brandenburg, Mecklenburg, Pomerania) in the classical phase of the Únětice culture, Br.A1b (= the LN II Period in Denmark). C. Southeast central Europe in the late part of the early Bronze Age, Br.A2 (= Period IA in Denmark). D. Central Germany and north Bohemia in the post-classical phase of the Únětice culture, Br.A2 (= Period IA in Denmark). E. Central Europe in the middle Bronze Age, mainly the early part of the Tumulus culture (= partly Period IB in Denmark).

In order to illustrate further the dating potential of metal analysis we shall look briefly at the locally manufactured shafthole axes of Fårdrup type. The find contexts of the Fårdrup axes do not allow a more accurate date than to period I in general (Lomborg 1969, 96ff; Vandkilde 1990b, 181), but on stylistic criteria Lomborg has dated them to early Period I, his "Fårdrup phase". The pattern of metal types of the Fårdrup axes is, however, almost identical to that of the local production of Period IB (figs. 7C and 7D), suggesting a position primarily within this period. It has been shown elsewhere, that Lomborg's Fårdrup phase is not confirmed by a study of the closed finds of period I of the Bronze Age (Vandkilde 1989, 29ff; 1990b, 178ff).

The metal analyses do not contradict the archaeological description of the *Skeldal hoard* as a chronologically homogeneous find, typologically related to the classical Únětice culture of central Europe. It fits perfectly into the pattern of metal groups that characterizes the LN II Period (figs. 6 and 7A). The presence of copper A/A1/A2 and B2 makes a position within the Period IA possible, but such a date is unlikely due to the *Materialgruppe* FG and C2/C2A–C, which are rarely found in later periods. C2/C2A–C is rather uncommon in the local production of the LN II Period, but it is frequently found in contemporary central Europe (figs. 8A–B), where it is sometimes called *Ösenring* copper, because around three fourth of all objects assigned to this metal group are neckrings and neckring ingots (cf. Butler 1979, 353, graph IV; Liversage *et al.* 1989, 60ff). In a general way the cultural attachment of the Skeldal hoard to the classical Únětice culture is confirmed by metal analysis, as the dominating metal types, A/A1/A2, B2, and C2/C2A–C, are the same (figs. 6 and 8B). Only the FG copper type of the trapezoidal axe occurs rarely in the Únětice culture (fig. 8B), and the FG-metal appears to be more common in the Anglo-Irish region than anywhere else (Junghans *et al.* 1968, SAM 2, 2, Diagram 11). Perhaps this allows for suggesting an Anglo-Irish origin for this metal type. At least it would be in harmony with the overall west European style of the axe and its high tin content, both of which set it apart from the rest of the objects in the hoard.

## *2. Tin content*

The tin content of copper and bronze objects in the early European metal age undergoes a systematic change through time, as do the metal types. This development of tin content is illustrated in fig. 9. The six tin classes used here simplify the twelve tin classes of Spindler (1971, 207, 250f), with the addition of a tin-free class. The hardness (HV) of each class is given according to Tylecote (1986, table 16; 1987, table 7.1, fig. 7.4), and it pertains only to the effect of the tin, not to the various impurities (9).

*Class 1: tin-free copper.* The hardness of pure copper is in the cast condition c. 40, and when it has been worked and annealed c. 45. After having been work-hardened by 50% reduction in thickness, the hardness has risen to 120. Tin class 1 is associated mainly with pure and low impurity copper.

The succeeding tin classes 2–6 are typically associated with medium and high impurity coppers.

*Class 2: copper with tin present as an impurity* (trace-0.126%), either in the copper itself or in the arsenic that may have been added. Hardness approximately as class 1.

*Class 3: tin copper* (0.127–2.0%); the tin may not have been added, but may be present as a result of remelting and thus mixing of discarded copper and bronze objects as argued by Spindler (1971, 250f). He suggests, that this class will be found primarily in regions at some distance from naturally occurring ore (*op.cit.*) – at least in the initial period of tin bronze technology, where tin bronze has not yet become standard. Each remelting means c. 0.5% reduction in the tin content (J. P. Northover pers. comm.). An object with 2% tin has a hardness of 50 in the worked and annealed state and of 140 when work-hardened by 50% reduction in thickness. The effect of 2% tin is, thus, relatively limited compared to copper of class 1 and 2.

*Class 4: low tin bronze* (2.01–4.00%) may likewise be a result of mixing objects of copper and bronze, or the tin may be an addition. A tin value of 4% will raise the hardness of a worked and annealed object to 60, and to 165 when work-hardened. It is, thus, within this tin class, that the functional advantage of tin bronze becomes clear.

*Class 5: medium tin bronze* (4.01–7.95%) is mainly copper with tin as an alloying addition. A tin value of 6–8% will raise the hardness to 65–70, when worked and annealed, and to as much as 185–210 after work-hardening. The effect is thus very clear.

*Class 6: high tin bronze* (7.96–>10%), where tin has been added to the copper. A tin percent of 10% results in a hardness of 80 before work-hardening and 230 after work-hardening. When around 16% tin is added, the metal becomes brittle when cold-worked.

In the Danish LN I Period the copper objects belong primarily to tin class 1 and 2, whereas earlier copper objects are predominantly attached to class 1 (Vandkilde 1989 and 1990b, Figs. 10B–C). In the Danish LN II Period the tin classes 2 and 3 dominate the local production, but also class 4 and especially 5 are quite important (fig. 9A) (10). In general, the tin pattern of the LN II

Period is comparable to that of contemporary central Europe (figs. 10A–B), with the closest resemblance to areas where tin does not occur naturally. In Period IA the picture has changed completely (fig. 9C); now medium and high tin bronzes are absolutely dominant, and this is even more true in Period IB (fig. 9D). This reflects the central European situation, where tin bronze has become standard from Br.A2 onwards (Spindler 1971, Diagram 1, 3 and 5).

Compared to the Late Neolithic Period we are in Period IA dealing with a standardized alloying practice, which agrees well with the tendency to less variation in metal

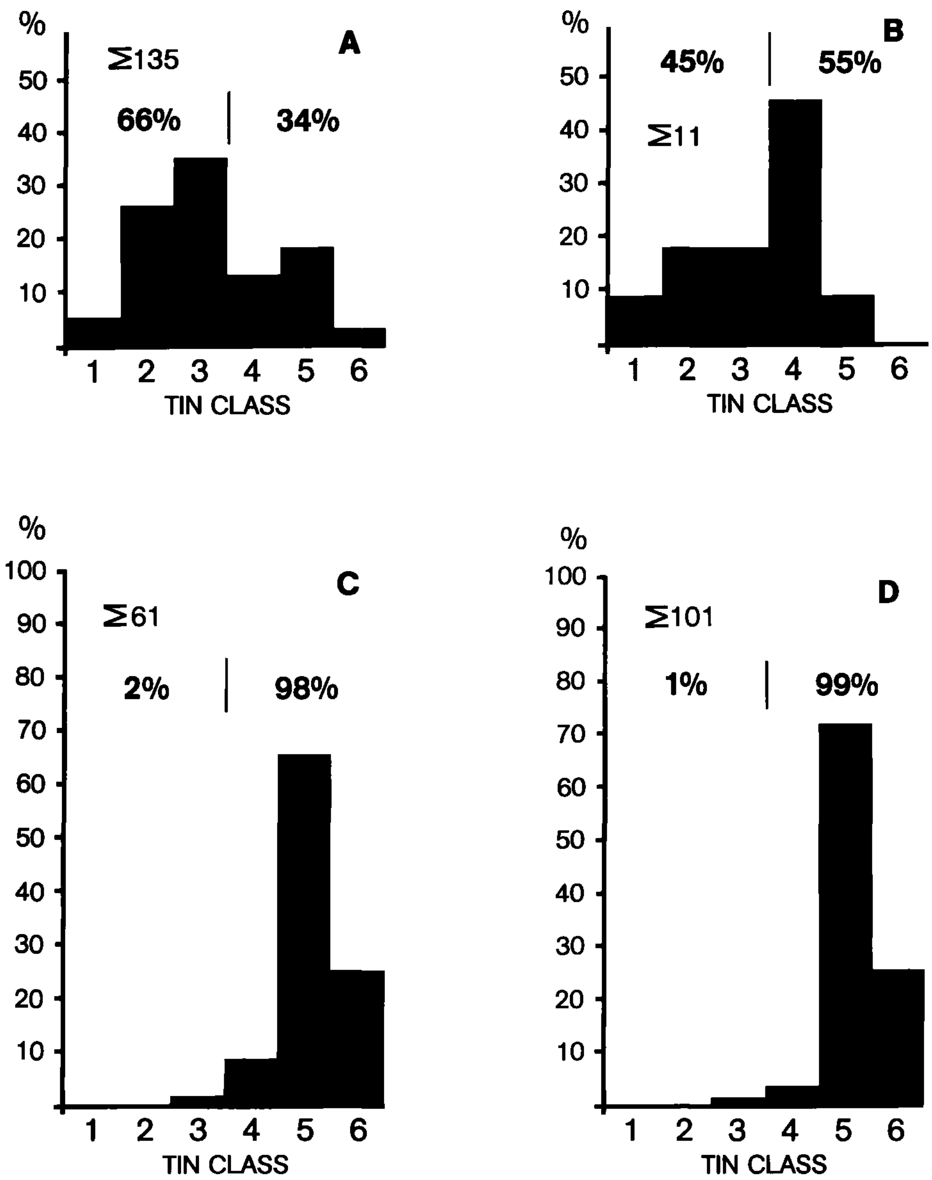



Fig. 9. The distribution of tin in Danish metal objects within archaeologically defined periods and groups. (Data from SAM 2,3 and 2,4; Cullberg 1968, Catalogue; Appendix). A. Locally made metal objects (mainly flanged axes and halberds of south Scandinavian type) of the LN II Period. B. The bronze and copper objects of the Skeldal hoard. C. Locally made metal objects (mainly flanged axes) of Period IA. D. Locally made metal objects (mainly flanged axes) of Period IB.

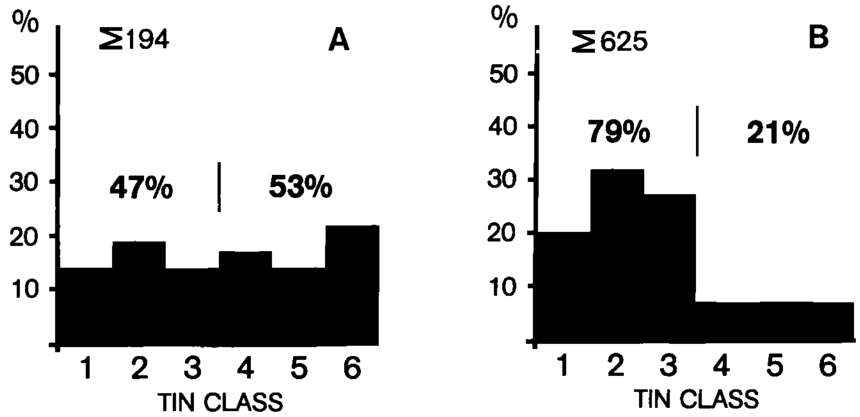



Fig. 10. The distribution of tin in Úněticean metal objects. A. The classical Úněticean centre at the Unstrutt-Saale in Thuringia. B. The periphery of the Unstrutt-Saale classical Úněticean centre, i.e. the regions of north Bohemia, Spree-Neisse, Riesa-Dresden-Bautzen, Berlin-Brandenburg, and Mecklenburg-Pomerania (data from SAM 2,3 and 2,4; Otto & Witter 1952 and Breddin 1969).

composition, that becomes evident in Period IB (figs. 7B–C). It is still an open question whether the Danish local production of bronze objects in Period I is based on separately imported tin and copper, or the result of remelting tin bronze objects of central European origin. Till now, specialized ingots are unknown in the Danish material from the earliest Bronze Age. A comparison of the tin patterns in Denmark and central Europe may, however, throw some light on this problem. In central Europe the high tin bronze (7.96>10%) is more common than medium tin bronze (4.01–7.95%) – in contemporary Denmark it is the opposite. As the concentration of tin is reduced during the process of remelting, this might perhaps suggest that the Danish local production depends on remelting of imported, tin bronze objects rather than importing ingots of copper and tin.

The introduction of the FB1–2 copper type at the beginning of Br.A2, c. 1700 B.C. coincides with a standardized use of medium and high tin bronze in most areas. According to Waniczek (1986, 130) a homogeneous tin level indicates that metallic tin was used. With reference to archaeological finds Roden (1985, 50–57) also suggests the use of metallic tin. This is in agreement with Tylecote (1987, 143), who maintains, that the close control exercised in tin composition in the Bronze Age suggests the use of metallic tin rather than cementation with tin oxide under reducing conditions. Charles (1975, 22f), however, believes, that the latter method was used throughout the Bronze Age, as tin appears to be difficult to refine. Further analysis should examine these two methods more carefully and consider whether there is a transition from tin oxide cementation to addition of metallic tin around the beginning of Br.A2, as may be indicated by the development from a highly variable tin content to a standardized high tin level.

The tin values of the *Skeldal hoard* are given in fig. 9B, and they show a good resemblance to the tin level of the LN II Period (fig. 9A), whereas there is no similarity to Period IA. The date achieved archaeologically of the Skeldal hoard is thus confirmed by the tin analysis as well as by the composition of its copper. Correspondingly there is good correlation with the tin level of the Únětice culture (figs. 10A–B).

## METAL ANALYSIS OF THE SKELDAL GOLD RINGS

Most Danish Bronze Age gold has been analysed and published by Hartmann in SAM 3 and 5 (1970, 1982; cf. Thrane 1985 and Hartmann 1987). The analysis method is the same as used in the SAM analysis program of copper and bronze objects, i.e. optical emission spectroscopy. The two golden *Noppenringe* from Skeldal were analysed by the Oxford laboratory using electron probe microanalysis. Additional comparative material from Great Britain, Ireland, and France is found in Taylor 1980 and Eluère 1982.

From a Danish point of view the closest gold resources are found in the Erzgebirge between Saxony and Bohemia and in Great Britain and Ireland. More distant, there is gold in the southern part of Bohemia, Slovakia, Siebenbürgen, France, and Switzerland (Tylecote 1987, fig. 3.6; Coles & Harding 1979, fig. 3). Gold occurs mainly in the native state and is easy to locate because of its lustrous appearance. It does not demand the same technological skills of the smiths as copper and copper-base alloys, because it can be hammered into shape without annealing, and it was presumably the first metal known to man (Coles 1981, 96f; Tylecote 1986, 1f). Consequently gold working may be found in societies that do not yet master copper technology or are in the process of developing a copper technology. This is probably how we should understand the group of Danish gold sheet ornaments, lunulae and the closely related ornaments with oar-shaped ends (11). They most likely belong to the LN I Period and may have been made in Denmark (Vandkilde 1989, 38, fig. 12; 1990b, 190f, Abb. 12), probably from different sources of west and central European gold (Vandkilde in preparation). In the LN II Period and Period IA less gold is in circulation, and none of the objects, all Noppenringe, seem to be locally manufactured. In Period IB the first "ring gold" appears with other kinds of gold ornaments, for instance the *Lochhalsnadel* from Buddinge, County of Copenhagen (Lomborg 1969, 101ff, 107). The pin from Buddinge has presumably come from the Danubian region in the earliest part of the Tumulus Period. A Tumulus culture origin for the bulk of the "ring gold" of the Danish early Bronze Age does not seem unlikely.

Neolithic and early Bronze Age gold is close to natural gold in composition and was less frequently than later gold alloyed with other materials. Occasionally copper seems to have been added to the EBA gold, probably to counter the whitening effect of the silver content (Tylecote 1986, 2ff; 1987, 72ff), or to make the precious gold last longer. Technologically this would offer no difficulty, as we are now well within the age of copper. Hammering is more frequent than casting in the early production of gold objects, implying that mixing of gold of various origins may have been practised less often than is the case with contemporary copper. On the other hand, the composition of the elements present in gold apparently varies less than in copper. There is nevertheless some variation in regard to time as well as space, as demonstrated by Hartmann, Taylor, and Eluère, which may be of use archaeologically.

Apart from the Skeldal *Noppenringe,* four other gold *Noppenringe* are known from Denmark. Of the six gold rings, four constitute pairs. Archaeologically they cover

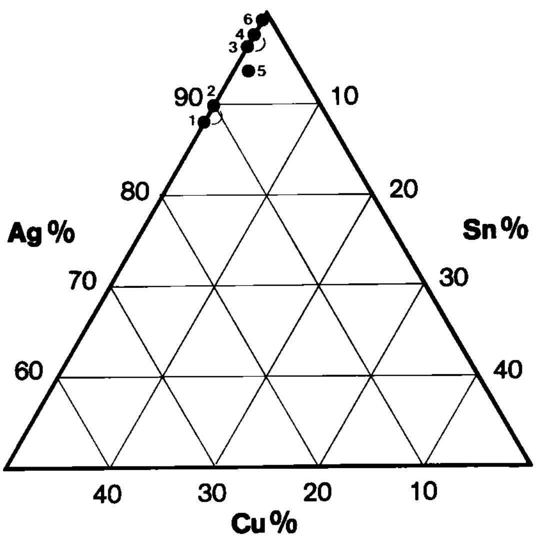



Fig. 11. Triangular proportional plot of Danish gold *Noppenringe*. Those found together have been connected. (Data from Hartmann 1970 and 1982) (12).

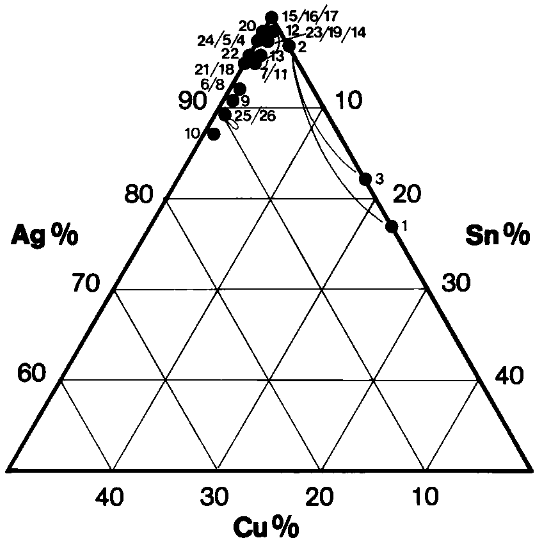



Fig. 12. Triangular proportional plot of central European EBA gold objects, primarily *Noppenringe*. Those found together have been connected. (Data from Hartmann 1970 and 1982: nos. 5, 24 from central DDR, nos. 6–10, 19–20, 23, 25–26 from north Bohemia, nos. 14–18 from southwest Slovakia, nos. 1–4, 11–13 from Bavaria and no. 21 from Siebenbürgen) (14).

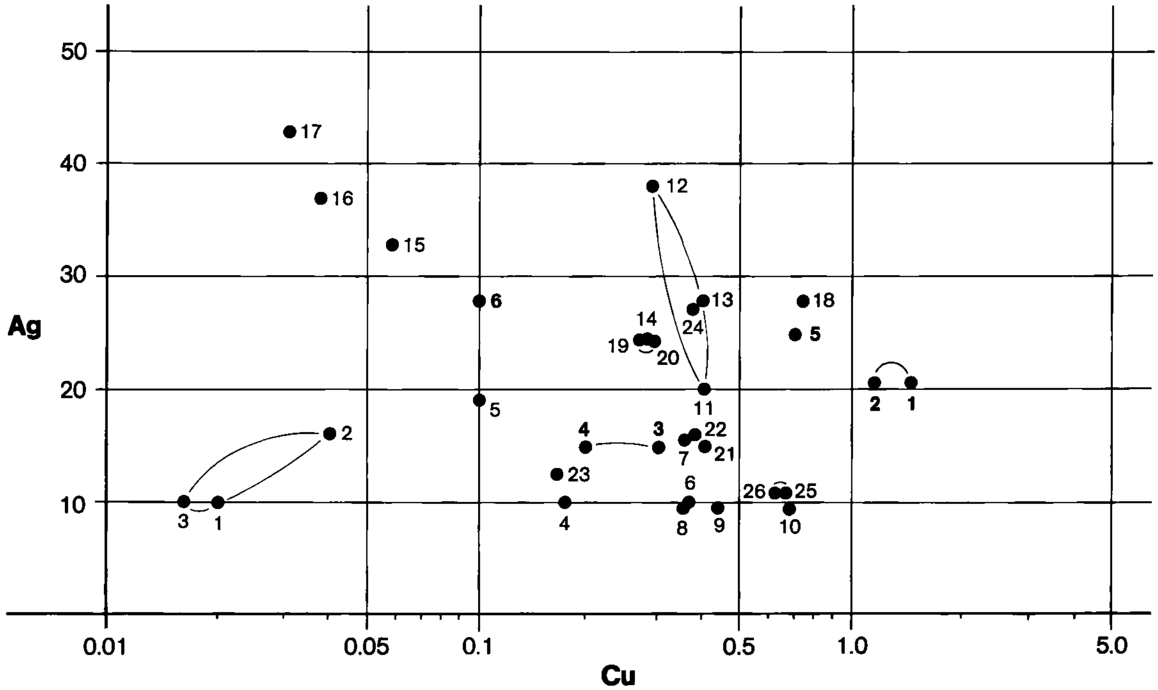



Fig. 13. Semi-logarithmic plot of Danish gold *Noppenringe* (bold numbers 1–6) and central European EBA gold objects, primarily *Noppenringe* (weak numbers 1–26). Objects found together have been connected. See fig. 11–12 for the corresponding triangular plots. (Data from Hartmann 1970 and 1982) (12), (14).

the timespan LN II – Period IA, and they belong to two different types. The large, simple ring with one end twisted, found in the Skeldal hoard, has been described earlier (Vandkilde 1990a, 120f). The other type is much smaller, more complicated, and contrary to all other types of *Noppenringe* it is open in front (cf. Lomborg 1973, fig. 84B). Quite possibly the Skeldal type of *Noppenringe* belongs primarily in the LN II Period, whereas the small frontal type may belong to Period IA (12). Both types of *Noppenringe* have exact counterparts in the central European early Bronze Age, and doubtlessly they were manufactured there. They are different from later gold rings, though the large *Noppenring* may be confused with the "ring gold" of later periods. The latter ring type, however, is always without twisted end.

In order to see if the archaeological evidence was supported by metal analysis, the analytical data (from Hartmann 1970 and 1982) of different archaeological groups were plotted into two kinds of diagrams, introduced by Taylor to describe the British, Scottish, and Irish gold (1980, 17). Whereas the triangular proportional plot describes the relative proportions of the three main elements of prehistoric gold, Ag, Cu, and Sn (13), the corresponding semi-logarithmic plot includes the absolute values of Ag against Cu, as a control of the triangular plot. Such diagrams are easier to read than the statistical system employed by Hartmann (1970, Diagram 3 ff; 1982, Diagram 1ff).

To judge from the triangular proportional plots (figs. 11–12) the composition of the six Danish *Noppenringe* is very similar to the composition of central European *Noppenringe*. The silver content is high, the copper value low, and tin is absent or nearly so. In a general way, the distributions confirm the archaeological evidence concerning location in time and space. The affinity between the two diagrams (figs. 11–12) is in fact surprising as the central European gold rings come from many different regions and therefore presumably many different sources of gold. The more scattered picture appearing on the corresponding semi-logarithmic plot (fig. 13) probably reflects these geographical differences. The amount of analysed gold from the central European early Bronze Age is, however, too limited to infer the exact place of origin for the Danish rings. The scattered appearance of

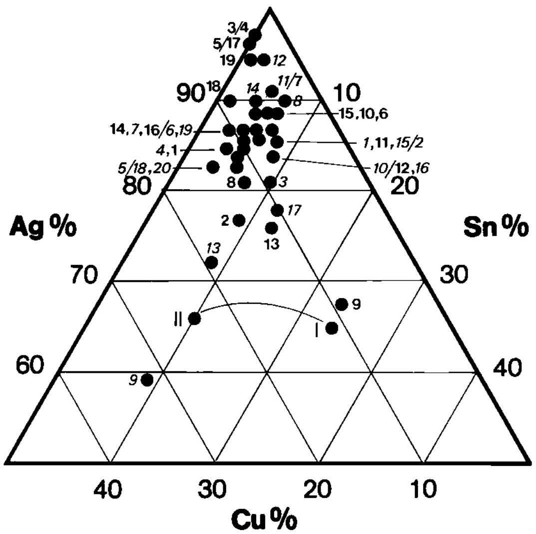



Fig. 14. Triangular proportional plot of Danish spiral rings of doubled-up gold wire, "ring gold" of Period II (bold numbers 1–19) and Period III (weak numbers 1–20) of the early Bronze Age. The spiral and the pin (I–II, connected) from the Period IB burial at Buddinge are included. (Data from Hartmann 1970 and 1982) (15).

the latter diagram indicates that they originate in different parts rather than one part of central Europe. Pairs of rings are very close to each other in the plots, suggesting that they are produced in pairs of exactly the same raw material.

An origin for the gold in the Anglo-Irish region is excluded by the absence of tin or extremely low tin level in the six Danish *Noppenringe*. Apparently this is typical of central European EBA gold (fig. 12), whereas tin is present in most contemporary British, Scottish, and Irish gold (Taylor 1980, figs. 14–15, figs. 22–23). Tin in gold indicates, that the gold was collected from tin-bearing areas (Tylecote 1987, 79), which are much more numerous in Great Britain than on the Continent. In regard to later central European gold, the presence of tin in the gold may be due to alloying with copper containing tin, or to the collection of gold in tin-bearing areas, first and foremost the Erzgebirge.

The copper content of the Skeldal rings is above the level found in the other central European EBA ornaments (fig. 13). According to Tylecote (1987, 74) natural gold rarely has values exceeding 1% Cu. Thus the Skeldal rings could have been made from alloyed gold.

The composition of "ring gold" from the Danish early Bronze Age is distinctly different from the *Noppenringe*. Around forty spiral rings made of doubled-up gold wire have been included in a triangular plot, fig. 14. They have either loops in both ends, or one end is open. The rings are very closely distributed in the uppermost part of the triangle, but the distribution is different from that of the *Noppenringe* (figs. 11–12), due to the tin value being markedly higher. It should indeed be possible to separate gold rings of a LN II-Period IA date from later rings solely by their metal composition.

Rings of Period II and Period III were entered into the diagram (fig. 14) separately, but there is no difference in

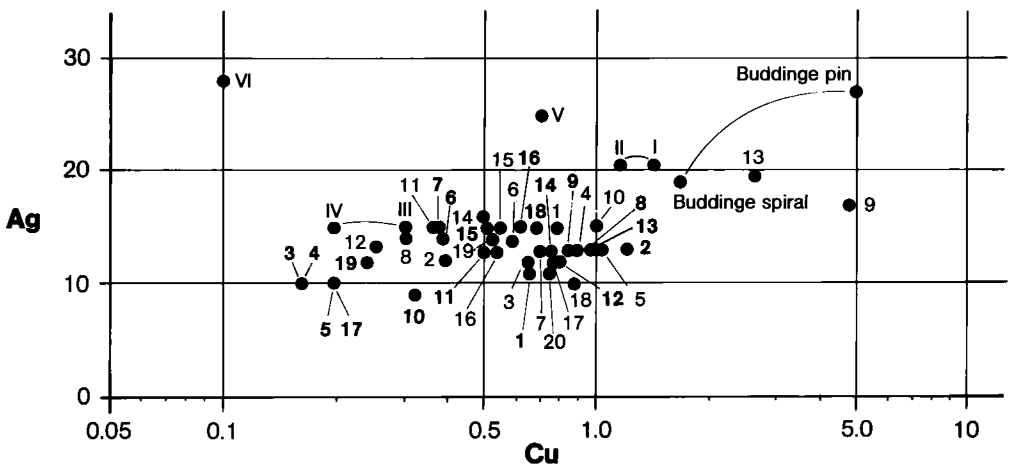



Fig. 15. Semi-logarithmic plot of Danish spiral rings of doubled-up gold wire ("ring gold") of Period II (bold numbers 1–19) and Period III (weak numbers 1–20) of the early Bronze Age. The spiral and the pin (connected) from the Period IB burial at Buddinge are included, as well as the six Danish gold Noppenrings (I-VI, pairs connected). See fig. 11 and fig. 14 for the corresponding triangular plots. (Data from Hartmann 1970 and 1982). (15).

the distribution. The *Lochhalsnadel* and its spiral from the burial at Buddinge have also been included. The deviating position in the plot compared to "ring gold" as well as *Nopperinge* (fig. 11) emphasizes the outstanding position of the Buddinge gold. Its supposed origin in the region of the middle Danube (Lomborg 1969, 101ff, 107) should be further examined by compositional comparisons with central European gold of Br.B1.

The corresponding semi-logarithmic plot (fig. 15) supports the above evidence. The "ring gold" is found within a small area of the diagram with a silver content between 9 and 18 and a copper value between 0.15 and 1.2, implying that the "ring gold" is made from natural, non-alloyed gold, with a few possible exceptions. There is no difference between the "ring gold" of Period II and Period III. The compositional homogeneity of the "ring gold" suggests, that it originates from a single resource, or at least related sources of gold within the same region. The presence of tin in the "ring gold" (fig. 14) may suggest, that the gold has been collected in the Erzgebirge near the tin deposits. The *Noppenringe* and the Buddinge gold have also been included in the plot (fig. 15), and the difference already noted repeats itself. The *Noppenringe* fringe the upper periphery of the "ring gold", whereas the *Lochhalsnadel* and the spiral from Buddinge are located towards the upper right. The latter gold has clearly been alloyed with copper, and the rather high tin value of the gold may imply that the added copper contained some tin. After all, these ornaments belong in the age of tin bronze.

In conclusion, the archaeological evidence is indeed reflected in the gold analysis, which besides chronology and origin may also be informative regarding the technique of early gold manufacture.

Helle Vandkilde, Institute of Prehistoric Archaeology, University of Aarhus, Moesgaard, DK-8270 Højbjerg.

## APPENDIX

### The Raw Metal Analyses of the Skeldal Hoard

| An.no. NM. | object | Sn | As | Sb | Pb | Co | Ni | Fe | Ag | Au | Zn | Bi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 B17061/1 | *Noppenring* | 3.51 | 0.39 | 1.39 | 0.05 | – | 0.76 | 0.03 | 0.92 | – | – | tr. |
| 2 B17061/2 | *Noppenring* | 2.92 | 0.59 | 1.08 | – | 0.02 | 0.73 | 0.05 | 0.79 | tr. | – | – |
| 3 B1762 | armring | – | 1.89 | 0.88 | 0.08 | tr. | – | tr. | 1.14 | – | – | 0.16 |
| 4 B1763 | box | 2.13 | 0.49 | 0.60 | 0.04 | – | 0.31 | 0.02 | 1.16 | – | – | 0.03 |
| 5 B1763 | lid | 2.76 | 0.79 | 0.93 | tr. | tr. | 0.31 | 0.03 | 1.07 | – | tr. | – |
| 6 B1764 | solid ring | 0.03 | 2.61 | 0.90 | tr. | – | – | – | 1.09 | – | – | 0.06 |
| 7 B1765 | chisel | 0.04 | 0.43 | 0.47 | 0.07 | – | 0.19 | 0.02 | 0.86 | – | – | 0.02 |
| 8 B1766 | small axe | 1.55 | 0.50 | 1.17 | tr. | 0.02 | 0.96 | – | 0.86 | – | – | 0.02 |
| 9 B1767 | trapez axe | 7.66 | 0.05 | 0.20 | – | – | 0.17 | – | 0.14 | – | – | – |
| 10 B1768 | large axe | 3.13 | 0.77 | 0.87 | tr. | – | 0.21 | 0.02 | 0.70 | 0.05 | tr. | 0.02 |
| 11 B1769 | axe butt | 1.38 | 0.41 | 0.94 | 0.08 | – | 0.98 | tr. | 0.88 | – | tr. | 0.03 |

| The gold analyses | FE | Co | Ni | Cu | Zn | Bi | Sb | Sn | Ag | Pb | Au |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 *Noppenring* NM19/82 | 0.02 | 0.02 | 0.02 | 1.05 | – | – | tr. | – | 20.53 | – | 78.32 |
| 2 *Noppenring* NM19/82 | 0.03 | tr. | 0.02 | 0.90 | – | – | 0.02 | – | 20.54 | – | 78.48 |

NOTES

1. The Danish Research Council for the Humanities financed the metal analyses of the objects, which were carried out by Dr. J.P.Northover from The Department of Metallurgy and Science of Materials, University of Oxford. I am much indebted to D.Liversage and P.O.Nielsen, *Nationalmuseets 1. Afdeling* for support during the investigation, to J.P.Northover for advice in regard to alloying practices, to D.Liversage and T.Rehren for a critical review of an earlier draft of this paper, and to J.Kirkeby, who drew the diagrams and the tables. A complete publication of the chronology, on which this article is based, is being prepared. The manuscript was completed October 1990.
2. Apart from the Skeldal objects, a dagger and a flanged axe from the contemporary Vigerslev hoard (see this volume), sixteen copper flat axes, four halberds, one tanged copper dagger, and one early, presumably, Anglo-Irish axehead were analysed by the Department of Metallurgy and Science of Materials, University of Oxford, using electron probe microanalysis (EPM). In addition, the same group of objects, except those from the Skeldal hoard, were analysed by *Risø National Laboratory*, some of them twice, using energy-dispersive X-ray fluorescence (EDXRF) and induction-coupled plasma-mass spectroscopy (ICP-MS). A few of these objects had already been analysed by SAM, by optical emission spectroscopy (OES). This represents a rare opportunity to compare and evaluate a number of different methods and to discuss the problems of combining metal analyses from different laboratories (in preparation by J.P.Northover).
3. A triangular proportional plot of the relationship between Ni, Bi, and Sb was also attempted. Only the deviation of nos. 3 and 6 was clearly indicated. Since the proportional plot illustrates the relationship in percentages and not the real values, low impurity copper may actually group with high impurity copper!
4. See Boomert (1975, 134ff) for a summary of the critique of the SAM programme and Härke (1978, 226–241) for an evaluation of the classification methods of SAM and Waterbolk-Butler.
5. Härke (1978, 238) has pointed out that departing from an archaeologically defined group, as advocated by Waterbolk and Butler (1965, 230) gives similar results as a non-archaeological departure.
6. Nos. 1, 3, 5, 7, 8, and 11 could be classified directly, however, without being identical with the *Materialgruppen, nach den tatsächlichen Maxima der Verteilung* (Junghans *et al.* 1968, SAM 2.2, Tab. 1: lower horizontal column). Nos. 4 and 9 appeared to be slightly deviating in relation to the groups into which they were classified. Exact counterparts do, however, not exist to these analyses anywhere in the SAM system. These minor divergences are probably due to the fact that two different analysis methods are involved, OES and EPM (2).
7. Also Härke has pointed out that the classification systems of SAM and Waterbolk-Butler arrive at similar results. This appears to be due to the fact, that they belong to the same statistical family, the former being a mathematical analysis of frequency, the latter a graphical analysis of frequency (1978, 234ff, 236).
8. The heterogeneous assemblage of copper types in Period IA is not a simple reflection of contemporary central European conditions in Br.A2 (figs. 7B, 8C, and 8D). The arrival of the FB1–2 copper to Denmark may reflect a major shift in the supply of raw materials from the Úněticean to Alpine and Transsylvanian copper ores. This is in accordance with the archaeological evidence of increased contact with the east Alpine-Danubean-Transsylvanian region in Period I. The continued importance of *Materialgruppe* A/A1/A2 and B2 in Period IA may then reflect re-cycling of LN II metal, or a weakened flow of metal from the mines of the north Únětice culture, which is now rapidly loosing its former importance. In the mining areas the increasing importance of FB1–2 copper from Br.A2 onwards could possibly also reflect the development of new technical abilities to process uniformly a particular kind or related kinds of copper ore.

8a Also the hoard from Underåre has been metal analysed (SAM 2, 4: 11989–11991; FB1–2). Its exact chronological position within Period I is at present uncertain, and it has therefore been left out of consideration. The four metal analyses of axes from the Torsted hoard have recently been carried out by J.P.Northover from Department of Metallurgy and Science of Materials in Oxford, and they are unpublished.

9. Future examinations of early Danish alloying practice should consider other elements than tin. The impurities in the copper may together increase the hardness. The so-called "Singen metal" (Waterbolk & Butler 1965, graph 8–9; Butler & van der Waals 1967, fig. 27; Liversage 1989, graph 7), which is equivalent to *Materialgruppe* A/A1/A2 and a frequently used copper type during the main part of Br.A, is most often associated with tin class 2 and 3. However, this copper type and related types of coppers, for instance the frequent B2 copper, may be quite good natural alloys because of the high values of As, Sb, Ni, and Ag. In Danish metal objects the value of As very seldom exceeds 2%, and most objects contain between 0.5% and 1% As. This means, that arsenic is unlikely to have been added to the copper, but is present in the copper as an impurity (Tylecote 1987, 43). An As value of 0.25–2%, which is representative for the great majority of Danish early metal objects, will raise the hardness of a worked and annealed object to 68–85 and to 122–140 after work-hardening (Tylecote 1986, table 16; 1987, fig. 7.4). The effect is thus almost like the effect of tin, and the reason for preferring tin bronze may be that it is easier to control during the process of production.
10. The great variation in the Danish LN II tin levels raises more questions than can at the moment be answered: Does it reflect an unsatisfied demand for tin bronze, or does it reveal a lack of awareness in regard to the technical and functional advantages of different tin levels? Were other alloys, e.g. with As, able to compete with tin bronze? Was copper used primarily for prestige objects and tin bronze for tools? Or perhaps the other way around, because of the attractive, golden colour of tin bronze?
11. Some of the Danish gold sheet ornaments have evidently been made from gold alloyed with copper. These alloys could have been made anytime during the lifetime of the gold, and thus not necessarily in Denmark. Some of the Irish lunulae are also made from alloyed gold (Tylecote 1987, 79).
12. Danish gold *Noppenringe* referred to firstly by their numbers in the diagrams of this text (figs. 11, 13, and 15) and secondly by their Au-numbers in SAM 3 and 5: *1–2, OX/EPM:* the two Skeldal rings of the LN II Period. *3–4, Au 3291 and 4967:* A pair of small rings of the open, frontal type. Found with flint daggers of type I and IV, below a stone heap at the bottom of a mound, Tvillingegård near Nørre Snede, County of Skanderborg; there is no information on the

relationship between the objects (Broholm 1943 I, 23). *5, Au 4968:* Small ring of the open, frontal type from the latest burial in Brønhøj *Jættestuen*, County of Randers. The ring was associated with a pin with spherical, obliquely perforated head of an early type, datable to Br.A2. This burial superimposes burials containing flint daggers of type IV and V (cf. Lomborg 1973, 145–147). The gold ring is thus clearly datable to Period IA. Another ring of this type, but of bronze, is known from a cist burial at Søsum, County of Frederiksborg (*op. cit.*, fig. 85). This ring is associated with other metal objects of a general *Frühbronzezeit* character, and the burial superimposes a burial with flint daggers of type VA and VI, a combination that implies a date within Period IA for the daggers. Although stratigraphically later, the burial with the *Noppenring* probably also belongs to Period IA. The latest appearance of the frontal, open *Noppenring* in central Europe is a Br.B1 burial (Kibbert 1980, Taf. 68J), but this is most likely an exception. *6, Au 3431:* Small ring of the simple type with one end twisted. Single find from Hjelm, County of Præstø. Found close to a burial mound. The ring is smaller than the Skeldal rings, but belong to the same type.

13. The elements of the Skeldal gold included in appendix are weight percent of the total weight of the alloy. The SAM gold analysis, however, presents the values of Cu and Sn as weight percent of Au (= 100), a system used also by Taylor (1980). In order to make the data comparable, the Skeldal values of Cu and Sn were, therefore, changed according to the formula of Hartmann (1970, 20, note 23).
14. Central European EBA gold objects included in figs. 12–13: 1 = Au 3333, 2 = Au 3335, 3 = Au 3336, 4 = Au 5030, 5 = Au 4574, 6 = Au 182, 7 = Au 183, 8 = Au 184, 9 = Au 185, 10 = Au 186, 11 = Au 1330, 12 = Au 1331, 13 = Au 1338, 14 = Au 150, 15 = Au 151, 16 = Au 152, 17 = Au 153, 18 = Au 158, 19 = Au 189, 20 = Au 190, 21 = Au 261, 22 = Au 157, 23 = Au 188, 24 = Au 1814, 25 = Au 1487, and 26 = Au 1488.
15. Danish "Ring gold" from Period II-III of the early Bronze Age included in figs. 14–15. Period II (bold numbers 1–19): 1 = Au 3340, 2 = Au 3422, 3 = Au 3876, 4 = Au 3874, 5 = Au 3879, 6 = Au 3893, 7 = Au 3892, 8 = Au 3994, 9 = Au 3990, 10 = Au 4081, 11 = Au 4063, 12 = Au 4144, 13 = Au 4312, 14 = Au 3275, 15 = Au 3282, 16 = Au 3283, 17 = Au 3262, 18 = Au 3397, 19 = Au 3320. Period III (weak numbers 1–20): 1 = Au 3303, 2 = Au 3306, 3 = Au 3307, 4 = Au 3315, 5 = Au 3317, 6 = Au 3311, 7 = Au 3321, 8 = Au 3324, 9 = Au 3348, 10 = Au 3340, 11 = Au 3363, 12 = Au 3401, 13 = 3412, 14 = Au 3421, 15 = Au 3424, 16 = Au 3469, 17 = Au 3468, 18 = Au 3491, 19 = Au 3488, and 20 = Au 3489. Period IB gold from Buddinge: I = Au 3258 (the spiral), II = Au 3257 (the pin).

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# *Egshvile*
# *– A Bronze Age Barrow with Early Urn Graves from Thy*

by ANNE-LOUISE HAACK OLSEN

In the north-western part of Thy, an area well known for its many grave finds, especially from Period III of the Early Bronze Age (EBA), Thisted Museum has recently excavated a ploughed-over barrow with some rich and rather unusual grave finds: A rich man's grave from Period III and two urn graves from Period II – a child's grave and an adult woman's grave with rich grave-goods, possibly the earliest known urn graves from the Danish Bronze Age (1).

## TOPOGRAPHY

Egshvile lies at the end of a NW-SE oriented strip of land, 2,5 km wide, which separates two lakes – Nors sø and Vandet sø (fig. 1). To the west and north of these lakes lies a large area dominated by sand dunes and wind-blown flats which extends all the way to the North Sea Coast 7 km away. Today, large parts of this area are covered with forests planted at the end of the last century, but 3–400 years ago there were many instances of wind-blown sand covering the fields and causing people to leave their homes. The sand all but reached Egshvile, and to the north and west it undoubtedly covers areas that were occupied during the Bronze Age. Due to the sand dunes it is difficult to determine where the Bronze Age coastline lay.

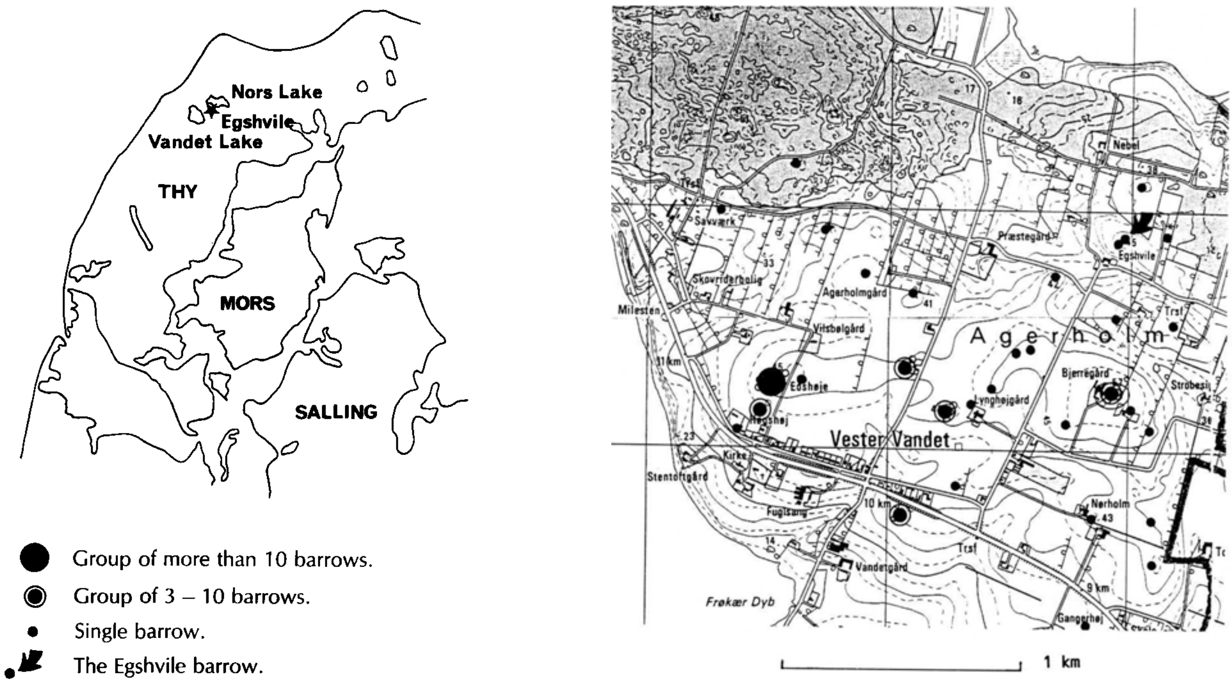



Fig. 1. Map of the north-west part of Jutland, showing the location of the barrow at Egshvile, Thy. With a detailed map of the strip of land dividing the two lakes, showing all known prehistoric barrows. Reproduced with permission from the Geodetic Institute no. A. 404/85.

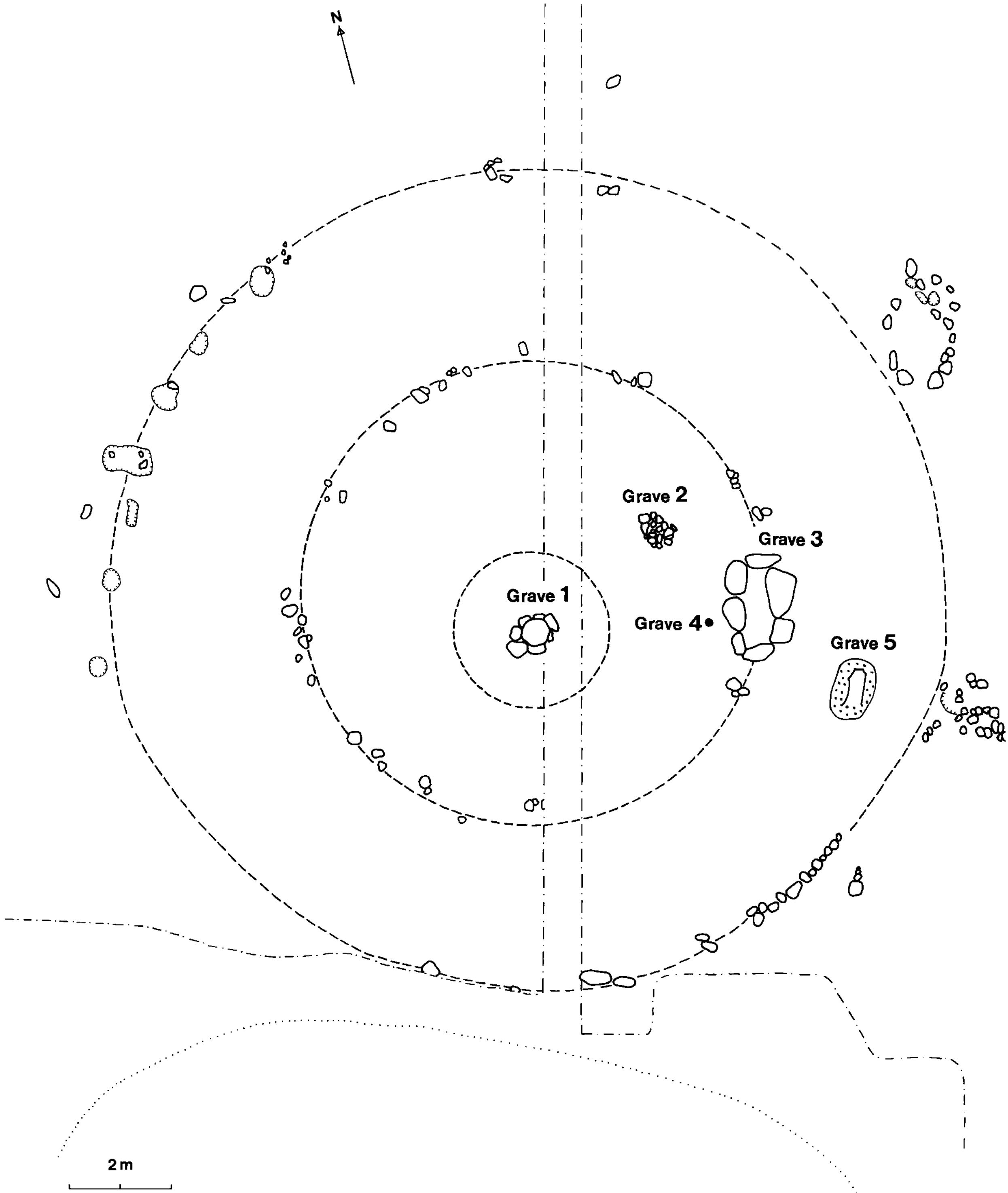



Fig. 2. Plan of the barrow. 1 – 3, phases of construction. Grave 1 – 3, early Bronze Age. Grave 4 – 5, late Bronze Age. ........., perimeter of preserved barrow immediately south of the excavated barrow.

The landscape consists of moraine hills, many of which are crowned by barrows, mostly in pairs or little groups. The subsoil is moraine sand with gravel and small stones, and further down chalky deposits, which in this part of Thy lie close to the surface. The Egshvile barrow was situated on top of a ridge on the edge of a northward-facing slope. Immediately to the south lies another barrow which is untouched by the plough and is therefore still intact. It is now protected by the law protecting ancient monuments.

## HISTORY

The cause of the excavation was classic: A passer-by noticed a cluster of large stones lying in the field and contacted the museum. The stones had formed the lid of a stone-built cist of normal EBA type, and this was excavated in the early spring of 1989. In the autumn of the same year the rest of the mound was excavated. The barrow was found to consist of three phases, all dating from the EBA, with one grave corresponding to each phase. In addition there were two graves from the late Bronze Age inserted into the EBA mound (fig. 2).

## PHASE I

In its first phase the barrow was very small – only 3 m in diameter and probably around 0,8 m high before the partial destruction. Its greatest height below the plough soil was now 0,4 m. It was built of turves and had no demarcation of the perimeter. There was no traceable vegetation layer on the surface of the first phase, but the fill could be clearly distinguished from that of the second phase, especially to the south. To the north, the extension of the mound was indicated by the preservation of a layer of excavated subsoil arising from the construction of the grave (figs. 3–4).

*Grave 1*: The grave was a small stone cist with a trapezoid ground-plan. It measured 50x30 cm internally and was 30 cm deep, with a small opening at the narrow end where the stones did not meet (fig. 6). The cist was covered by a single flat stone and it was surrounded by other stones without any load-bearing function. One of the stones in the side was too short, and an extra stone had been inserted. The stones included fragments of saddle querns. The grave was dug 0,3 m into the ground, the lower surface of the cap stone corresponding to the original ground surface prior to the construction of the barrow.

In the cist, on a layer of gravel 2–5 cm thick, stood the bottom and lower part of a large ceramic vessel, filled with cremated bones. On top of these lay one complete amber bead and half of another, plus 20 small pieces of unworked amber, some of which had fallen out of the urn and lay close by. The rest of the urn was present as large sherds packed around the bottom. One of them had been pushed down rim first, showing that it had been deliberately placed like this (figs. 5A–B). The cist was too small ever to have housed the urn in an unbroken state, since its height after conservation and reassembly was 42 cm, whereas the inside height of the cist, as mentioned above, was only 30 cm (figs. 5–6).

Upon examination, the cremated bones from the grave proved to be those of a child – probably a boy. Judging from the teeth, which included a milk tooth as well as permanent teeth which apparently had not emerged at the time of death, the child was around 5 years of age (2). Among the cremated bones were also bones from the leg of a calf – a phenomenon also seen in the graves in the second and third phases (see below) (3).

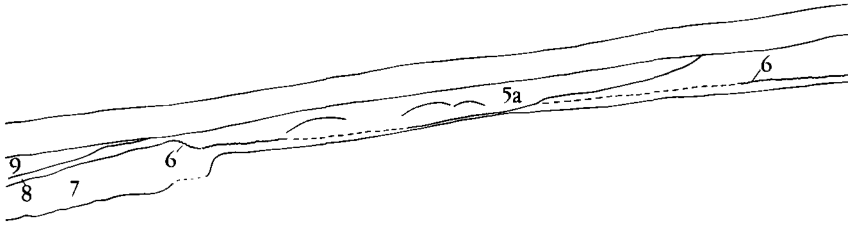
The dating of the grave is difficult, due to the very uncharacteristic grave goods, but as it must necessarily be older than the second phase of the barrow, it cannot be later than Period II of the EBA (see below).

## PHASE II

Whereas in its first phase the barrow was so small that it would hardly have survived to the present day on its own, the second phase was more impressive. The barrow had now a diameter of 9 m, and a single row of kerbstones marked the perimeter. The height was probably between 1,5 and 2 m, and the center lay slightly to the north compared with the first phase, cf. fig. 2.

Like the first phase, the second was built of turves, and it covered another urn grave from the EBA. This was placed c. 1,5 m outside the foot of the first small barrow and was dug approximately 0,5 m into the ground. To the north and south of the grave, a layer of excavated subsoil could be seen under the turves, showing clearly that the grave was dug prior to the construction of the second phase of the barrow.

Fig. 3. Section through the barrow N-S. A – Grave 1; B – Kerbstones around phase II; 1 – buried soil under the barrow; 2 – excavated subsoil from the construction of grave 1; 3 – fill in phase I; 4 – fill in phase II; 5 a–b – fill in phase III; a – with turf structure; b – without turf structure; 6 – thin layer of hard-pan; 7–9 – a filled-in depression immediately north of the barrow. No traces of cultural activity.

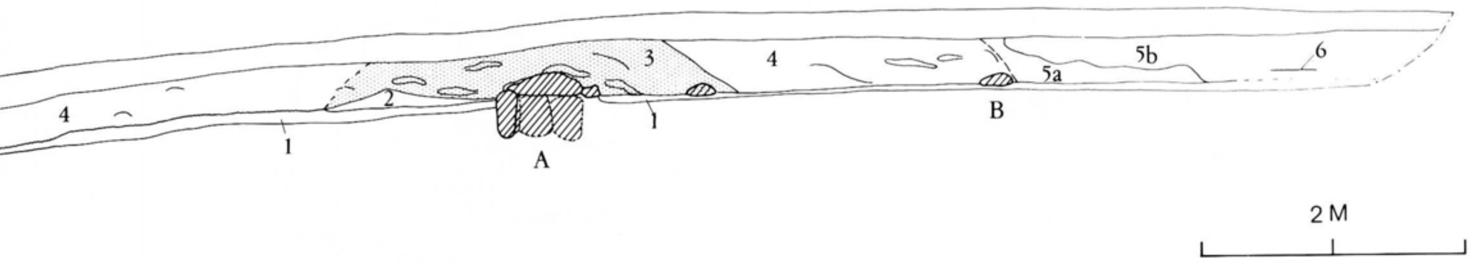



*Grave 2*: The grave was of quite a different kind compared to the first: A proper urn grave with a large vessel, 53 cm high, almost completely buried in the ground. It was covered with a small concentration of stones, 15 – 30 cm in diameter. In conjunction with the stones there was a layer of hard-pan, formed after the construction of the last phase of the barrow. This had helped to prevent loose earth from falling into the grave. Underneath the small concentration of stones was a ring of stones, some of which had fallen in. A larger, flat stone had served as a lid. The sherds of the rim and upper part of the urn could be seen between the stones (fig. 7). Further down the urn was partially set around with stones, a large flat one had fallen in and partially destroyed one side of the urn, fortunately without damaging its contents.

Due to the state of the urn and the surrounding stones it could not be taken up intact with its contents, and it was emptied on the spot, the grave goods being in a fair state of preservation.

A long fibula of bronze protruded from among the cremated bones which filled the lower part of the urn. Beside it lay a smooth, round object – a small vessel lying

Fig. 4. Profile through the barrow N-S with grave 1 and the kerbstones around phase 2.




upside-down and shielding two awls with wooden shafts which had originally lain in the vessel. Among the cremated bones were 6 glass beads, one bead of deer antler, and 10 small bronze spirals, all from the same object, probably a bracelet. Also among the bones were a bronze armring, an amber bead pressed into a lump of pitch, some small fragments of pitch sealant (all that remained of a small box of organic material), and lying on the bottom with the edge upwards, a single-edged bronze knife. Remains of organic material, probably textiles (not yet analyzed), were found adhering to the fibula and lying at the bottom of the urn.

The cremated bones from the grave show that the deceased was an adult woman, which fits in very well with the grave-goods. Her age was difficult to determine, but she must have been between 30 and 50 years old at the time of death (2).

Animal bones were again among the cremated bones – they comprised the hind and the forelegs of a lamb (3).

The contents date this grave to the later part of Period II of the EBA, thereby giving a *terminus ante quem* for the first grave (see below).

## PHASE III

It was the stone cist which originally attracted attention to the barrow. It had been dug into the side of the second phase of the barrow, partly destroying the ring of stones around its perimeter. The cist belonged to the third and final phase of the barrow, which now measured 16,5 m in diameter and was surrounded by an only partially-preserved ring of kerbstones which appear to have been larger than in the second phase. On the outside of the ring

Fig. 5. Grave 1 after opening the cist from the west side. A. With sherds packed around the lower part of the urn. B. With the lower part of the urn and cremated bones after removing most of the packed sherds. One sherd is standing rim downwards behind the urn.

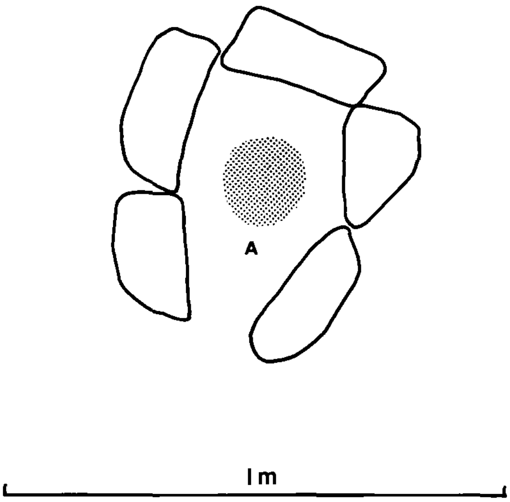



Fig. 6. Grave 1 – plan of the cist. A, bottom of the urn fig. 10.

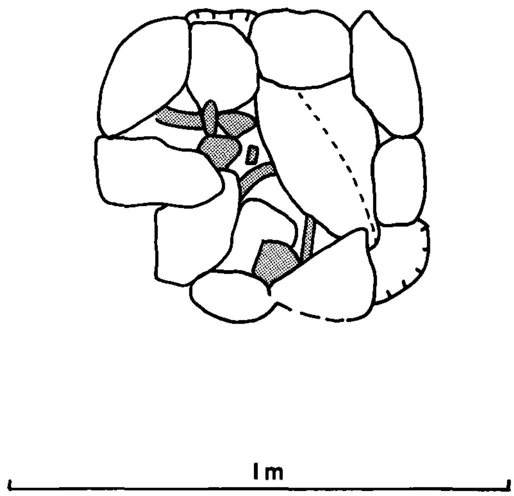



Fig. 7. Grave 2 – plan after the removal of the topmost layer of stones. Hatching indicates sherds from the rim and upper part of the urn.

the remains of a paving of smaller stones could be seen, but this was not very well preserved and was only partially examined (fig. 2).

*Grave 3*: The cist was oriented N–S and built of large, unworked stones – two in the east side, three in the west and one at each end. It measured 1,4 x 0,5 m internally and was 0,45 m deep (figs. 8A–B). The cist had been covered with three large stones which had been removed during ploughing shortly before the excavation. All gaps between the stones had been meticulously sealed with yellow clay and smaller stones, which to a great extent had prevented loose earth from entering the grave before the lid was removed. An overlying mound of stones, such as has been found covering many other EBA cists, was not present here.

Almost in the middle of the cist, on a layer of small rounded pebbles, was a heap of cremated bones. On top of these lay the rich grave-goods : A flange-hilted sword in a wooden sheath, a fibula, a small knife, two double studs, and six small spirals, all made of bronze, plus one spiral of gold, 6 cm long, and 15 small gold spirals. The cremated bones seem to have been wrapped in skins and a piece of cloth, but only small fragments remained where the organic materials had been in direct contact with bronze objects (4).

The cremated bones from the grave show that the deceased was an adult man, which corresponds well with the grave- goods. His age cannot be determined more closely than between 20 and 40 years, but the teeth were only moderately worn, showing that he must have been fairly young (2). As was the case in the urn graves, this grave also contained animal bones among the cremated bones – part of the cranium of a larger animal, the species of which could not be more closely determined (3).

The grave- goods place this grave in Period III of the EBA (see below).

## SECONDARY GRAVES

*Grave 4*: Immediately to the west of the stone cist from Period III , the remains of an urn grave were found. Most of the grave had been removed by the plough, and only the bottom and some loose sherds from the urn were found together with a small concentration of cremated bones. The urn had originally stood on six stones, and it was inserted into the barrow subsequent to the latter's construction. The grave can be dated to the late Bronze Age.

*Grave 5*: A little to the south-east of the large stone cist, a smaller one was found, dug secondarily into the third phase of the barrow. It consisted of a small oval pit, oriented NE-SW and filled with pebbles, among which stood thin limestone flags. These formed the sides and the northern end of a small cist, which measured 95 x 30 cm internally. The southern end and the lid had been re-

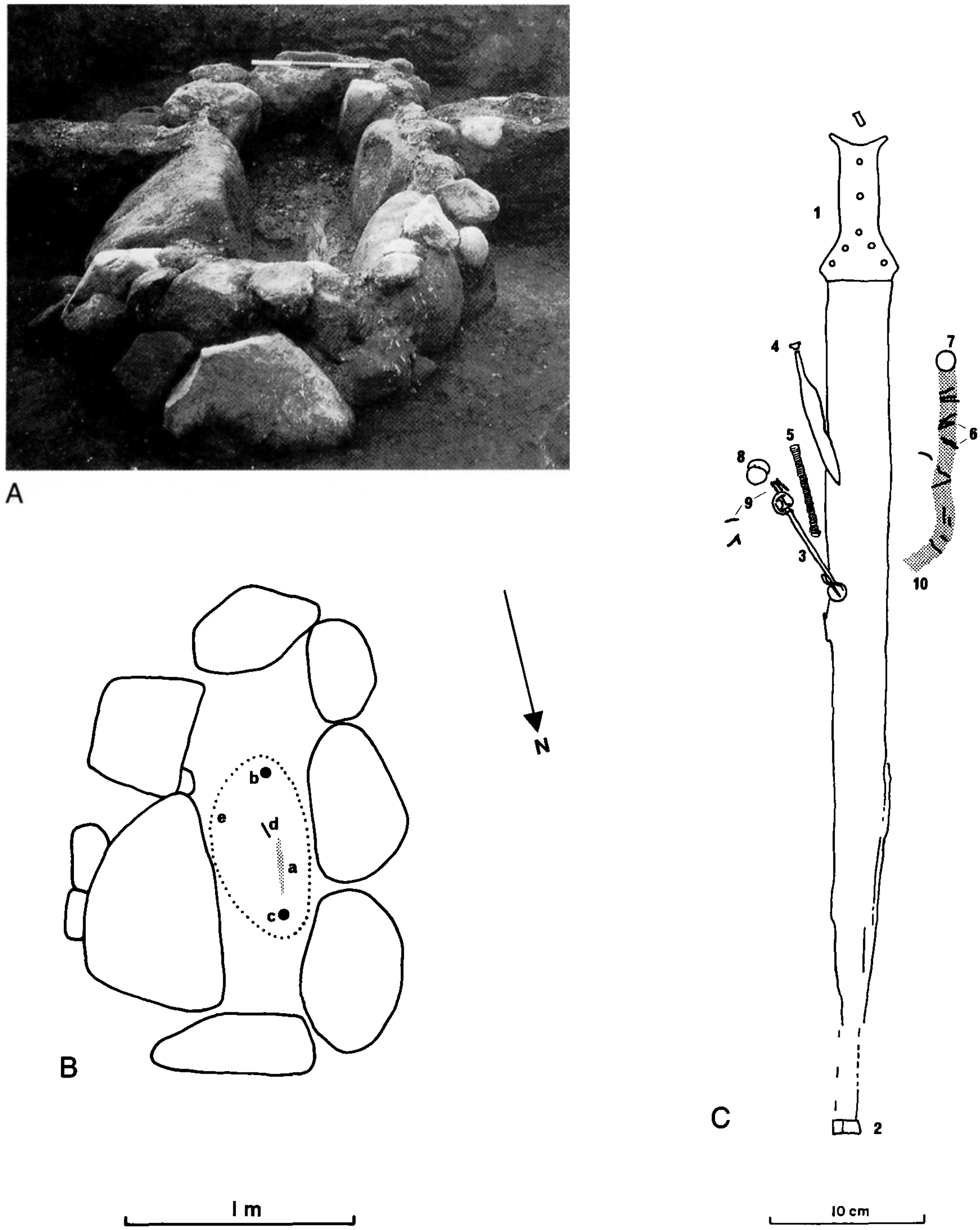



Fig. 8A–C. Grave 3 – the stone cist. A – the cist after the partial uncovering of the sheath. Seen from the north; B – plan of the cist with those parts of the grave-goods which were visible before the removal of the paraffinwax block; a – uncovered part of the sheath; b – rivet at the end of the hilt; c – ferrule; d – fibula; e – cremated bones; C – the objects from the grave *in situ*. Based on an outline drawing after an x-ray photo of the paraffin block, in combination with observations made during the excavation by Viborg Amts Conservation Unit, Skive. 1 – sword and sheath; 2 – ferrule; 3 – fibula; 4 – knife; 5 – large gold spiral; 6 – small gold spirals; 7–8 – double studs; 9 – small bronze spirals; 10 – traces of leather.

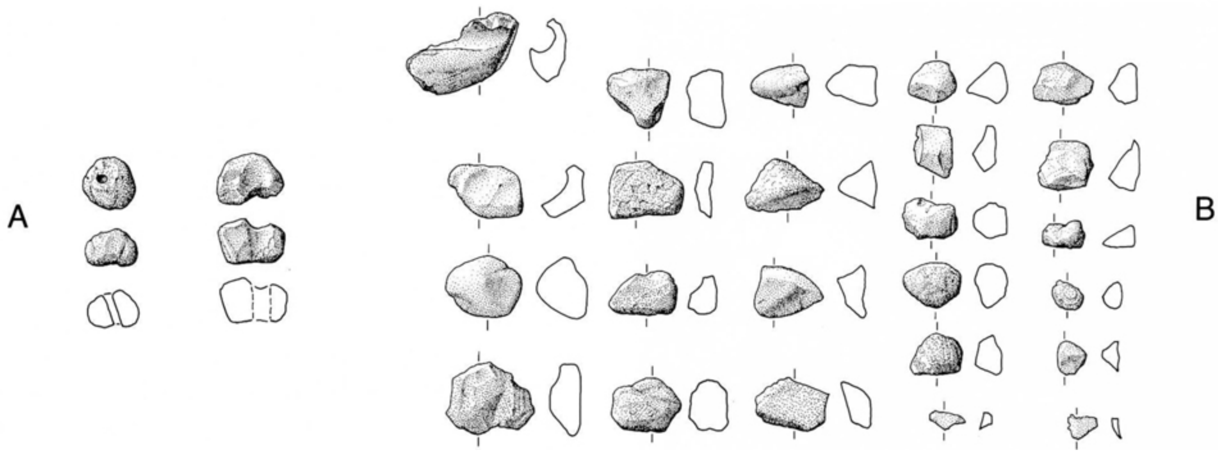



Fig. 9 A–B. Objects from grave 1. Th. Bredsdorff del. 2:3.

moved by ploughing. The construction was so weak that it could hardly be called a proper cist. The grave contained cremated bones, a pair of bronze tweezers, and some fragments of bronze, probably a razor. The grave can be dated to Period IV of the late Bronze Age (5).

## THE ARTIFACTS

*Grave 1 – the child's grave*

*Amber beads* (fig. 9A): One small, irregular, rounded amber bead. Diameter 1,1 cm, diameter of the hole 1,5 mm. Half of one irregular, rounded amber bead. Diameter 1,3 cm, diameter of hole 3 mm. Possibly unfinished.

*Unworked amber* (fig. 9B): 20 small pieces of unworked amber, up to 2,6 cm in length.

*Urn* (fig. 10): A large four-partite vessel, 42 cm high. Diameter of rim 29,5 cm, largest diameter 38,5 cm, diameter of base 17 cm.

The rim is rounded, but rather flattish, and slightly everted, followed by a sloping shoulder and a convex belly. The lowest part of the side is concave, thereby accentuating the base which cannot, however, be described as an actual foot. The bottom is flat.

The clay is very coarsely tempered with granite, the large grains of which are visible on the inside surface as small lumps around which the surface of the clay has cracked slightly. The outside surface is smeared with a coarse coating also tempered with large granite grains.

*Grave 2 – the woman's grave*

*Fibula* (fig. 11A): Fibula of bronze, 12,9 cm long. The fibula has a broad head, flat on the reverse side, with a shape which can be characterized as a double hour-glass. It has 3 crests, the one at the end being a little shorter than the other two. The end of the head is flat. At the point where the bow enters the head it widens, almost creating a third "hour-glass", but without a distinct crest.

Fig. 10. The urn from grave 1. Frank Svendsen fot.

The head is unornamented apart from a faint line on the outer crest. The bow is rhombic in section, and it is ornamented with double lines on the two surfaces which face outward. At both ends the bow becomes round in section and continues in two coils, 1,4 cm in diameter, each coil with 6 turns.

*Awls* (fig. 11B): Two bronze awls with wooden shafts. In both cases the point had broken off, leaving a small piece of the awl sitting in the shaft. Both shafts are of wood and very well preserved. One (fig. 11B, left) is made of a split willow twig and has a conical shape, measuring 4,9 x 1 cm. Fine lines can be seen on the surface, which may possibly have been made with a sharp knife. They seem, however, to be random scratches rather than ornamentation. The other shaft (fig. 11B, right) is cylindrical, measuring 4,3 x 1,2 cm and made of a whole hazel twig (6). The diameter of both bronze awls is 2 mm, the section of the part outside the shaft is round while that of the part in the shaft is flat.

*Armring* (fig. 11C): Armring of bronze, in several pieces and partly damaged by fire. The original diameter was probably around 8 cm. The ring is round in section with a diameter of 3 mm. The outside is diagonally-grooved, but it cannot be determined whether the ring has had smooth ends.

*Bracelet* (fig. 11D). The bracelet consists of:

6 round glass beads, measuring between 10 and 12,5 mm in diameter. The diameter of the hole is 3 – 4,5 mm. Three beads are blue and two greenish-blue, the latter were probably originally blue like the others. The last bead is marbled in dark and light green. Unlike the others, this bead is not translucent.

10 small bronze spirals, mostly in a rather damaged state. Original length 10 – 11 mm, diameter 3,5 mm.

One tubular bead of deer antler 13 mm long, 9 mm in diameter. Diameter of hole 5 mm.

The latter was found on a double string, probably of leather (6), together with one of the glass beads, and separated from it by one of the bronze spirals. Three of the spirals were also found together, two on two parallel strings which were gathered in the third spiral. The remainder of the beads and spirals were found distributed randomly among the cremated bones, but there can be no doubt that they belonged to the same object, probably a bracelet.

*Knife* (fig. 11E): Single-edged knife of bronze, 16,3 cm long. The blade is curved, 11,2 cm long, with a concave edge, and it is 3 mm thick at the back. Two shoulders mark the transition to a flat, rectangular tang, 5,1 cm long, 8 mm broad, and 3 mm thick. The end is broken off, but may have been slightly wider than the rest of the tang. The knife is unornamented.

*Amber bead in pitch inlay* (fig. 11F): One cylindrical amber bead, 12 mm in diameter, 9 mm long. Diameter of hole 3 mm. The bead is well-made with a smooth surface. Bronze remains can be seen in the hole, and the bead is mounted in a conical lump of dark pitch, 31 mm in diameter, which appears to be made out of coiled strips (7). The hole in the bead continues through the pitch which, together with the traces of bronze, is consistent with a bronze rivet having been passed through both. The piece probably served as inlay in some object of organic material which has not been preserved.

*Small pieces of pitch sealant* (fig. 11G): One piece and two small flakes, seemingly of the same dark pitch as mentioned above. The small piece has a triangular section, is c. 5 mm broad, and represents an arc, 2 cm long, of a small circle which was originally c. 5 cm in diameter. On the two short sides there are closely-spaced, parallel marks in the surface which resemble impressions of wood-grain. Other marks seem to come from a seam where two pieces were sewn together. The two small flakes show the same wood impressions with a 1 mm groove (6).

There can be no doubt that the pieces served as sealant inside a small rounded box made of thin wooden strips which were sewn together. The arc piece of sealant was used at the transition from the bottom to the side, the small flakes are from the overlap where the side was joined. The box may have been circular with a diameter of approximately 5 cm, or it may have been oval, in which case the length cannot be determined. The height was at least 3 cm.

*Ceramic vessel* (fig. 11H): Small ceramic vessel. 5,5 cm high, diameter of rim 4,5 cm, largest diameter 6 cm, diameter of base 1,5 cm. The rim is rounded and everted, followed by a sloping, slightly concave shoulder, a rounded belly-turn with three short vertical ridges and a convex belly. The bottom is flat. The vessel has had one handle, fastened on the rim and the belly-turn respectively. The handle was broken off before deposition in the

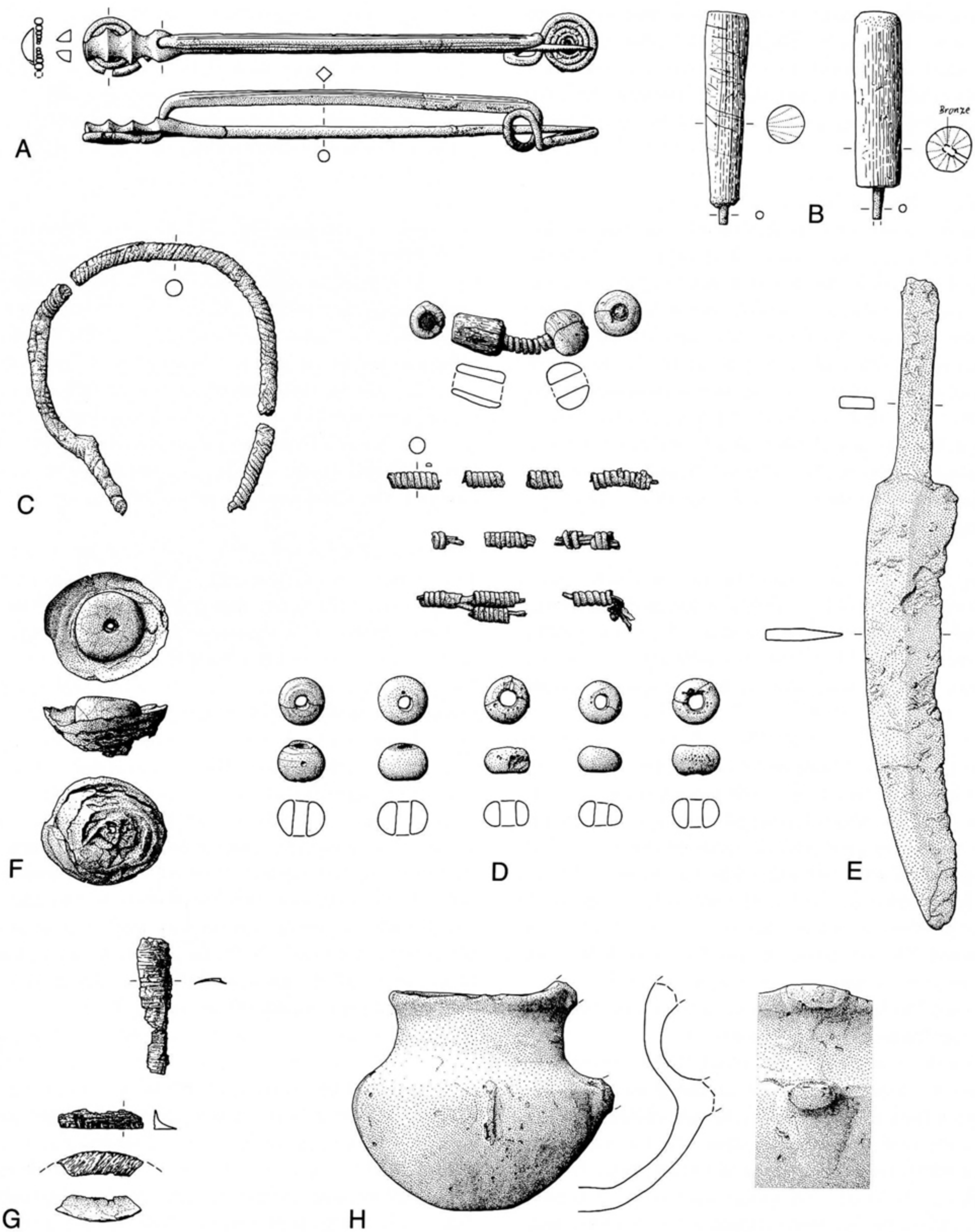



Fig. 11A–H. Objects from grave 2. Th. Bredsdorff del. 2:3.

grave, but judging from the fragments it may have been extended above the rim. The remains of the handle are rather worn, indicating that it was broken off some time prior to deposition. The clay is finely tempered and well fired, with a smooth, glossy surface. The colour seems originally to have been a dark grey. The vessel had originally contained the two awls, fig. 11B.

*Urn* (fig. 12): Large bi-partite vessel, 53 cm high. Diameter at the rim c.33 cm, greatest diameter 41 cm, diameter of base 18 cm. The rim is flat and neither everted nor inverted. The vessel has a slightly bi-conical form with a rounded belly-turn placed c.38 cm above the bottom. The bottom is flat. The clay is very coarsely tempered with granite, and badly fired, which gives it a great tendency to crumble. The outside surface is covered with a smeared coating, over most of which there are vertically-running, parallel lines. Part of the rim and upper part were destroyed by a falling stone.

Fig. 12. The urn from grave 2. Frank Svendsen fot.

*Grave 3 – the man's grave*

*Flange-hilted sword* (fig. 13A): Flange-hilted sword of bronze, 57 cm long, original length including the pommel c. 61 cm, with remains of a hilt and pommel made of horn (6). The sword is very well preserved apart from the extreme end which has been broken off. The grip is 5 cm long with flanges 7 mm high. There are 3 rivets in the grip and 4 in the hilt-plate, another rivet was found at the end of the hilt. This originally fastened the pommel, and remains of horn can still be seen on it. The sides of the hilt are slightly curved, the shoulders sloping. The blade is 49 cm long and 42 mm broad immediately below the hilt. It has a broad, flat rib and no ornamentation. The edge is sharp and shows no visible signs of use or wear. On the surface of the blade can be seen short hairs sticking to the bronze – arising from a skin-lining of the sheath.

*Sheath* (fig 13B): The wooden sheath of the sword described above. The sheath extended beyond the point of the sword, its total length being 58 cm including the ferrule. The extension had almost completely disintegrated, the preserved length of the sheath being 46 cm. The total length of the sword and sheath was originally 65,6 cm.

The surface of the sheath is plain and shows no ornamentation. Remains of leather with diagonally-running hairs on the outer surface and remains of skin and hairs on the inside at the edge, together with the hairs adhering to the sword, show that the sheath was both lined and covered with skin. The sheath is made of hazel wood (6). The extended part was rhombic in section, corresponding with the ferrule in which the end of the sheath still sits. Immediately above the ferrule a 6 mm broad lashing, probably of plant fibres, can be seen (8).

The ferrule is made of bronze, has a rhombic shape and measures 13 x 14 x 8 mm. The side is ornamented with fine, horizontal grooves. At the end there is an aperture, 8 mm broad, where the extended part of the sheath ends.

*Knife* (fig. 13C): Small, single-edged knife, 9,9 cm long. The blade is curved with a concave edge and 4 parallel ridges across the upper end. The grip is oval in section and is quite plain. It ends in a flat, rhombic, rounded knob. The edge is partly damaged.

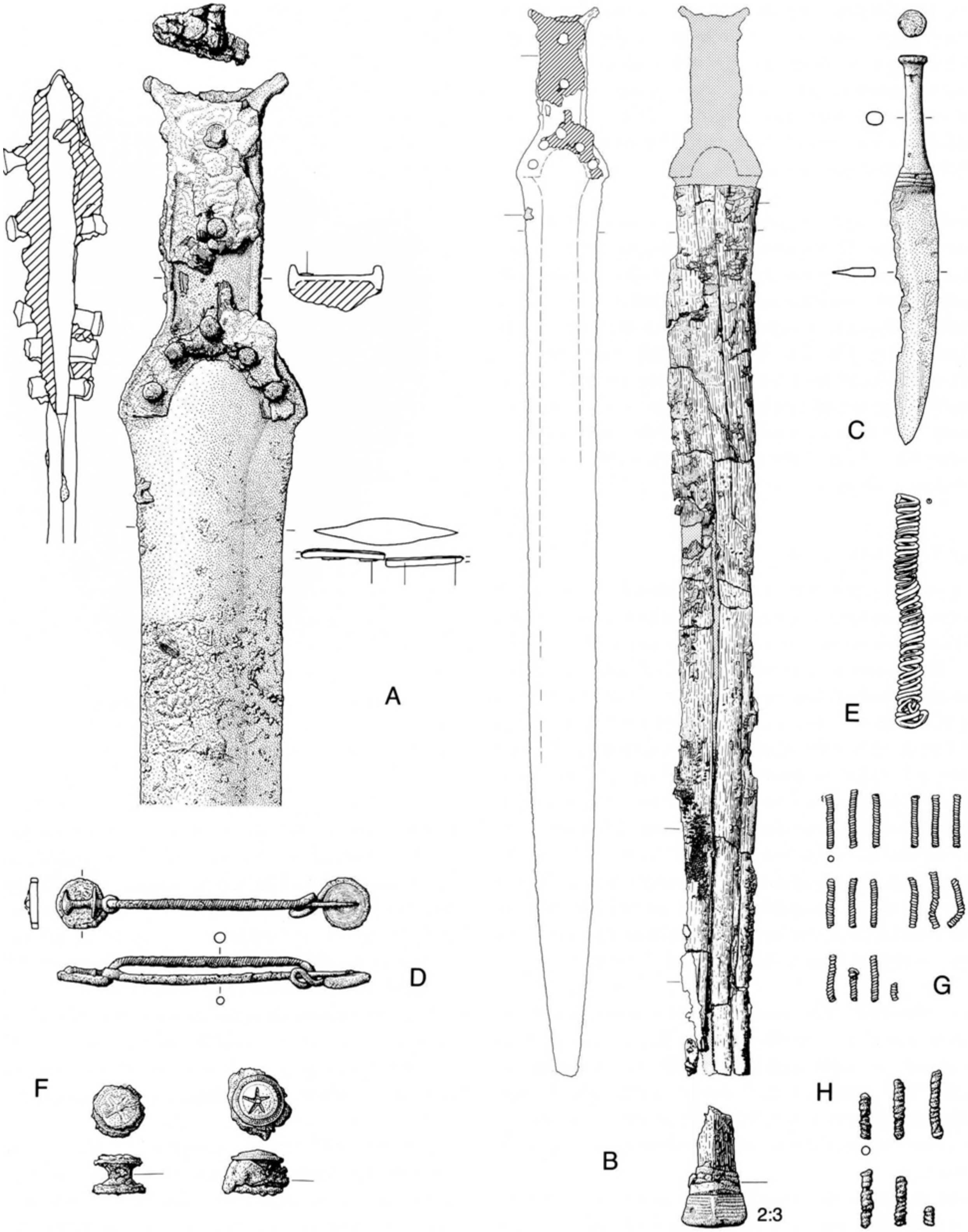



Fig. 13A–H. Objects from grave 3. Th. Bredsdorff del. A, C–H 2:3; B 1:3.

*Fibula* (fig. 13D): Fibula of bronze, 8 cm long, with a head shaped like a double cross. The bow is round in section and diagonally grooved. The spirals are beaten flat with the windings still visible, diameter 13 mm.

*Spiral of gold* (fig. 13E): Spiral roll of gold wire, 6 cm long, 0,6 cm in diameter. The wire is double, and it is broken at one end. Weight 10 g.

*Double studs* (fig. 13F): Two almost identical double studs of bronze, one well preserved, the other rather corroded. Diameter 13 mm, height 11 mm. Both have one slightly-domed disc ornamented with a 5-rayed star surrounded by a double row of beading. The other disc is flat and unornamented. Remains of leather can be seen on both studs (8), and they have belonged to a leather belt (see below).

*Small gold spirals* (fig. 13G): 15 small spiral rolls of gold wire, c. 14 mm long and 2 mm in diameter, (some of them in fragments). The spirals are made of a single wire with a D-shaped cross-section and are tightly- coiled, forming a small tube (8). The gold spirals belong to the same belt as the studs (see below).

*Small bronze spirals* (fig. 13H): 6 small spirals of bronze wire, c.14 mm long and 2 mm in diameter. All rather corroded and several are fragmented. Like the gold spirals, they are made of tightly-coiled single wire. The bronze spirals belong to the same belt as the gold spirals and the studs. Inside the bronze spirals are remains of organic material, possibly leather (6).

The two studs, the 15 small gold spirals, and the 6 bronze spirals belong to a leather belt of which only traces were found. The gold spirals lay in 5 groups of 3 at intervals of c.1 cm, along one side of the sword, in continuation of one of the double studs. In the same area traces of leather could be seen in a line corresponding exactly with the spirals and the stud (8). The bronze spirals were found on the opposite side of the sword in 2 groups of 3, together with the other stud on which, as mentioned above, traces of leather could be seen (fig. 8c). The spirals, which are rather delicate, must have been sewn on to the belt.

## DISCUSSION

### *Grave 1 – the child's grave*

The grave- goods do not provide a precise dating for this grave, as neither the amber beads nor the urn can be dated accurately at the moment. However, the rich woman's grave from phase II gives a *terminus ante quem* for this grave, making sure that it cannot be later than Period II of the EBA.

The *urn* (fig. 10) is distinctly EBA in character as regards the temper and the way the latter shows in the surface (9). The author is not acquainted with any exact parallels in the Danish material, but the urn is very similar to a find from Gottrupel, Kr. Schleswig-Flensburg – also an urn grave, presumably from Period II (Aner & Kersten 1973–1990, vol. 4 cat. 2220H). Unfortunately only the lower part of this urn is preserved. It does show, however, great similarity to the urn from Egshvile as regards proportions and temper. The urn from Gottrupel, however, shows no smeared coating. It contained a dagger blade with a trapezoid hilt-plate and two rivet holes, plus the burnt bones of one, possibly two, adults and a child. The dagger blade had been damaged by fire. (Aner & Kersten, op.cit. p.28). The Egshvile urn, therefore, is consistent with a date in the early Bronze Age, probably Period II.

There were no indications in the stratigraphy of a great length of time having elapsed between the burial of the child and the woman. On the contrary, the absence of a vegetation-layer on the surface of the barrow of phase 1 and the incorporation of so small a mound in a later burial point to a close connection, both chronologically and possibly socially. On the other hand, pollen analysis of samples from the fill and the soil beneath the barrow showed a marked change in pollen frequencies from phase 1 to phase 2 and 3, showing that some years must have elapsed between the two burials (Andersen 1991 and personal comm.).

The *amber beads* and the *pieces of unworked amber* (fig. 9 A–B) cannot be dated with any accuracy, but amber beads of a corresponding type are occasionally found in small numbers in graves from the EBA, some of them children's graves (e.g. Aner & Kersten 1973–1990, vol. 5 cat. 2675B and vol. 6 cat. 3017C). More unusual are the 20 pieces of unworked amber also found in the grave. Unworked pieces of amber, singly or in small numbers, are sometimes found in graves from the EBA. The most famous instances of this being the finds where the amber pieces were found in leather pouches together with small bronze objects such as razors and tweezers and, in some cases, with objects that have presumably had magical uses (see Lomborg 1957, p. 177ff).

The occurrence of 20 pieces of amber in a grave is, to the author's knowledge, unparalleled in Danish finds from the early Bronze Age, the nearest example is a Period III grave on the island of Amrum, where 10 unworked pieces of amber, between 0,9 and 2,7 cm in length, were found in a man's grave together with several small bronze objects. Judging from the available information, the pieces of amber and the bronze objects appear to have lain in a bag or pouch of which no trace remained (Aner & Kersten 1973–1990, vol. 5:8 and cat. 2572C, compare Lomborg 1957).

This raises the question as to whether the pieces of amber were put in the Egshvile grave as valuables or because of their supposed magical properties, as has previously been discussed by other authors (e.g. Thrane 1984, p. 19). No definitive answer can be given to this question, but the way in which the amber pieces were strewn over the urn (see above) could indicate their being in some way connected with the grave ritual (10).

*Grave 2 – the woman's grave*

Most important for the dating of this grave is the *fibula* with double hour-glass-shaped head and rhombic bow (fig. 11A). It belongs to the broad-headed type which characterizes the later part of Period II (Broholm 1944 vol. 2, 126).

The fibulae of this type have been studied closely by K. Randsborg (1968), who shows that they occur in western Slesvig-Holstein and the southern, western, and northwestern parts of Jutland in Period II, whereas in Period III they are replaced by cross-headed fibulae in this area. In the eastern and middle parts of Slesvig-Holstein and the eastern and northern parts of Jutland, fibulae with hour-glass-shaped head are found together with objects characteristic of Period II, as well as those belonging to Period III, but in a milieu that is contemporary with early Period III finds with cross-headed fibulae of the western parts of Jutland and Slesvig-Holstein. This latter group of broad-headed fibulae are characterized by ornamental traits suggestive of Period III, such as many ornamented ridges and a very careful workmanship with great attention to detail (Randsborg 1968, 101ff.) One such fibula was found in Thy, in a grave which can be dated to Period III (Randsborg 1968, 81 & Abb. 40).

The Egshvile fibula, on the other hand, must be dated to Period II judging from its size and the almost completely unornamented head (11). The head has a very close parallel in a grave from Sylt dated to Period II (Aner & Kersten 1973–1990, vol. 5 cat. 2664A; Randsborg 1968, 135, note 346). This fibula, however, has a flat bow ornamented with two zigzag-lines. It is interesting to note that this grave is also a cremation burial, although not an urn grave, but in a stone cist (see note 17, Aner & Kersten 1973–1990, vol. 5, 69).

*The awls* (fig. 11B) are of normal Bronze Age type, and although they are most often associated with male equipment, they have also been found in other women's graves from Period II (Broholm 1944, 2:123). The most famous of these is the Egtved grave, where the awl lay in a small bark-box, very much like the two awls from Egshvile which had lain in the little vessel (Brøndsted 1958, 73). The fact that there were two awls in the Egshvile grave, but no other objects normally associated with manicure etc., indicates that these awls must have been tools, probably for the working of leather, wood, and bark – very important occupations in the Bronze Age, a fact to which the graves from Egshvile also bear witness (see also Hvass in Alexandersen *et al.* 1981, 22).

It is impossible to ascertain whether the points of the awls were broken off prior to or after deposition in the grave, but the latter seems most probable, the broken-off pieces having disappeared.

The fire-damaged *armring with diagonal grooves* (fig. 11C), is chronologically somewhat ambiguous. Armrings of bronze with diagonal grooves and plain ends are a common type in women's graves from Period III (Broholm 1952 no. 290). According to K. Randsborg, however, armrings with diagonal grooves can be encountered in Central European finds older than the Urn Field Culture, contemporary with the Nordic Period II (Randsborg 1968, 122, note 323.)

As was the case with the fibula, a close parallel can be found on the island of Sylt, where a fire-damaged armring with diagonal grooves was found together with, i.a. a round-headed fibulae in a cremation grave in a stone cist from Period II. (Aner & Kersten 1973–1990, vol. 5 cat. 2705). It is striking that in both cases stylistic similarities go hand in hand with similarities in funeral-rites – in the latter case even in a detail like the fire-damaging of part of the grave-goods, which was also a feature of the Period II urn grave from Gottrupel, mentioned above (12). In conclusion it can be said that the presence of the armring does not change the over-all dating of the grave to Period II (confirmed by K.Randsborg, pers. comm.).

*Glass beads* (fig. 11D) are not very common in graves the EBA, but they do occur both in Period II and III, mostly in women's graves and often in combination with small bronze spirals and beads of other materials, mostly amber (Thrane 1962, 93 and notes). From finds in inhumation graves it can be seen that both of these have been used as necklaces, e.g. in a grave from Skrydstrup (Aner & Kersten 1973–1990, vol. 7 cat. 3521D) and in bracelets. The most famous example of this is the oak coffin grave from Ølby, Zealand, where one dark blue glassbead, two amber beads, and several bronze spirals were found in the region corresponding to the upper arm (Boye 1896, pl. XXVI) (13). In the Lüneburg area, glass beads, together with small bronze spirals, were often used in necklaces (Piesker 1958).

The graves from Skrydstrup and Ølby are both of Period II date, and they show that composite jewellery with glass beads can be found in eastern Denmark as well as in Jutland, although the distribution of EBA glass beads in Denmark is centered on south-east Jutland (see map in Sprockhoff 1961). In Thy a similar bracelet, but with smaller beads of a light blue-green colour, has been found in a rich woman's grave from Period III (Bech 1981).

Nothing can be said about the provenance of the glass beads at the moment as they have not been analysed, but there can be no doubt that they are imported.

The *bronze knife* (fig. 11E) is of an unusual type to which the author knows no parallel in the Danish material. The fact that it has two shoulders at the transition from blade to tang links it with the single-edged knives from Period II (Broholm 1944, vol. 2, pl.18), and distinguishes it from the tanged knives of Period III which are usually ornamented, and in which the tang follows the line of the back (Broholm 1944, vol. 2, pl. 29, 6–7).

The *amber bead in pitch inlay* (fig. 11F) is another object to which the Danish material does not seem to offer any parallels. As mentioned above, it probably served as an inlay in some object made of organic material – maybe wood or bone which has now disappeared, just as was the case with the little box made of wooden strips mentioned earlier of which the only remnants are the three small pieces of *pitch sealant* (fig. 11G). Similar fragments and even whole rings of sealant showing impressions of wood are known from a small number of Bronze Age graves (Sarauw 1929, 78f.).

Sewn boxes or buckets of bark or wood are fairly common in EBA graves under conditions favourable for preservation, such as existed in the oak coffins (Boye 1896). The box from Egshvile seems to be smaller than most, but this only shows that the variations in form and size were probably much greater than is apparent in the finds to date. All the known boxes are quite plain, but it is tempting to see the amber bead as a part of the box, perhaps inlaid in a knob on the lid.

With regard to the two *ceramic vessels*, the urn is of a well-known EBA type (9), whereas the small vessel, which had contained the two awls, seems to have no Danish parallels. 3 ornamental knobs placed on the belly-turn can be seen on a vessel from Borum Eshøj (Broholm 1944, 2, pl. 24:8), but these are round knobs, not vertical ridges, and the vessel from Borum Eshøj has no handles. Taking into consideration the lack of parallels and the unusually careful workmanship, it is possible that the small vessel from Egshvile was imported (K. Randsborg, pers. comm.).

In conclusion it can be said that grave 2 contained the remains and the grave-goods of an adult woman of high social status, buried sometime during the second half of Period II of the EBA.

### *Grave 3 – the man's grave*

The objects in grave 3 (fig. 13A–H) are typical of male graves from Period III of the EBA : The *flange-hilted sword*, belonging to Sprockhoff's type IIa, the *elongated sheath* with the small *rhombic ferrule* together with the smaller bronze-objects – the *cross-headed fibula*, the small *single-edged knife*, and the *double studs* – are known from many finds and with some variety often occur together, constituting a warrior's equipment typical of the period (Broholm 1944, 1, e.g. grave 1283, 1347, 1464, 1622, 1692). In most cases, however, one or more of the objects are missing. The Egshvile grave is therefore richer than most – a fact which is emphasized by the occurrence of gold in the grave in the form of one large and 15 small gold spirals from the belt. Collectively, these finds make it one of the richest EBA graves from Thy.

The function of the *large gold spiral* cannot be determined with certainty. It lay between the knife and the fibula, the orientation following that of the knife, but it seems to have been worn separately, maybe on a string of

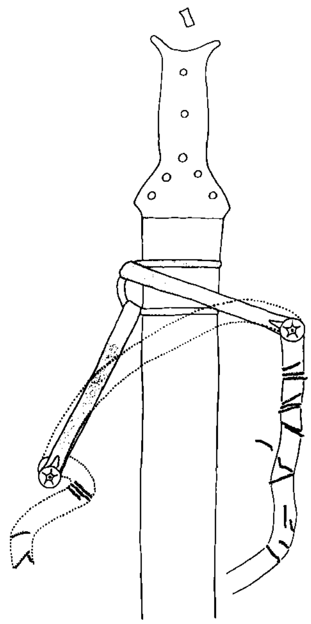


Fig. 14. Reconstruction of the sword hanging in the grave. The position of the metal objects are taken from the outline drawing of an x-ray photo of the objects in situ, cf. fig. 8C. The outline of the remains of the leather belt with the gold spirals is taken from the same figure. Originally the belt was probably at least 1,4 cm broad, corresponding with the length of the spirals. Stipling indicates a possible continuation of the belt, based on the position of the metal objects. Hatching, reconstruction of sword-hanging.

organic material. The one broken end may be the result of small pieces having been broken off as payment (cf. Lomborg 1957, 153) (14).

As regards the 15 *small gold spirals*, they have, as mentioned above, belonged to a leather belt to which the *6 small bronze spirals* and the *2 double studs* also belonged. The spirals occurred in two rows on either side of the sword, with a double stud at the end of each row. In the rows, the spirals were in groups of three with regular intervals, and under the gold spirals, traces of leather could be seen in a breadth corresponding to the length of the spirals, c. 1,4 cm. The length of the decorated belt or part of a belt cannot be determined exactly. Traces of the belt itself could not be followed very far beyond the gold spirals, neither could it be seen on the other side of the sword in connection with the bronze spirals (8) (cf. fig. 8C).

The grouping of the spirals and the studs shows that the two studs were an integral part of the belt, which probably carried the sword, corresponding well with the many finds in which a sword is found together with two or more studs (Broholm, 1944, vol. 1 graves cited above, Müller 1909, p. 97).

The question is then: How was the Egshvile belt worn, and how was the sheath fastened ? In the attempt to solve this problem, another find comes to our aid – a rich man's grave from Period III at Hvidegård, Zealand (Aner & Kersten 1973–1990, vol. 1 cat. 399; Herbst 1848). Like the Egshvile grave, this is also a cremation grave in a stone cist. It was excavated as long ago as 1845, but was very well documented according to the standard of the time (Herbst 1848). The grave contained, among other things, a sword in a very well preserved sheath.

On the upper part of the sheath there was a leather loop in which there was a narrow leather thong, c. 9 mm broad, which had originally been c. 20 cm long and had been bent double (all measurements are taken from the drawings in Aner & Kersten). This thong was fastened with a small double bronze stud to a broader leather strap – the belt itself, c. 15–18 mm broad, of which a 36 cm length was preserved. Another identical stud fastened the remains of another thong to a detached leather strap of the same breadth as the belt and no doubt a part of it. A small piece of this second thong was preserved in the loop of the sheath. It was interpreted during the excavation as the remains of an earlier hanging which had been torn off and substituted by a new one (Herbst 1848, 344. Visible on the drawing in Aner & Kersten, but not in Herbst). The fact that the sheath actually hung from two straps is confirmed by another find – a dagger sheath from Magleby, which has two loops of bronze on the upper part of the sheath (Müller 1909, 95 and fig. 101; Broholm 1952 nr. 247).

Returning to the Egshvile find it is striking that the pair of studs lie beside the upper part of the sheath with a distance to the sheath and each other that fits exactly with them having fastened the sheath to the belt by way of two thongs running through a loop on the side of the sheath (fig. 14), exactly as was the case at Hvidegård. The question remains as to how the belt itself was fastened. Whereas the Hvidegård find has a third, larger stud, which may have fastened the belt itself, nothing like that was present in the grave from Egshvile. It is unlikely that the small bronze studs also served to close the belt, but there may have been a third stud made of organic material (now disappeared), as was the case in some of the oak coffins (Boye 1896, 162).

Usually the sword hangings of the EBA are reconstructed as a diagonal belt across the chest, on the basis of

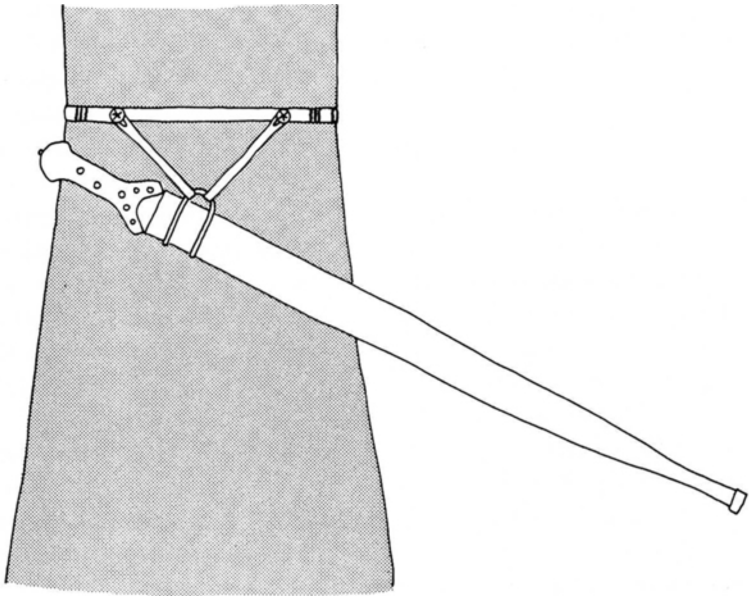


Fig. 15. Reconstruction of the way in which the Egshvile sword was probably worn. The angle between the body and the sword corresponds well with the rock-carvings and the carvings in the grave of Kivik, Scania.

the young man's grave from Borum Eshøj (Boye 1896, 56). This is not necessarily the only solution, however, and the way in which the sheaths from Hvidegård, and probably also Egshvile, are fastened is more compatible with a conventional belt round the waist (see reconstruction fig. 15). The placing of the gold and bronze spirals close to the studs also points to a conventional belt rather than a diagonal belt, where the obvious place for decoration would be across the breast, not on the lower part. It is likely that this kind of belt and hanging were also used in the other Period III graves with corresponding pairs of small double studs of bronze (Broholm 1944 vol. 1, e.g. grave 1347, 1464, 1622). This design may have been more widespread than is evident from the graves – one or both studs may have been made of organic materials and therefore have disappeared. Instead of the studs, two tutuli may have had the same function (cf. Fischer 1977 with ref.).

The spiral-decoration on the belt is unusual, but a few other finds of small gold spiral rolls are known from Jutland (Broholm 1944, vol. 1, 232–233 nos 53, 108, 140, 158. Vol. 2, 169). The best parallel to the Egshvile grave is another Period III grave from Nustrup parish, Haderslev county (Aner & Kersten 1973–1990, vol. 7 cat. 3487). A cremation grave in a stone cist contained a flange-hilted sword, an armring of gold, fragments of several small bronze objects, i.a. a fibula, a needle, and a small single-edged knife, plus 37 small gold spirals of the same type as those from Egshvile, only shorter. They were found lying on a stone, and nothing can be said about the way in which they were worn. There were no double studs in the grave, but as it was excavated by a layman in 1884, and considering the very damaged condition of the small bronzes in the grave, this can hardly be regarded as conclusive (Aner & Kersten 1973–1990, vol. 7, 56). What is obvious is the similarity in the cultural milieu and the social status of the deceased.

The only other grave with numerous small gold spirals known to the author is a find from Bække parish, Anst county (Müller 1909, 96; Broholm 1944, vol. 1 no. 2304; Aner & Kersten 1973–1990, vol. 8 cat. 3788). This grave contained 21 small gold spirals, two double studs of bronze, and a gold spiral of normal type, probably a finger ring.

These finds show that the occurrence of numerous small gold spirals is not an isolated phenomenon in the Egshvile grave. Both parallels mentioned come from the southern part of Jutland, which may not be a coincidence. Müller (1909, 96) mentions that small spiral rolls of gold and bronze seem to be more numerous in northern Germany, where there is an example of their having been used for a decoration of the same type as in Egshvile : In small groups of four, forming small squares and placed in rows with small intervals – only in this case they were fastened to cloth.

*Funeral rites and grave forms*

The introduction of cremation burials into EBA Denmark is traditionally seen as a gradual process – a few cremation graves occurring in Period II, with an increasing frequency in Period III during which cremation graves rapidly became numerous, at first in long cists or coffins like those of inhumation graves, later in smaller cists or coffins, and finally in urns (e.g. Brøndsted 1958, 106 f). The urn graves follow the same pattern, only with a certain time lag: A sparse occurrence in Period III, developing into a common phenomenon in Period IV.

Excavating the barrow at Egshvile, therefore, made one feel a little like Alice in Wonderland. Things were turned upside down – in the center two urn graves from Period II, followed by a "normal" stone cist from Period III as the last EBA grave in the barrow.

If we compare the two urn graves from Egshvile, it is obvious that grave 1, the child's grave, is rather unorthodox compared to the more normal urn in grave 2. Actually, grave 1 could be described as combining elements from normal EBA cremation graves with the use of a ceramic vessel as a receptacle for the bones.

A small stone cist of very similar type was found in a barrow at Villerup in southern Thy (15). This grave, datable to Period II/early Period III contained the cremated bones of a ten month old child, and it was the primary grave in a barrow that was 4,1 m in diameter in its oldest phase, later achieving the dimensions of a "normal" EBA barrow. Among the later graves was a man's grave with a sword and a bronze pin- a cremation grave in a stone cist from Period III. The similarities to the barrow at Egshvile are striking, and show that Egshvile is firmly rooted in the local EBA milieu, the only exotic trait being the urn, which had obviously presented some practical difficulties at the time of the funeral.

The woman's grave, grave 2, on the other hand, represents the urn grave in a more typical form – a large vessel with cremated bones and grave-goods, set around with stones and covered with a flat stone. Only the rich grave-goods show affinity to contemporary inhumation graves. It may be worth noting that the bones of both grave 1 and 2 were rather badly cremated compared to grave 3 and other Period III cremation graves.

The two urns are – as far as published material goes – the oldest in the Danish EBA. The only other Period II urn graves from the Nordic EBA known to the author are 1: The grave from Gottrupel, Slesvig, mentioned above, and 2: A grave from Hammah, Kr. Stade in North-West Germany (16) (Pantzer 1984). It is impossible on the basis of these four occurrences to determine whether they should be seen as the beginning of a continuous process introducing the urn-grave custom into the Nordic EBA, but it is worth noticing that another trait connected with cremation graves in a more developed form also occurs in Period II, namely a marked shortening of the cist or coffin (17).

All three EBA graves from Egshvile contained animal bones among the cremated bones – from a calf, a lamb, and an unidentified larger animal respectively. The species of animals clearly show that the bones represent food – either provisions as part of the grave-goods, or the remains of a sacrifice or a ritual meal that took place at the funeral. Viewing the bones as part of the grave-goods seems the most reasonable interpretation, but this does not necessarily mean that the rest of the animal was not partaken of by the living in a ritual meal. Unfortunately, few analyses of bones from Danish cremation graves have as yet been carried out, compared with the vast amount of material available. Accordingly, it cannot be determined how widespread a phenomenon the occurrence of animal bones in EBA cremation graves is (18).

*Cultural connections*

In their work on The Prehistory of the North Friesian Islands, K. Kersten and P. La Baume (1958) repeatedly stress the close cultural similarities in the EBA between these islands and the former Thisted county, comprising Thy, Mors, and Thyholm (e.g. pages 34, 37, 47, and 58). Several details in the graves from Egshvile bear this out (see above).

Kersten and La Baume stress the importance of long distance exchange for the thriving communities of these densely populated islands. Thy was likewise extremely densely populated in Period III. It is possible that both the islands and Thy were stations along the same exchange route – going along the West Coast of Jutland, through Skibsted Fjord into the Limfjord, from where both Norway and eastern Denmark could be reached by water (Strand Petersen 1976).

Several elements in the finds from Egshvile also show connections to South Jutland and North Germany – the glass beads in grave 2 and the small gold and bronze spirals in grave 3 are instances of this. Maybe these connections are also mirrored in the early urn graves from Thy, Slesvig, and Northwest Germany.

Imported goods such as the glass beads and perhaps also the small vessel from grave 2 are indicators of contacts going further south into Central Europe.

### *A family monument ?*

The graves from the barrow at Egshvile contain many elements that shed additional light on different sides of EBA society and material culture in Thy specifically, and in Denmark generally. One aspect, necessarily of a rather speculative nature, has not yet been touched upon, namely the relations – social and personal – between the three persons buried in the EBA graves. The presence of a child, an adult woman, and an adult man naturally leads to the question, as to whether this might be a small family. Were the man and woman husband and wife, and was the child their son?

In the light of the datings of the graves, and the respective ages of the man and the woman, the first assumption does not seem very likely, whereas the woman and the child may have been mother and son, and in some other way related to the man in grave 3. Of course this remains purely hypothetical, but in any case it seems reasonable to assume that they all came from the same influential (chieftain's ?) family.

### *Pollen analysis*

In addition to the graves, the barrow at Egshvile and the soil beneath it also provide important information about the EBA landscape and subsistence economy in this part of Thy. These aspects are dealt with by Sv. Th. Andersen in a separate article in this volume.

Anne-Louise Haack Olsen, Museet for Thy og Vester Hanherred, Mellemvej 18, Vang, DK-7700 Thisted.

## NOTES

1. The barrow has no. 12 in Vester Vandet parish, Hillerslev district, Thisted county. Jour.nr. THY 2554, RAS no. P 2288/89. The excavation was financed by Rigsantikvarens Arkæologiske Sekretariat and carried out by the author and Peter M.D. Jensen, Sjørring. Preliminary accounts of the finds have been published in Historisk Årbog for Thy og Vester Hanherred 1989 and 1990.
   The drawings in this article of the objects from the three EBA graves were financed by a grant from the Danish Research Council for the Humanities.
   The english text was corrected by David Robinson.
2. The identifications of the cremated human bones from the three EBA graves were carried out by Verner Alexandersen, The Panum Institute, Copenhagen, and lic. med. Pia Bennike.
3. The identifications of the cremated animal bones from the three EBA graves were carried out by Knud Rosenlund, Zoologisk Museum, Copenhagen.
4. The grave- goods in grave 3 were taken up in a paraffin wax block and excavated at Viborg Amts Conservation Unit, Skive.
5. The secondary graves from the late Bronze Age are not considered further in this article.
6. The identification of organic material from the three EBA graves were carried out by Claus Malmros, The National Museum, Natural Sciences Research Unit, Copenhagen.
7. According to Claus Malmros, the dark material commonly used as inlay on swords, studs etc. should also be described as pitch, cf. Sarauw (1929).
8. Based on a report from Ove Madsen, Viborg Amts Conservation Unit, Skive.
9. According to a lecture by mag.art. Marianne Rasmussen at Krabbesholm Højskole, Skive, on the 24.01.1990.
10. In an EGK grave from Skjoldborg, Thy, small unworked pieces of amber were found mixed with the fill over the coffin (Bech & Olsen 1985, 42).
11. Personal communication by Klaus Randsborg who is thanked for illuminating discussions about the finds.
12. Not too much importance should be attached to this circumstance, however, as it seems to occur sporadically both in Period II and Period III, see Kunwald (1954, 95) and Thrane (1984, 134).
13. A bracelet with 8 amber beads, 1 blue glass bead, and 4 bronze spirals was found in a rich man's grave at Ry near Skanderborg (Fischer 1977).
14. A gold spiral of the same type, found on the island of Falster and possibly part of a hoard from Period III, can be seen in Aner & Kersten (1973–1990, vol. 3 cat. 1598). This, too, seems to have been broken at one end.
15. THY 1696. Villerup, no. 86, Vestervig parish, Refs herred. Report by Per Orla Thomsen and Jakob Vedsted in Thisted Museum.
16. This grave contained parts of a fibula with flat bow ornamented with concentric circles (the outline of the bow following that of the circles), a pair of tweezers with thick ends, and a dagger blade with a rounded hilt plate and two rivets. The urn is very similar to a vessel from a Period II grave at Thorup, Ribe amt (Pantzer 1984).
17. E.g. a Period II cremation grave from Lækjær, Thy (THY 1492, sb.nr. 1, Nors parish, Hillerslev district) with a beltplate and a dagger in a stone cist measuring 1,6 x 0,5 m internally, and a similar stone cist, 1,5 x 0,55 m internally, from Kampen, Sylt, containing the fibula with double hour-glass-shaped head mentioned above (p. 120) and a small tanged knife (Aner & Kersten 1973–1990, vol. 5 cat. 2664A). Lomborg (1964, 28) cites even smaller coffins, but of these, the ones from Skåninggårde and Stenløse are from Period III (comp. Aner & Kersten, 1973–1990, vol. 3 cat. 129 +276).

18. Lomborg (1964) cites an example of burnt animal bones lying beside an uncremated body (p. 24).
In the late Bronze Age Graves in Lusehøj, there was only one instance of animal bones being found among the cremated bones – part of the leg of a sheep (I.Tkocz and K.R.Jensen in Thrane 1984, 199).

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# Pollen Spectra from the Bronze Age Barrow at Egshvile, Thy, Denmark

by SVEND TH. ANDERSEN

## INTRODUCTION

The Bronze Age barrow at Egshvile, Thy, northwest Denmark, was excavated and described by Anne-Louise Haack Olsen (this volume). The barrow is situated on a morainal ridge south of the lake Nors Sø. Only its basal part was preserved, due to overplowing. The barrow was built in three phases. Phase 1 was 3 m in diameter and was built over an urn grave, not later than period II of the early Bronze Age (1500–1200 BC). Phase 2 was built over and around the barrow of phase 1 and was 9 m in diameter. It contained an urn grave from period II. In phase 3 a stone cist from period III (1200–1000 BC) was dug into the foot of the phase 2 barrow, and the barrow was extended to 16,5 m in diameter (see Olsen 1992 (this volume)).

## POLLEN SAMPLES

*Phase 1.* Under the barrow was seen a 4–6 cm deep layer of brown humic sand with pebbles, covered by yellowish subsoil, which had been dug up during the construction of the urn grave. The humic sand constitutes an original surface horizon. The lower limit was sharp indicating a rendzina-like structure. Beneath the soil was seen yellowish sandy subsoil with pebbles. Samples from the surface horizon at 1 m north and 1 m south of the centre of the grave were analyzed (analyses nr. 1 and 2 in tables 1–2). In the fill were seen 6–8 cm thick horizontal layers of material similar to the surface horizon beneath the barrow. Samples from these layers, taken north and south of the grave, were analyzed too (analyses nr. 3 and 4).

*Phase 2.* Samples were collected in a vertical section in fill from phase 2 west of the stone cist. A humic sandy layer, 5 cm deep, constitutes an original surface horizon. Below was yellow stony sand and above the humic layer 43 cm fill. The fill consisted of yellow sandy clay with rust spots and contained horizontal layers of humic sandy clay. Hence, the fill deviates from the subsoil beneath the barrow, which did not contain clay. Samples from the original surface soil and at 14–19 cm above it were analyzed for pollen (analyses 5–6 in tables 1–2).

*Phase 3.* Samples were collected from humic layers in the fill, in a vertical section east of the stone cist (analysis nr. 7 in tables 1–2). Below the fill was seen disturbed material from phase 2.

## POLLEN ANALYSIS

The samples used for pollen analysis were treated with potassium hydroxide, hydrofluoric acid, and acetolysis mixture, and were mounted in silicone oil. The pollen grains were strongly crumpled and the exines were often thinned (cp. Aaby 1983), whereas grains with corrosion scars were infrequent. These features made identification laborious, but it is unlikely that the original pollen composition was affected. The numbers of pollen grains counted vary 115–140 grains, per sample. The names of plant species in latin follow *Flora Europaea.*

## GRASS POLLEN MEASUREMENTS

Diameter of the pore *annulus* in 175 measured grass pollen grains varied 3–7 μm, and no grains with average diameters above 33 μm occurred. It can be concluded that all of the grass pollen grains derive from wild grasses and that no cereal pollen is present (cp. Andersen 1979).

## RESULTS OF THE POLLEN ANALYSES (TABLES 1–2)

Pollen sums and tree pollen numbers are shown in table 1. Average tree percentages were calculated for six samples, which appear uniform, whereas one sample (analysis nr. 4) was calculated separately. Non-tree pollen was calcu-

| | phase 1 | | | | phase 2 | | phase 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Origin | surface | surface | fill | fill | surface | fill | fill | | |
| Analysis, nr. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1–3 5–7 | 4 |
| Pollen sum P | 133 | 118 | 133 | 133 | 115 | 116 | 140 | 755 | 133 |
| Tree-pollen sum AP | 2 | 15 | 5 | 20 | 12 | 4 | 12 | 50 | 20 |
| Trees % P | 1,5 | 12,7 | 3,8 | 15,0 | 10,4 | 3,4 | 8,6 | % of trees | |
| Lime, *Tilia cordata* | – | 2 | – | – | 2 | – | 2 | 48,3 | |
| Hazel, *Corylus avellana* | – | 2 | 2 | – | 2 | 3 | 6 | 15,1 | |
| Birch, *Betula* | 1 | 5 | 2 | 15 | 2 | – | 2 | 12,1 | 75,0 |
| Alder, *Alnus* | – | 4 | 1 | 3 | 4 | 1 | 2 | 12,1 | 15,0 |
| Oak, *Quercus* | 1 | 1 | – | 2 | 1 | – | – | 3,0 | 10,0 |
| Ash, *Fraxinus* | – | 1 | – | – | – | – | – | 8,1 | |
| Hornbeam, *Carpinus betulus* | – | – | – | 1 | – | – | – | 1,3 | |
| Deformed (birch) | – | – | 1 | 5 | – | – | – | | |

Table 1. Tree pollen in 7 samples from the Egshvile barrow. The tree pollen percentages were corrected according to Andersen (1970, 1980).

lated in percentages of non-tree pollen (table 2). Pollen from ligulate composites (Liguliflorae), which probably were buried in the soils by burrowing bees (cp. Andersen 1988), and fern spores, were calculated outside the pollen sums.

It is assumed that the pollen spectra from the surface soils beneath the barrows represent vegetation growing at the site at the time, when the barrows were erected, whereas the pollen spectra from the fill layers represent vegetation from sites around the barrow. The pollen grains are likely to derive mainly from vegetation growing near the sampling spots (inside tens of meters) and were buried in the soils within a short span of time (cp. Andersen 1988).

*Trees.* Tree pollen is very scarce in all the samples in table 1 (2–15% of the total pollen). It can be concluded that the samples derive from places devoid of trees. Lime (*Tilia cordata*) predominates in the average tree spectrum. Lime was scarce in regional tree vegetation in the Bronze Age (unpublished pollen diagram from central Thy). It is, therefore, not unlikely that this pollen was derived from former vegetation at the sites. The tree spectrum in analysis 4 is dominated by birch. Several of these pollen grains were deformed due to heating (cp. Andersen 1988). This sample comes from a site, where birch woodland had been burned at a former time.

*Non-tree vegetation.* The non-tree pollen taxa are grouped in plants from bare soil, dry-meadow plants, other herbs, shrubs, and plants from heaths and bogs, in table 2 (cp. Andersen 1988). The *Artemisia* pollen was rarely deformed, in contrast to the *Artemisia* pollen from Neolithic barrows in Denmark (Andersen, this volume and in print). Hence, there is no evidence that *Artemisia* had been present in burnt coppices, as in the Neolithic samples, and rather grew in vegetation in open areas. *Artemisia* (probably mostly mugwort, *A. vulgaris*) was therefore grouped with the plants from non-described open habitats (other herbs).

The non-tree pollen spectra from the soils in phase 1 (nr. 1–4 in table 2) are uniform, and so are the spectra from phases 2–3 (nr. 5–7). Hence, it is indicated that the samples from phases 1 and 2–3, respectively, derived from places with the same vegetation, and that the vegetation in phases 2–3 differed from that of phase 1. Average pollen spectra were, therefore, calculated separately for phase 1 and phases 2–3.

Plants characteristic of bare soil are scarce in all the pollen spectra. Solely sheep's sorrel (*Rumex acetosella*) occurs with a notable frequency in one sample, knot-grass (*Polygonum aviculare*) in one, and pollen from cereals are absent. It can be concluded that arable fields were not present near the sites.

| | phase 1 | | | | phase 2 | | phase 3 | phase 1 | phase 2+3 |
|---|---|---|---|---|---|---|---|---|---|
| Analysis, nr. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1–4 | 5–7 |
| Non-tree pollen NAP | 131 | 103 | 128 | 113 | 103 | 112 | 128 | 475 | 343 |
| Bare soil, % NAP | – | 8,7 | 0,8 | – | 1,0 | 1,8 | 1,6 | 2,1 | 1,4 |
| Sheep's Sorrel, *Rumex acetosella* | – | 8,7 | 0,8 | – | 1,0 | – | 0,8 | 2,1 | 0,6 |
| Goose-foot Family, Chenopodiaceae | – | – | – | – | – | 1,8 | – | – | 0,6 |
| Knot-grass, *Polygonum aviculare* | – | – | – | – | – | – | 0,8 | – | 0,3 |
| Dry meadow | 27,4 | 25,2 | 30,4 | 24,8 | 48,5 | 48,2 | 52,3 | 27,2 | 49,9 |
| Ribwort, *Plantago lanceolata* | 26,7 | 25,2 | 28,1 | 22,1 | 48,5 | 47,3 | 51,6 | 25,7 | 49,3 |
| Adder's Tongue, *Ophioglossum* | 0,8 | – | 0,8 | 0,9 | – | – | 0,9 | 0,6 | 0,3 |
| Moonwort, *Botrychium* | – | – | 1,6 | – | – | 0,9 | – | 0,2 | 0,3 |
| White Clover, *Trifolium repens* | – | – | – | 1,8 | – | – | – | 0,4 | – |
| Other herbs | 72,5 | 66,0 | 68,8 | 74,3 | 48,5 | 50,0 | 46,1 | 70,5 | 48,1 |
| Wild grasses, Gramineae undiff. | 66,4 | 58,3 | 55,7 | 58,4 | 40,8 | 39,3 | 43,0 | 59,6 | 41,1 |
| Mugwort, *Artemisia* | 3,1 | 1,0 | 7,0 | 7,1 | 1,9 | 3,6 | 0,8 | 4,6 | 2,0 |
| Bedstraw, *Galium*-type | 1,5 | 2,9 | 1,6 | 2,7 | 1,0 | 0,9 | 2,1 | 2,1 | 0,9 |
| Buttercup, *Ranunculus* | 0,8 | – | 3,1 | 2,7 | 3,9 | 4,4 | 1,6 | 1,7 | 3,2 |
| Pink Family, Caryophyllaceae | 0,8 | 2,9 | 0,8 | 1,8 | – | – | – | 1,4 | – |
| Milfoil, *Achillea*-type | – | – | 0,8 | 0,9 | – | 0,9 | – | 0,4 | 0,3 |
| Ragwort, *Senecio*-type | – | 1,0 | 0,8 | – | – | – | – | 0,4 | – |
| Crucifer Family, Cruciferae | – | – | – | 0,9 | – | 0,9 | – | 0,2 | 0,3 |
| Pea Family, Fabaceae | – | – | – | – | 1,0 | – | – | – | 0,3 |
| Shrubs | – | – | – | – | 1,0 | – | – | – | 0,3 |
| Willow, *Salix* | – | – | – | – | 1,0 | – | – | – | 0,3 |
| Heaths and bogs | – | – | – | 0,9 | 1,0 | – | – | 0,2 | 0,3 |
| Heather, *Calluna* | – | – | – | 0,9 | – | – | – | 0,2 | – |
| *Sphagnum* | – | – | – | – | 1,0 | – | – | – | 0,3 |
| Ligulate Composites, Liguliflorae, % P | 5,3 | 7,6 | 1,5 | 14,3 | 5,2 | 1,7 | 10,4 | | |
| Ferns, *Dryopteris*-type | 1,5 | – | 0,8 | – | 3,4 | 2,6 | 1,7 | | |

Table 2. Non-tree pollen in 7 soil samples from the Egshvile barrow, in percentages of non-tree pollen (NAP) and total pollen (P, Liguliflorae and ferns).

Among the dry-meadow plants, ribwort plantain (*Plantago lanceolata*) is common, but the ribwort pollen frequencies differ noticeably in the two average pollen spectra (26% in phase 1 and 49% in phases 2–3). Other dry-meadow plants are scarce in number and frequency.

The total of other herbs also differ in the two sample sets. Wild grasses are particularly frequent (60 and 41%). The other herbaceous plants are very scarce, and so are shrubs and plants from heaths and bogs.

The frequencies of the ligulate composites (Liguliflorae) differ widely in individual samples. Hence, there are distinctive traces of the activity of burrowing bees in some of the samples, but it is impossible to tell how much of this pollen derived from bee activity.

## RECONSTRUCTION OF THE VEGETATION BENEATH AND AROUND THE BARROW

The barrow was erected in an intensively exploited country-side devoid of trees. In one case, from phase 1, the soil derived from a place where a birch coppice had been burned some time ago.

Arable fields were not present. Ribwort plantain and wild grasses are the main contributors to the pollen flora. The high frequencies of ribwort indicate widespread grazing by domesticated animals. These frequencies differ in samples from phase 1 and the phases 2 and 3. Ribwort is less frequent than wild grasses in the samples from phase 1 (26 and 60% respectively) and more frequent than the grasses in phases 2 and 3 (49 and 41%). Like other plants, ribwort is damaged by grazing (Groenmann van Waateringe 1986), however, ribwort survives grazing, as its leaf rosettes are close to the ground, and the plants keep producing new flower spikes throughout the summer, in contrast to the grasses, which are prevented from flowering by grazing. The high frequencies of ribwort pollen in the samples from the phases 2 and 3, therefore, indicate intensive grazing pressure, whereas grazing was less intensive in phase 1. This difference indicates an increase in exploitation from phase 1 to the phases 2 and 3. The scarcity of pollen from other herbaceous plants is probably due to the grazing.

The near absence of heath plants indicates that the soils in the area had not been leached in spite of the strong grazing.

The pollen spectra from the Egshvile barrow indicate vegetation cleared from trees and emphasize a great importance of cattle rearing in the early Bronze Age.

Svend Th. Andersen, The Ministry of Environment, The Geological Survey of Denmark, Thoravej 8, DK-2400 Copenhagen NV, Denmark.

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# *Radiographic and Forensic Aspects of the Female Huldremose Body*

by DON BROTHWELL, DAVID LIVERSAGE, and BIRTHE GOTTLIEB

## INTRODUCTION

Though the region is renowned for its bog bodies, no well preserved prehistoric corpses have been found in Danish or north German peat bogs since 1950. The recent discovery of the Lindow body in England is a reminder that such finds can still occur (Stead *et al.* ed. 1986; Brothwell 1986). While waiting we can be usefully occupied making sure that sufficiently full and accurate information is available about the older discoveries, as Fischer already has done with the Elling body (Fischer 1980) and the Borremose 1948 and Vester Torsted finds (Andersen and Geertinger 1984).

A quite considerable number of skeletons and bodies have been found in north European bogs (map of Danish finds in Fischer (1980), fig. 2), but radiographic and forensic examinations made at the time of discovery are only available in a few cases, i.e. Grauballe (Glob 1956; Krebs and Ratjen 1956), Windeby I (Schlabow *et al.* 1958), and Dätgen (Struve 1969). As the possibilities for forensic research increase, old finds can be taken out and re-examined (Andersen and Geertinger 1984; Fischer 1980). There are also good archaeological accounts without expert forensic participation, i.e. Borremose 1 (K. Thorvildsen 1947), Borremose 2 (E. Thorvildsen 1952), and Tollund (K.Thorvildsen 1951; Fischer 1980). As well as this a great deal of scattered information is available about other bodies which for one reason or another could not be professionally examined and may not have been particularly well preserved. Much information on these is collected by Dieck (1965), can be gleaned from Hald's work on textiles (1950), or is available in semi-popular surveys such as Glob (1965), Lund (1976), or Ebbesen (1986), with many references to primary sources.

Here yet another old find will be taken out and examined forensically. It was made in 1879, but escaped attention owing to being transferred in 1905 from the National Museum to the anatomical institute of Copenhagen University without accompanying information. It was identified some years ago as the body to which the famous Huldremose clothing belonged (Liversage 1974 and 1985). The clothing, which is one of the most complete such finds, has been described fully by Hald (1950) and dealt with on a number of other occasions. The primary examination reported on here was made by one of the authors (D.B.) in 1986, and as far as the scalp hair is concerned in 1988. The examination was completely non-destructive except for the taking of a few hairs, and consisted of visual examination and radiography. Here we will present the results of this examination together with the information about the find circumstances contained in old letters. The clothing will only be mentioned so far as it enters into these. It has already been described. As controversy and speculation persists about the significance of the prehistoric bog bodies (Fischer 1980; Andersen and Geertinger 1984), it is important to have as many full and correct facts available as possible.

## THE CIRCUMSTANCES OF DISCOVERY

The body was discovered in May 1879 during peat cutting in Huldremose bog, Ørum parish, in Djursland, eastern Jutland. The find was dealt with by the local authorities according to the rules and practice of the times, but with a combination of official correctness and private enthusiasm that has given us a unique series of documents on the clothing of what was probably a fairly well-to-do woman in Denmark near the time of Christ, and about the manner of her death. No authorized archaeologist was directly involved. This was probably a good thing, considering the contempt later shown by the archaeological establishment for this remarkable find, describing her to the Normal-Anatomisk Institute as "a Tartar woman clothed in skins". It seems that the archaeologists of the day had no use for anything so outlandish as an undated body.

All the information not obtained by direct examination of the surviving remains comes from a series of letters in the archives of the National Museum in Copenhagen.

The first is dated May 22nd, 1879, and is a quite informal letter from Dr. Steenberg, the district doctor in Grenå, to *Justitsråd* (Legal Counsellor) Herbst. Clearly Steenberg saw himself as a personal friend of Herbst's, for he begins the letter with "Dear Friend", and uses the familiar form of address. This letter is rather picturesque and breathless with excitement. It loses a good deal in translation, but we will do our best.

"Only a few lines to tell you that I was yesterday called upon by the Police to be present at the digging up of a body out in Ramten bog, two (Danish) miles from town, where a body had been found during peat cutting, but instead of finding a fresh newly buried body we found a very old one of a woman wrapped in a skin garment, well conserved, and in a plaid skirt of woven cloth and a neck scarf of the same material. The body was of a woman, it was completely like a mummy, almost the whole musculature was reduced and the skin dried in like pergament with the appearance of an old smoked ham and greatly shrunken. Adipocere formation was beginning in the knees. I succeeded in getting the clothes off her nearly complete, and they are now hanging in my yard to dry after being cleaned. Everything has been recovered and will soon be sent. The body has been put in a coffin and laid in the ground in the churchyard, but can be taken up again if wanted by the museum. An official report will follow together with the finds. In haste. Your faithful Steenberg."

The museum replied by telegramming that it also wanted the body. One shudders at the thought of the original clothing from the time of Christ hanging on the line in the doctor's back-yard, but it seems not to have suffered much in the process. The description of the clothing in this letter is much simplified. The official report followed three days later and is more detailed and accurate. It is headed "Report on the discovery of a mummified female corpse in Ramten Fen near Grenå, dug up the 21st of May, 1879", and signed by Christian Siersten, chief police officer, and S.A. Steenberg, chief medical officer in the market- town of Grenå, about 18 km away, together with apothecary F. Hoffmeyer, who was "assisting". The report appears from its style to have been written by Steenberg, but was no doubt checked and approved by the police chief. The site was close north of the village of Ramten and is a separate narrow bog 2–300 m long separated by a narrow strip of dry land from what is now a somewhat larger lake and perhaps earlier was a bog.

After a few introductory remarks about the legal and administrative background for the investigation the report goes on:

"The workman had struck a hard object with his spade, and this on examination showed itself to be a human body. Its upper surface lay 3 feet below the surface of the ground, which had already been dug away. The peat in the brink beside where the body still lay had the remarkable feature that the peat formed different clearly recognizable layers or courses, so that it appeared probable that the place had been dug up and put back again, so as to form a compact layer. The different layers were so loosely joined that they fell apart upon a light pressure. Immediately over the body there were still unrotted stems of heather, and other plant remains in a partially rotted state. The body itself lay in a yellowish fibrous mass, that was said to occur regularly under the proper peat and resembled half rotted long grass and moss. It was observed that the peat walls beside the place described here showed no trace of the above-mentioned layers".

Steenberg's account is almost as good as a palynological report! He was obviously a keen observer and his opinion that the body had been buried deserves a good deal of respect, particularly the observation that the same stratigraphy was not seen anywhere else on the working faces. However there is no actual documentation, and eyewitness accounts are notoriously uncertain. If Steenberg believed that the body had been buried, his recollection could easily have been influenced thereby. Moreover the description does not quite tally with a backfill, which would be an amorphous mixture of different kinds of peat rather than a layered deposit. When Steenberg writes "tørvejorden dannede forskjellige let kjendlige lag eller skifter" it sounds like a sequence of different kinds of peat that formed one above the other. A little of the "yellowish fibrous mass" is preserved in corners of the body, and a sample was identified by David Robinson of the National Museum's Scientific Department as sphagnum. Unfortunately Steenberg's account cannot be regarded as definite evidence that the body was buried, but tends if anything to point in the opposite direction.

The report continues, "The body lay on its back with the left hip somewhat raised and both thighs drawn up towards the body. The head lay to the west, the legs to the east. Crossing the chest obliquely from NW to SE was a fencing stake of willow, fragile, somewhat rotten, about 3 feet long and 1½ to 2 inches thick. It had been broken into several pieces during peat digging. The right arm was broken off, and its hand was found cut through by the spade, which had also caused a hole in the right knee". This arm is specifically mentioned both here and in another letter as already separated from the body. The examination of the body (see below) showed that it had been cut off before burial.

There follows, "The entire body was covered with clothing, shaggy and woollen, penetrated and covered by the mire where she lay. With all due care the body was laid complete on a barrow and brought out of the bog to a farm in Ramten, where, after pouring water over it, the investigation continued".

This rather cavalier treatment contrasts with what one would do today, compare the Lindow investigation, but the investigation of the Huldremose body was far ahead of all earlier and many later studies. Though in the absence of previous experience or knowledge of bog bodies, the investigation amounted only to removing the clothing and later writing down what was observed and remembered, Steenberg was fortunately both a keen observer and a vivid writer.

"The outermost item of clothing was the shaggy skin" (it was really a sheepskin cape of the finest workmanship) "that covered the entire upper part of the body except the right arm, which was broken off between shoulder and elbow and lay extended towards the southeast. Around the body outside the sheepskin was tied a narrow leather strap that bound the left arm fast to the body under the outer, but over the inner cape". This was a thick rawhide strap 1/2 to 3/4 cm wide, a decidedly efficient means of binding. One end was doubled back and sewn to itself as a loop. There is no more exact information as to how the arm was tied, and the strap is now incomplete and in three pieces. The description is contradictory, as the strap is described both as outside and inside the outer cape. The surviving position of the left arm of the body shows clearly that it had been bound (figs. 2a,b). We continue: -

"There was a scarf around her neck, an end of which was tucked under the left arm. The lower part of her body was wrapped in a voluminous plaid skirt of woollen cloth, that was supported around her waist by a leather cord passed in and out through holes in the textile". This is all described more fully by Hald (1950) and Liversage (1985).

"Nearest the skin of the upper part of her body was a second cape, rather similar in design to the first, but light and made of lambskin". This was the inner cape which

Fig. 1. General frontal view of the Huldremose body, showing the dried but good state of the body. Photo, Lennart Larsen.

her left arm was described as bound to the body outside of. Steenberg writes, "In removing the clothes it had to be cut open on one side". We can detect an impatient use of the penknife whenever the clothing gave difficulty. In fact both capes, not just the inner, were cut at the shoulder and were originally closed at the neck so they had to be put on over the head.

"The long red hair lay stretched out backwards and was tied around with a cord, which was also wound several times around her neck". The question of the hair is a problem, and it is obvious that the field observations on this point were not sufficiently exact. Though nothing in the letters suggests that there was anything unusual about the hair, the examination of the body suggested rather strongly that the woman's head had been carefully shaved (see below). Here in the police report we are only told that a cord was wound around her neck. The surviving cord is 1.10 m long and of wool or other animal hair, twisted like a rope of two strands. It seems unlikely that it can have got around her neck except as a deliberate act. Later, in a letter from Nissen, we are told that also a lock of hair was wound around her neck, and that there had been two amber beads on the cord.

"On opening the mouth, which was closed, the tongue was found to be loose. There was adipocere in the hole in the knee. ..... The body was placed in a coffin and buried in Ørum churchyard, from which it was taken up again on May 24th as the Museum for Nordic Antiquities wished it surrendered".

This is the main document in the case, which lays out the facts in a careful and considered manner. There followed a small number of further letters, some in a more familiar tone. They give a few supplementary details, but the main circumstances had already been laid out. These letters need not be cited at length, but a few new points can be extracted from them.

On May 25th (the same day as the police report is dated) Steenberg wrote to Herbst, saying that they were going to pack the things together and send them with the steamer. Herbst is advised to negotiate a price with the company, as transport of bodies was rather expensive. There was no smell or anything unpleasant about this one and Steenberg thought it should go cheaper.

On the 26th J.V. Nissen, teacher and owner of the piece of bog where the find was made, wrote, "The accompanying woollen cord with two amber beads were yesterday or on Thursday found at Rasmus Jensen's farm by a little boy. After speaking to him there seems to be some assurance that this cord accompanied the lock of hair, that together with the cord was wound around the neck, was placed on the wheelbarrow.... one of the breaks in the cord was made by the boy, but the knots are certainly original. The smaller bead has been off the cord, but the larger one is in its original place. There were no other beads on the cord, and none can be expected, as I have very carefully searched the cartshed and that side of the farmyard".

This is interesting – for, as we have seen, in the official report only the cord, not the lock of hair, was mentioned as wound around the neck. When the cord was entered in the museum register in Herbst's handwriting, no mention was made of the two amber beads. In all events it is clear that they did not after all accompany Nissen's letter, for later Steenberg wrote that he was sending them himself.

The next letter is from Steenberg and is dated May 27th. It confirms a number of points, and is Steenbergs most specific statement about the hair at all. The body and accompanying objects had been expedited that morning with the steamer, and he wrote,

"It should be noted that the cord in the box is the one that as well as being wound around the hair was twisted several times around her neck. The broken off right arm was that way when she was found, but the cut off hand and the hole in the knee are the turf spade.... Unfortunately we forgot to bring with us the stave that lay across the body.... My wife has secured the head or neck scarf with a couple of pins the way it was before we took it off and had to cut it". The scarf looks torn rather than cut! "The hair was so full of mud and fine peat fibres that it was impossible to loosen these from it without it coming off. It has been put in the box together with the cord. There are also some teeth, which fell out when the body was being cleaned."

This confirms that the hair was sent to the museum. What happened to it after that is a mystery. It is not now to be found either at the museum nor the Anatomic Laboratory. It must be supposed that it was from its normal place on the head that the hair came off when being cleaned, for otherwise Steenberg would certainly have said so. This means that if it was already cut off, as appears to be the case, it must have been replaced in the head region when the woman was finally disposed of, as well as being wound around her neck. Also the loose teeth have been lost.

This letter also confirms that the woman was found with the right arm already amputated, but that the cut through the hand was made during peat digging and that there was a stave over the body. It also emerges that the cord was not sent by Nissen, as said in his letter, but was put in the box.

Apparently it was now without the amber beads, for in Steenberg's next letter, which is dated May 29th, he writes, "I think I ought to send these two amber beads, which were found at the place where we unclothed the body. It is regrettable that they escaped our attention, but

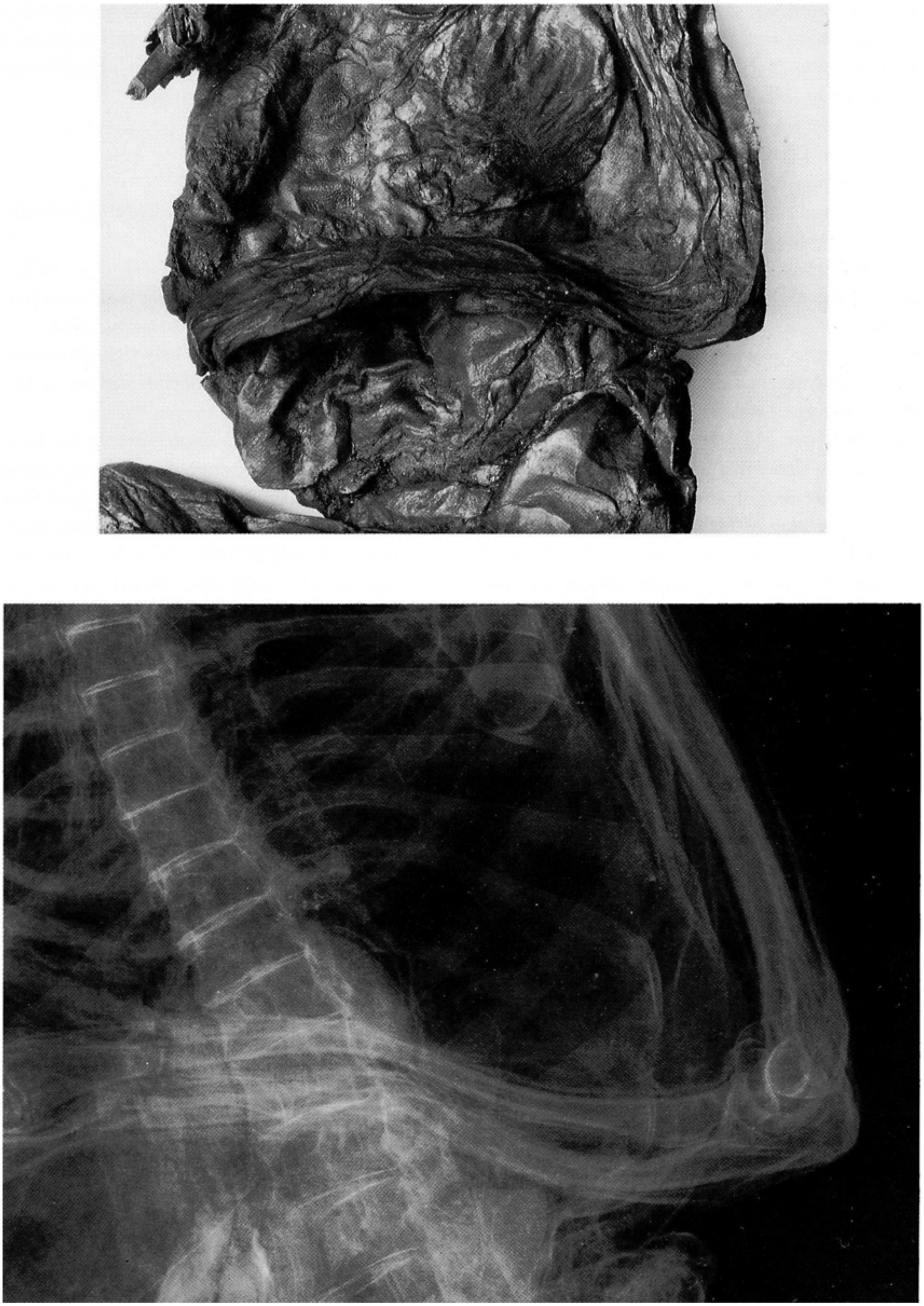

Fig. 2. a) Surface view of the left arm, showing the post-mortem deformity and curvature. Photo, Lennart Larsen. – b) X-ray detail of the deformed left forearm. No evidence of healed fracturing is present.

in all the mire and mud we, or more truthfully I, were messing around in, that sort of thing can easily happen." Presumably they were enclosed, but it is curious that they were not catalogued by Herbst.

That is the last letter with information about the discovery and investigation of the Huldremose body. A final letter dated June 3rd will not detain us here, but might be of interest to students of the history of attitudes to archaeology. Steenberg, it seems, is hurt by a newspaper article criticising his proceeding at once with the investigation instead of waiting for an expert from the National Museum; he defends himself.

The experts, it seems, despatched the body on its arrival to the Normal-Anatomic Institute, whence one by name G. Schmidt returned a letter of extreme conciseness and precision dated June 3rd.

".. I have found no sign from which with even reasonable assurance can be drawn any conclusion regarding the question whether the body is of a "Tater woman" (may be understood as indicating a gipsy – the inverted commas are Schmidt's) or not. It would not on anatomical grounds be possible to raise any objection to the result to which the study of the clothing, etc., might lead. I take the liberty of asking that the body be taken back by the Museum for Nordic Antiquities; it will be given out by Svensen".

It seems that the experts at the museum had rather inflated hopes of what could be learned from anatomical science but were quite unobservant of the wonderful and unique clothing!

## THE EXAMINATION OF THE CORPSE

Fig. 1 is a photograph of the corpse in its present condition. No special conservation was undertaken, and the body seems simply to have dried. Surprisingly perhaps it seems to have remained stable over the seasons and decades, and there is no evidence of rotting or fungal attack (although restricted beetle damage is evident). The scalp and some of the (front) teeth became detached when the body was cleaned by the finder in 1879, and are now missing. Adipocere is evident along the whole length of the thigh and extending up the buttocks. Perhaps because she was only recently re-identified, no detailed evaluation of the body has earlier been attempted. Liversage (1985) suggested that blood loss and shock could have resulted in death after her right arm was cut off. It seems worth reviewing in more detail the evidence for abnormality and lesions as revealed by surface and radiographic examination. It is also necessary to consider *post-mortem* changes of a pseudo-pathological kind.

### *External examination*

The surface features may be listed as follows:

1) On the left side of the chest, close to the left axilla, was a small area of skin damage, which is ragged and most likely to be of *post-mortem* origin.
2) A similar lesion, also likely to be of *post-mortem* origin, is present on the anterior surface of the left upper arm.
3) The left forearm is angled across the lower chest and displays an "S"-curved deformity along its whole length. There is clearly flattening of this forearm as well, and it seems likely that these features are the result of a tight strap which held the arm in position and which could have caused *post-mortem* deformity when the left ulna and radius became decalcified (figs. 2a,b).
4) The chest and well-defined breasts are flattened and have deformed towards the right side laterally. There are a few further areas of superficial *post-mortem* skin damage.
5) The right arm shows three contrasting forms of injury, only one of which is *post-mortem*. Approximately half-way along the upper arm, the humerus shaft protrudes from the dried and shrunken soft tissue. The shape of the end of the shaft may be modified by drying, and appears to be relatively "cleanly" broken across. While the end of the bone as now preserved does not show any clear evidence of cut marks, there is an associated shallow cut through the skin, which is straight and must originally have been caused by a sharp implement (figs. 3a,b). It is cut roughly at right angles to the long axis of the humerus and the broken end of the bone. This evidence would support the view that the arm was cut off, and agrees with the original observation at the time of discovery that the arm was separate.
6) There is the distinct possibility that the forearm was also hacked in two or the amputation of the arm was performed twice, first below and then above the elbow. In fact the whole elbow area is missing. The forearm is represented by the distal half, and again

Fig. 3. a) Surface detail of the upper right arm, in the region of the damaged humerus and cut flesh (now dried). Photo, Lennart Larsen. – b) X-ray of the hacked off humerus. Note also the rib cage with the unusual highlighting of the costal cartilages.

the bone shafts (ulna and radius) stand out from the soft tissue as a result of differential shrinkage. The ends of the bones are broken across without obvious splintering, and near the broken end of the radius are three fine cut marks at 45° to the long axis of the shaft and approximately 10 mm in length (fig. 4a). The fine nature of these cuts would again suggest that a sharp instrument was used, and that this was drawn across the arm to the bone three separate times. An alternative explanation might be that they resulted from a glancing blow, which jarred across the bone.

7) At about 90° to the orientation of the forearm cuts are three separate lines of damage, two rough "incisions" into the skin just above the wrist and a long cut which has severed the fingers (but not the thumb). The implement which took off the fingers has caused somewhat ragged damage across the metacarpals and irregular tearing to the non-palmar skin of the hand (fig. 4b). It was reported that the hand was accidentally taken off by the peat cutter at the time of discovery, and this is compatible with the nature of the damage to the region of the fingers. It should be noted that the damage to the wrist and hand does not have the same orientation as the fine cuts on the mid-forearm. Peat cutting was presumably always parallel or at right angles to the peat face, and is extremely unlikely to have given rise to cuts with differing directions. Also, the fine superficial nature of this surface damage is not the sort of thing which is likely to have occurred from a peat tool rubbing on soft decalcified bone.

8) On the left thigh, near the buttocks and knee, are two areas of damaged skin (exposing white adipocere which extends from the thighs onto the lower back). These are probably *post-mortem* in origin (fig. 5a).

9) In the femoral shaft region of the left thigh the skin surface has been pressed down and distorted (figs. 5 a,b). Can this have been the result of pressure from the post or stake found with the body? Pressure from such an object on the corpse could certainly have had this result. We will return to this question in the section on radiography.

10) Below the left knee, with an orientation of about 45° to the long axis of the tibia, is a fine straight cut through the skin. This incision is of about 30 mm in length and must have been made with a sharp instrument.

11) Above the outer aspect of the left heel, near the fibula articulation, is another lesion, some 31 mm in length, showing a broader zone of compressed damage which could indicate contact with a peat spade.

12) Below the inner aspect of the right knee, in an area of *post-mortem* damage to the soft tissues, the tibia is exposed and shows a deep broad cut into the bone 26 mm in length (fig. 6a). To the side of this, and parallel in orientation, is a short, fine cut about 7.5 mm long. This short and fine cut is similar to those on the forearm. Both of the injuries could have been made with the same instrument, but in one case the cut went deep into the bone (fig. 6b).

13) In the region of the right medial malleolus is another incision of about 21 mm in length, roughly at right angles to the injuries on the tibia (fig. 7).

14) In a different plane altogether to the other injuries on the right leg is a straight deep cut of about 30 mm in length on the upper surface of the foot, above the arch. The incision has opened out owing to drying and shrinkage, and clearly penetrates deep into the upper tarsal area (figs. 8a,b).

15) Two low-angle cuts into the skin on the medial side of the right foot have produced soft-tissue flaps about 20 mm and 15 mm long. A fine sharp cutting tool would have been needed to produce such injuries.

This, then, is the main evidence for external damage, possibly *ante-* and *post-mortem,* to the Huldremose woman. It will be seen that the injuries are mainly to the arms and legs. The back appears to be free of injury. The injuries appear only partly to be explained by damage from a peat-cutting tool.

### *The radiographic examination*

The X-rays of the Huldremose woman are remarkably good in view of the decalcification which occurred while she was buried in the peat. In this respect they are comparable with the quality of the Grauballe radiographs, but are noticeably different to those of the Lindow body, where sufficient contrast could only be obtained by xeroradiography. As in the case of the surface detail, comment seems best listed point by point.

16) Frontal and lateral views of the head provide much information on inner detail. Even allowing for drying and shrinkage, the cranial vault appears to be generally thin, and in frontal view there is the appearance

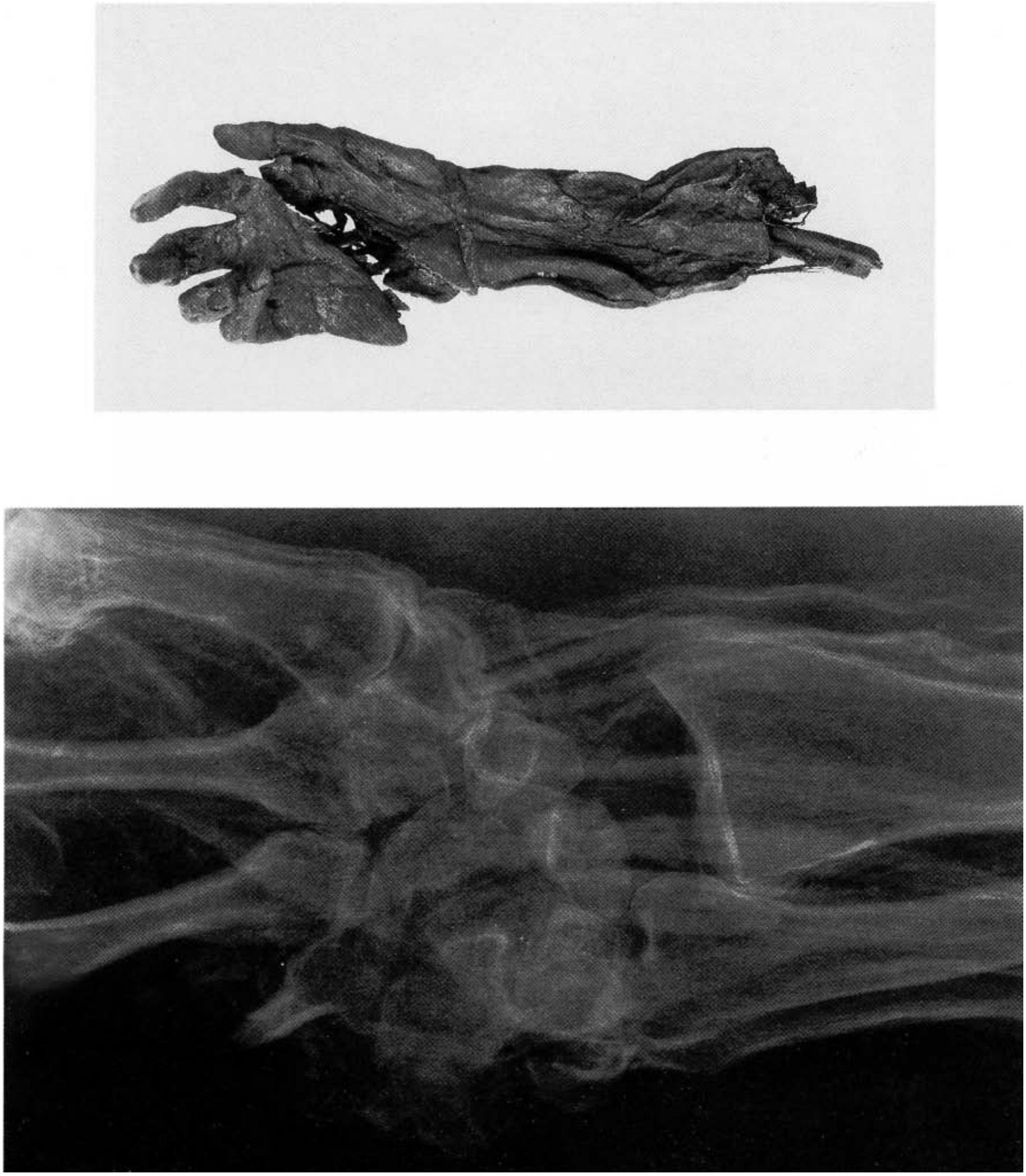

Fig. 4. a) Right distal forearm and hand (cut with a peat tool). Photo, Lennart Larsen. – b) X-ray of the hand and wrist, showing metacarpals damaged by the peat cutting tool. Note also that the impact of the tool has dragged the carpals away from the distal radius at the wrist.

of slight sagittal keeling associated with what is interpreted as pseudo-parietal thinning of *post-mortem* origin (fig. 9). The coronal suture is not well marked and could be partly obliterated, but the sagittal and lambdoid sutures are clearly present. The cranial base is well defined, with a normal shaped atlas and axis in articulation. There is little evidence of frontal sinus extension into the frontal region, a female char-

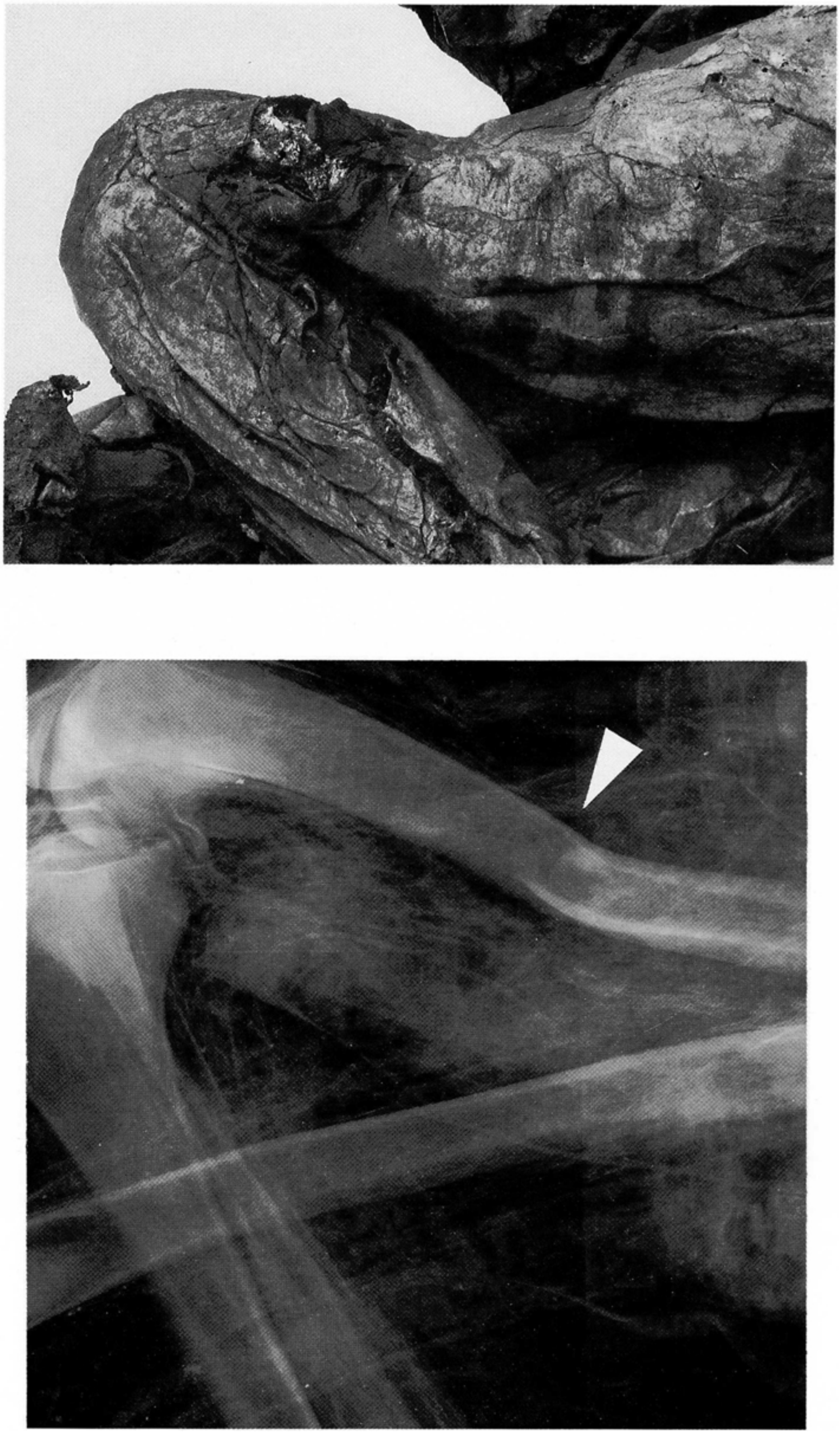

Fig. 5. a) Surface detail of the left thigh, showing post-mortem deformity. Photo, Lennart Larsen. – b) X-ray of the thigh deformity, showing the bowed femoral cortex (and lack of fracture callus).

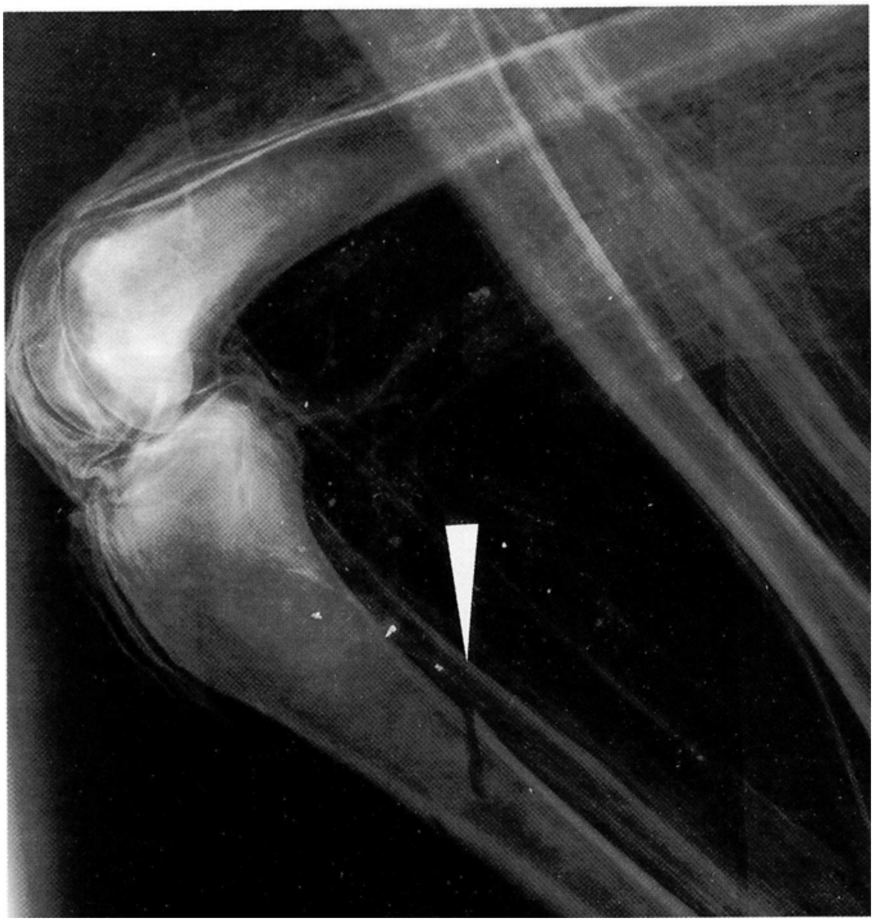

Fig. 6. a) Right tibia (exposed by post-mortem damage), showing a deep and sharply defined cut. Photo, Lennart Larsen. – b) X-ray detail of the injury to the tibia.

acteristic. The teeth are poorly defined and some are recorded as lost soon after the recovery of the body. The gonial region of the mandibular ramus is noticeably everted, a somewhat male characteristic. The brain mass is well defined, but much reduced and mainly restricted in extent to the occipital area (fig. 10). No evidence of structure can be seen, and like the Grauballe brain it may be somewhat altered and decomposed.

17) The vertebrae can be seen clearly, and could be scanned for evidence of arthropathies, especially the commonly occurring osteophytes. However no marked changes could be seen, and the state of the joints would give support to the view that the individual was probably under 40 years. However the sixth and seventh thoracics, and possibly some lumbars, display marginal "sharpening" of the joint margins, with perhaps slight lateral extension. There are no Schmorl's nodes.

18) The ribs, scapulae and sternum are relatively faint. Surprisingly, the costal cartilages show up far more clearly, and could have undergone considerable, but incomplete, calcification in life (showing up as a bubble effect). This is an uncommon feature which would suggest a person of more than young adult years. There is no evidence of rib fractures or other *antemortem* pathology. Extending up as far as the last rib, in the central area, is a granular mass, which is tentatively interpreted as material contained within part of the alimentary tract. The shape of this mass, which extends to the right side of the somewhat flattened abdomen, does not permit closer identification of which parts of the stomach and intestinal tract may be involved.

19) Both clavicles are clearly seen and may show slight deformation as a result of *post-mortem* changes. It should be noted that the right clavicle displays a more robust shaft, which could indicate an old well-healed fracture.

20) The left arm is complete, but the right one is clearly damaged. The left humerus is intact but a little distorted. The right humerus is only represented by the proximal half. The bone shaft terminates in a relatively flat end-face at right angles to the long axis of the bone, but owing to shrinkage and distortion it does not appear as a "clean" flat cut.
The left forearm is noticeably distorted into a flat "S" shape, possibly because this arm was bound to her body by a leather strap, as observed during the unclothing of the corpse in 1879. On one X-ray there appeared to be evidence of an unhealed fracture, but the subsequent X-rays revealed that this was pseudopathology caused by the superimposition of a hardened skin fold over the bone. There is no evidence of joint pathology, either at the left elbow, wrist or hand. The cortical bone of the ulna and radius are of normal thickness. At the right distal forearm and hand which were found detached from the body, there are no abnormalities in the X-rays which cannot be seen in the surface detail (and are described above).

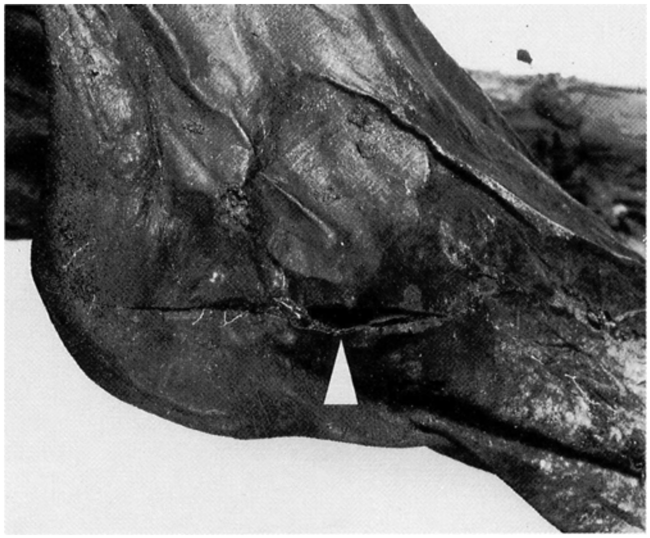

Fig. 7. Surface detail of the injury near the right ankle. Photo, Lennart Larsen.

21) The pelvic and abdominal area presents a very different picture to that of the thorax (fig. 11). In fact detail of the bones is partly obscured by what appears to be dried muscle tissue, adipocere, and food residue within the alimentary canal. X-raying this area of the body presented considerable problems owing to the positioning of the trunk in relation to the legs.

22) The legs are generally in a good state of preservation. The hips and knee joints appear to be normal. Cortical thickness at the femoral shafts is not great, but when shrinkage is allowed for is nevertheless well within normal range. The right femoral mid-shaft area displays an abnormal curvature which has previously been interpreted as indicative of an old healed trauma (Liversage 1985). However, further radiography shows fairly certainly that this may well be a

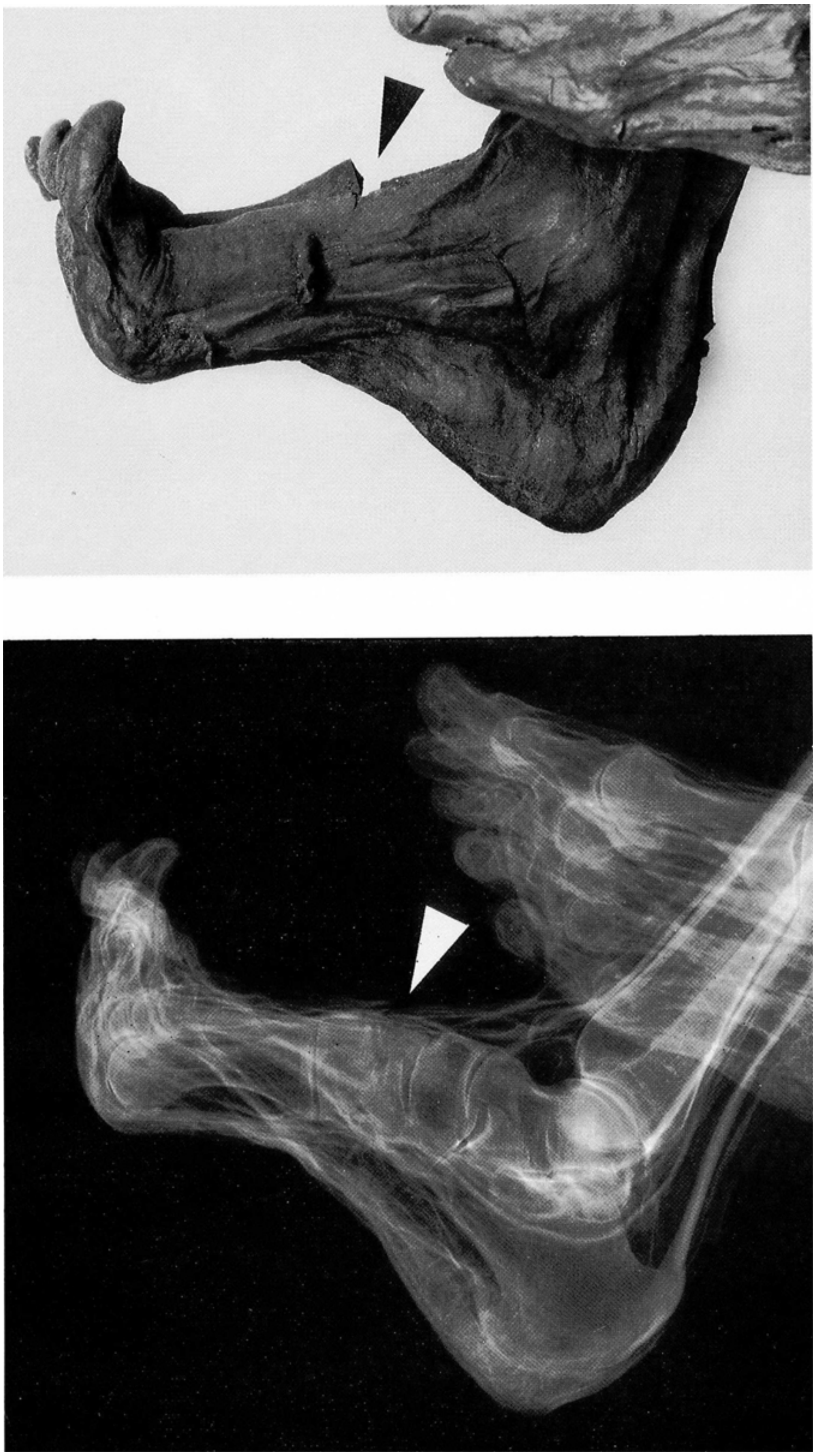

Fig. 8. a) The straight injury on the upper surface of the arch of the right foot. Photo, Lennart Larsen. – b) X-ray detail of the right foot, showing minor damage below the skin surface.

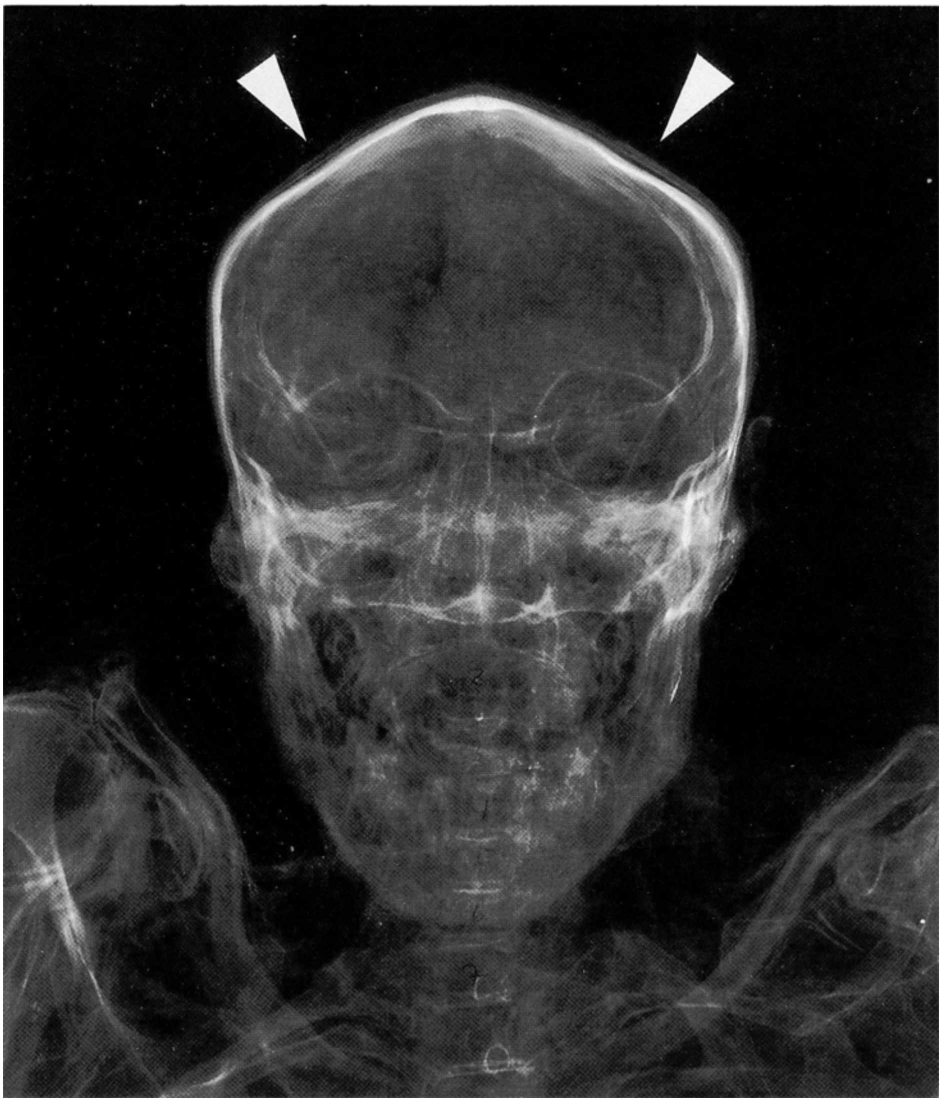

Fig. 9. X-ray of the antero-posterior view of the head, showing the thin (dried and shrunken) skull bones, with pseudo-parietal thinning.

*post-mortem* pressure deformity. Both tibiae are normal in size and general shape. The right tibia shaft displays evidence of trauma in the form of an approximately two centimetre deep cut at about a 45° angle to the long axis of the shaft. Owing to shrinkage the two sides of the cut are now well separated. There are no certain Harris lines on these or any other long bones. The fibulae show no pathology. The tarsal and foot joints all appear to be free of arthropathies. However in the case of the injury (deep cut) into the upper part of the right foot, there is clear evidence of penetrating bone damage, with some localised crushing of the cancellous tissue.

## COMPARATIVE FINDS

Here we will try as others have done before to summarize the essential facts about the find group. Full references will not be given as bibliographies are already available in several places, e.g. Glob (1965), Lund (1976), Fischer (1980), Ebbesen (1986), etc.

Fig. 10. X-ray of the lateral view of the skull vault, showing the posterior positioning of the reduced brain mass.

*Date*

Though hominid remains from virtually all Holocene periods can be found in peat bogs, those actually preserved as corpses, apart from a few that are later, for instance medieval, are shown by radiocarbon dating to be centred on the Pre-Roman Iron Age with some overlap over the periods before and after. Though finds of skeletons have a wider range than those of corpses do (see Bennike and Ebbesen 1987), it is clear that killing and submerging in bogs must have been a fairly widespread occurrence in the last centuries B.C.

It is thought that the bodies could only be preserved and survive as corpses if they were deposited in the winter (Gregersen 1980; Andersen and Geertinger 1984). The corpses should then only be a relatively small proportion of the original depositions, and the original bog burials may therefore have been more numerous than the finds suggest. Many discoveries of unaccompanied clothing may indicate bodies that were too badly preserved to be recognized as such by the peat cutters (see Hald 1950).

The radiometric dating bracket is firmly confirmed by Lise Bender Jørgensen's study of prehistoric textiles. She showed that the bog bodies are associated with a textile technology dated to the Pre-Roman Iron Age, and continuing in finer quality into the Early Roman Iron Age. She referred to this as the Huldremose group of textiles (Bender Jørgensen 1984; 1986). The radiocarbon datings of some bodies place the earliest of these textiles at the end of the Bronze Age, from which there are no other dated textile finds. There is a problem with the radiocarbon datings, as Tauber (1980) has shown that some of the first made of these were too young owing to contamination with humic products and possibly laboratory preservatives (Tauber 1980). Among these doubtful datings is K-1396, made of part of the inner cloak of the Huldremose woman and placing it in the Early Roman Iron Age (1920 ± 100 bp uncalibrated). A recent accelerator dating of a small piece of gut from the body agrees well with this dating ($O_x$A-2826, 1910 ± 110 bp), but suffers from the same problem of possible insufficient pre-treatment. These are the only dating indications we have apart from the textile technology, which, as said, points more to Pre-Roman times.

*Conditions of deposition*

These are often a little obscure because of the difficult field conditions. The questions are whether the bodies were placed in natural hollows or dug holes such as old peat cuttings, and more particularly whether or not they were then buried by having peat thrown on top of them.

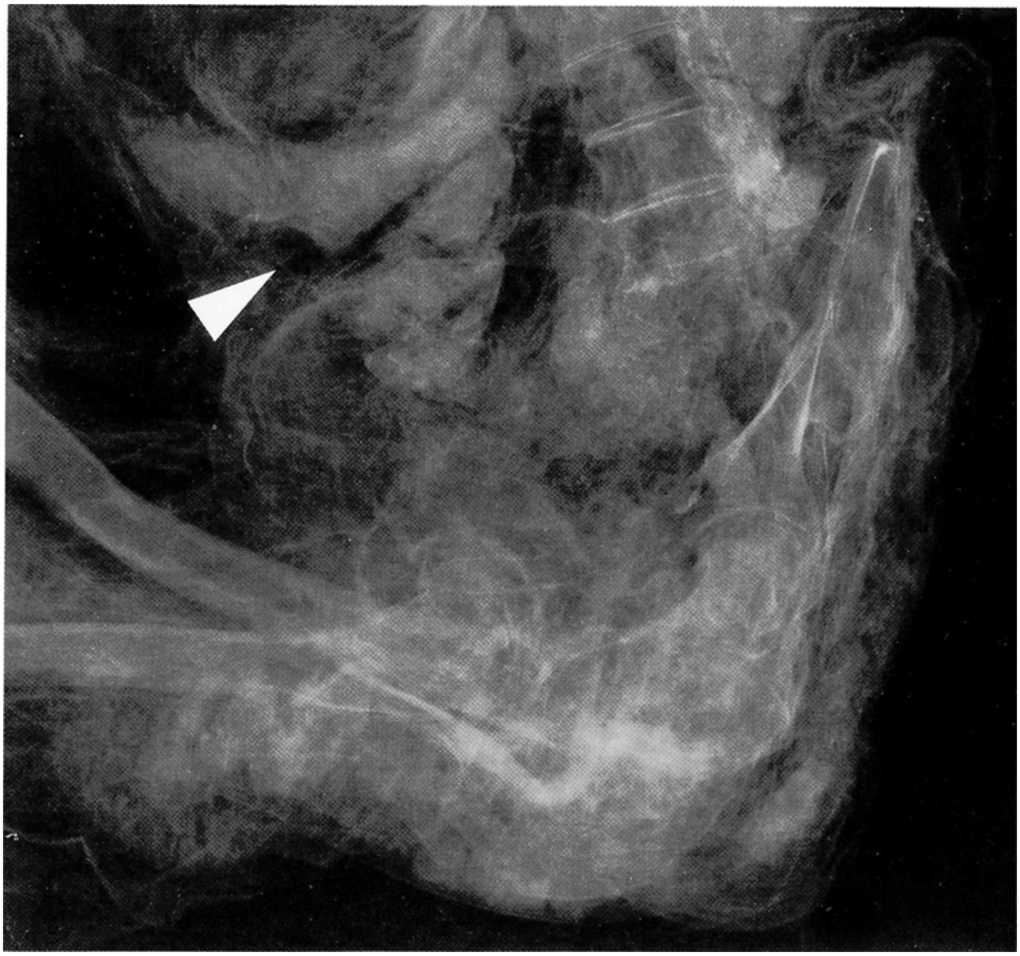

Fig. 11. X-ray of the region of the pelvic basin and upper thighs, showing skeletal detail and the apparent granular mass of material in the interior of the abdomen.

Liversage (1985) argued that the bodies must have been buried by throwing peat over them, for otherwise they would have been disturbed by animals and birds and in one way or another ended up in a more or less scattered condition. However in the report on the Lindow corpse in England it is pointed out that the fingernails had drifted away from the fingers, and the same was reported of the Borremose 1948 body, which implies lying loose. It could perhaps be argued that the fill in a carelessly refilled pool would be loose, and move enough with fluctuations in the water level for finger and toe nails to drift away; however the basic question is whether an unburied corpse can survive in articulation in an open bog pool, and this would be best answered through modern forensic science.

As regards the lesser question whether the bodies were placed in natural or artificial hollows, the answer is of course both are possible and do not exclude each other. There is much evidence of peat cutting in Iron Age times, so suitable old peat cuttings must have been available. On-site examination suggested that the bodies from Dätgen, Grauballe, and probably Kayhausen had been placed in natural hollows, while those from Store Arden, Windeby I, the Borremose bodies of 1946 and 1947, and probably Tollund came from ancient peat cuttings. A more detailed palynological examination at Store Arden established a hiatus in the pollen sequence, showing that the peat had been cut (Brorson-Christensen 1948), and at Grauballe the nearby undisturbed section was festooned with old peat cuttings (Jørgensen 1956). Conditions are naturally very difficult for carrying out systematic study in a peat cutting where a body has been found, and the important overlying deposits are likely already to have been removed.

Some specific field observations have been emphasized by earlier writers, but not always very carefully. For instance Christian Fischer (1980, 35, 38) writes that the Borremose body of 1948 lay on a layer of birch bark placed there deliberately. Unfortunately the bark was from a different find, the 1947 body, not the 1948 one, and E. Thorvildsen's original note reads, "The overlying peat was taken away. It contained much wood as did the corresponding layer in the bog ... and also contained peat lumps that were harder than the surrounding peat, i.e. were already dried out pieces that had fallen into the peat cutting. Also the peat around the body was rich in heather stems." The palynologist, A. Andersen, added wood determinations and wrote that there was birch bark underneath the body. The report appears to suggests a refilled hole, and in the absence of specific mention, especially from A. Andersen, the wood and bark may be taken to be part of the wood peat of which the bog consisted at this level.

C. Fischer also writes of the Borremose body of 1948, that ".. the survivors had gathered bog cotton and buried the body surrounded by it on a bed of birch bark, which does not suggest that violence was used as torture as part of punishment, but was necessary for the execution". He cites that in a lecture B. Brorson-Christensen had said that this material could not have grown in place and must therefore have been deposited. Whether the lecture is correctly remembered or not, the birch bark and the bog cotton were from different bodies, and Brorson-Christensen's original report on the separating in the laboratory of the 1948 body from the peat block it had been transported in gives a somewhat different impression. It says that the body was surrounded by a tough layer 2–6 cm thick of felted roots mixed with *Eriophorum vaginatum* peat. A little original peat still survived above the body and was described as nearly pure *Eriophorum vaginatum* peat. There is probably here also a case for some kind of refilling, but Fischer's idea of tender burial under a layer of bog cotton goes rather far considering the state of the evidence, and the piece of scalp thrown in the pit below the body and the smashed face with splinters of wood in the eye (Andersen & Geertinger 1984) do not suggest any great tenderness!

The Windeby I body is described as lying in an old peat cutting measuring 1.5 × 2 m, containing fen peat of lighter colour. This description suggests that the old peat cutting for a long time afterwards had been a pool in which reeds grew. Gebühr (1981) however quotes an unpublished letter according to which the body had first bog cotton over it, and above that a refill which included blocks of cut peat. It is hard to know which account to follow, but the letter sounds convincing.

On the other hand there was no evidence to show the Dätgen body had been deliberately buried at all, and apparently it was thought to have been placed in a steep muddy hole that more or less closed over it.

Also the Kayhausen body was said to have been laid in a hollow that grew over naturally.

Despite their deficiencies it seems arguable from these accounts that some bodies were deliberately buried and others left lying in hollows in the bog. Generally the best documented accounts are those supporting burial in natural hollows or old peat cuttings.

Gebühr (1981) has a novel argument that the bog bodies may have been normal burials that happened to be placed in bogs. The paper includes interesting supplementary information on specific finds, but is not convincing even for the Windeby I discovery, at which it is principally aimed, and certainly fits the evidence for bog bodies as a whole very badly.

### *Manner of death*

The more the evidence is considered, the clearer it becomes that a significant proportion of the bog bodies had suffered very violent deaths.

*Hanging or strangling.* The bodies from Borremose 1946, Tollund, and Lykkegårdens bog had a noose around their necks. The Tollund man had been hanged, and the cord was long with the slip-knot drawn up at the back. Borremose 1946 had the slip-knot in front with two short ends with added knots for purchase, as though for strangling by two people pulling in different directions. The Elling body had a hanging groove behind her neck and the noose was also present among the objects disturbed by the finders. The Windeby II body had a very nasty device still on the neck, in the form of a square frame of four hazel rods, each over one and under one of the others, surrounding the neck on all four sides. It is illustrated on the remains of the body by Gebühr (1981), fig. 7,3, and must presumably have been tied together with cords that have not survived, for otherwise it could hardly have remained in position when the body was deposited in the pit or hollow. It could perhaps have been manipulated to give prolonged strangulation, and recalls the Borromose 1946 noose for two men to work.

*Severe blows to the head.* As well as having a noose around the neck, the Borremose 1946 body had the back of the head smashed. Also Grauballe had suffered a fatal blow to the head. The blow to the Borremose 1948 woman had been from in front to the face and there were splinters of wood in the eye. A severe blow had also been inflicted to the Osterby head.

*Other beating* is reported at Dätgen, where there were several bone-breaking blows to the back and lower body. It may be pointed out that a very common field observation has been that substantial staves had been laid on top of the corpses (Havdals mose, Huldremose, Skærum mose, Vester Torsted, Windeby I, Dätgen). It is possible, and in fact the simplest explanation, that these stout sticks were merely instruments of coercion that were discarded at the site, presumably after serving their purpose. It is without doubt difficult to distinguish bones broken by beating from post-mortem damage.

*Broken legs* also can be difficult to distinguish from post-mortem damage, but are reported at Borremose 1946 and 1947, and at Grauballe, and also at Dätgen, where they were thought most likely to be post-mortem as the limbs were stretched out in a normal way. Breaking of a leg can have been used to make escape impossible in the pre-execution phase, and calls to mind an Assyrian relief of prisoners' legs being broken by soldiers.

*Cuts and amputations* are particularly clear at Huldremose, where the right arm was cut off, perhaps twice, and there were cuts on the right foot and leg that went deep into the bone and other cuts on the legs, foot, and right arm that reached the bone without penetrating it deeply. There were also gaping cuts on the back and chest of the Dätgen body, one of which was considered to be a fatal stab to the heart. Another possible case of amputation was a badly investigated occurrence in Lykkegårdens bog, where, after all the bones had been carefully gathered up after discovery the whole left lower arm was found to be missing. Wounds to the head or back of the neck were reported at Rendswühren and Bornhoved. The throat had been cut at Grauballe and there were other cuts on the body. Kayhausen had been stabbed in the throat and arms. In addition to the injuries mentioned above, the Dätgen body lacked genital organs though this part of the body was generally in a good condition when found. The skin in this area was too badly preserved to establish whether it had been cut, so the question is unsettled.

*Scalping* is reported at Driessen and must, despite the scepticism with which it has been regarded by some, have taken place in the case of the Borremose woman (1948), as a piece of scalp the size of a hand lay underneath the body near the throat (see original report in National Museum). There is therefore no possibility that it was a peat-cutting injury as suggested by Andersen and Geertinger (1984), who fail to describe the lesion properly, and generally treated this unique document in a cavalier manner.

*Beheading* is shown by heads found without bodies at Osterby, Stidsholt, and Roum Fen, and near the body from which it had been removed at Dätgen. The discovery of heads alone is particularly interesting, because it shows that the individual, represented by his head, could be subjected to disposal in a bog even when death had taken place elsewhere (perhaps even in fair fight). This must show that particular ideas were attached to this form of disposal of the body, perhaps that it was shameful or degrading, for otherwise there could be no reason to carry the head so far. Presumably the head was taken and buried in the bog alone because of the inconvenience of transporting the whole body.

*Drowning* does not leave definite traces, but comes readily to mind when fatal lesions have not been observed, as with the Haraldsted body, and seems not at all unlikely in the cases where the body was found held down by rails, or hooks, or oblique stakes (Haraldsted, Windeby I, Bunsoh, Hokkerup). The stones found in some cases on the body could hardly have been effective alone to produce drowning.

*Multiple injuries.* There are several cases with several severe injuries or more than one injury that alone would have been fatal. The Grauballe man had the skull broken, and the throat cut, as well as a leg broken in two places. The Borremose 1946 man was both strangled and given a fatal blow to the head. The Borremose 1948 woman had the face crushed in and had been scalped. The Huldremose woman had an arm hacked through (perhaps twice) and had been cut through the flesh and deep into the bone in other places. The Dätgen man had been cut, beaten resulting in broken bones, stabbed to the heart, beheaded, and possibly had the genital organs cut off. The most alarming account is Driessen, two bodies found in 1890 and said to have had lips and ears cut off, been incised down the back from head to foot, and to have had their scalps wound off around a stick (Dieck 1969). Despite the uncertainty of some of the accounts there seems to be evidence of what could literally be described as "overkill".

*Mutilation of the corpse.* Therefore some of the injuries must have been inflicted after death and really been mutilations of the corpse. Andersen and Geertinger (1984) lay emphasis on the absence of indications of haemorrhage in connection with the scalping and the smashed face of the Borremose 1948 body, and appear to regard both injuries as post-mortem. They also see the absence of warding-off injuries as indicating that the blows were administered after death. Here the question of the validity of negative evidence deserves more attention than it is given. There are scenarios where the woman could have been unable to ward off, and it is a fact that the body was so much less well preserved than normal forensic material that one also wonders if the lack of evidence of haemorrhage is definitive. On the whole it seems doubtful whether a great deal should be concluded from the multiple fatal injuries. It is not particularly likely that the executioners were closely observant of the exact moment of clinical death. After all a little extra beating is only being thorough, and there may have been standers by who wanted a turn!

It is worth pointing out however, that formalized mutilation of the corpse, as recorded for instance in some of the criminal justice of historical times, seems not to have taken place.

### *Other aspects*

There are some further features that to our way of thinking may seem more harmless, but nevertheless belong to the complex of phenomena accompanying the bog bodies and should be noted as such.

*Shaving the head.* Some of the individuals had their heads shaved. This may have been done twice with an interval between to the Windeby I girl, as the hair was freshly shaved on one side and 2–2.5 cm long on the other (Gebühr 1981). It now seems the whole head of the Huldremose woman had been freshly shaved (see below). The Tollund man had short hair, but this may have been his normal haircut. Presumably shaving the head was regarded as a degrading and humiliating procedure, and parallels are even known from Europe immediately after the Second World War.

*Nakedness.* Many of the victims were buried, and presumably also killed in a naked condition. The Grauballe, Tollund, Borremose 1948, Dätgen, Kayhausen, Bunsoh, and Damendorf Seemoor bodies were definitely unclothed. The Tollund body still wore his hat and belt, but not his blanket, as though the latter had been ripped brusquely off leaving only the belt. It seems that nobody wanted to inherit the clothes of the bog people, for in many cases these were found close to the body, lying at its feet, or under it, or spread over it. It is quite likely that some, or perhaps all of the textiles found alone during peat cutting are all that is preserved of a bog burial.

Some individuals, however, were found dressed, or at least partly so, for when only a cape or capes were worn, the question presents itself whether this really was all the victim's had to wear or not. One would suppose that the woollen blanket wound around the loins was the basic garment, which survived in its original form to modern times in the Celtic kilt – not to mention the sarong and lungi of Asia. The Windeby I girl wore only a leather cape. It seems that the Elling girl was wearing one of her capes, but the other was under her feet. It is not quite clear whether the Borremose 1948 woman died still wearing her blanket in a somewhat dishevelled state, or whether it was thrown over her corpse. The Huldremose woman was an exception in being almost elegantly dressed in plaid skirt (blanket), two capes, and scarf. Unfortunately with many chance finds it is unclear whether the body was found clothed or merely accompanied by clothing.

Despite these deficiencies, there is enough evidence to show that stripping was a common, but not universal accompaniment to the executions of this type.

*Other possibly superstitious aspects.* There were other aspects of a more superstitious nature, which may perhaps be seen as deterrents directed at society more than as retributory measures. The most obvious of these of course was the whole idea of burial in the bogs, remote places which through the ages had been connected with ritual offerings and no doubt aroused superstitious reverence or fear. Burying the victims in bogs was obviously important, for even decapitated heads were buried in bogs after death had occurred elsewhere.

In several cases the bodies were held down by rails or sloping stakes, or by stones. Windeby II and Hokkerup were held down by oblique stakes whose points were stuck into the peat. The Haraldskær and probably also Bunsoh bodies were secured by transverse rails held down by wooden hooks. There were stones over the bodies from Skærum, Tvedemose, and Windeby I. As said these may have been connected with death by drowning, but it can also be conjectured that they prevented the body from floating to the surface (assuming it was not buried under peat clods), or were superstitious arrangements to prevent the already dead individual from "walking" as a ghost.

*Sacrifice or retribution?* P.V. Glob's theory (1965) that the bog bodies were human sacrifices has been rightly criticised by Struve (1969) and Lund (1976), and is not effectively revived by Fischer's idea that they were conciliatory offerings from those causing environmental damage in the bogs (1980). It should be accepted that the finds do not have the stereotyped character expected of purely ritual acts. Each is a unique case, in which cruelty, humiliation, and shameful burial repeat themselves as recurring themes. They are hardly cultic. On the other hand they can hardly have been ordinary meaningless acts of common violence, casual robberies, etc. It is seen too clearly that killing took place as a collective act with a number of participants and that certain conventions or traditions were respected. The mode of disposal must at the very least have symbolized expulsion from society, which may have increased its deterrent effect. It is beyond the possibilities of archaeology and a waste of time to ask what offences were being punished, but offence of some kind there must have been.

A more interesting question is what socio-political frame such acts could take place in. From what little we know from early historical sources, which anyway are from somewhat later, we would expect that society was divided into kinship groups which lay in a nearly continual state of feud. One could ask whether the events took place inside kinship groups or between them, i.e. did the victim and the killers belong to the same or to different social groups? Were the killings part of feuds or were they the internal justice of the kin? Either way we should not expect society to be less violent, even if it was less organized, than medieval society, of whose violence we know a lot. Against the background of early criminal justice in the Mediterranean and Germanic legal sources, Struve placed these acts within the "private justice" of the kinship group rather than in the sphere of "public justice", if such a thing existed at that time, it may be added.

*The scalp hair; a final problem*

It is part of the beneficial outcome of collaborative research effort that problems are identified by different individuals, although perhaps investigated by someone else. In the case of this Huldremose woman, during conversation on the separateness of the hair it was remarked (BG) that in fact there was a fine bristle of hair over much

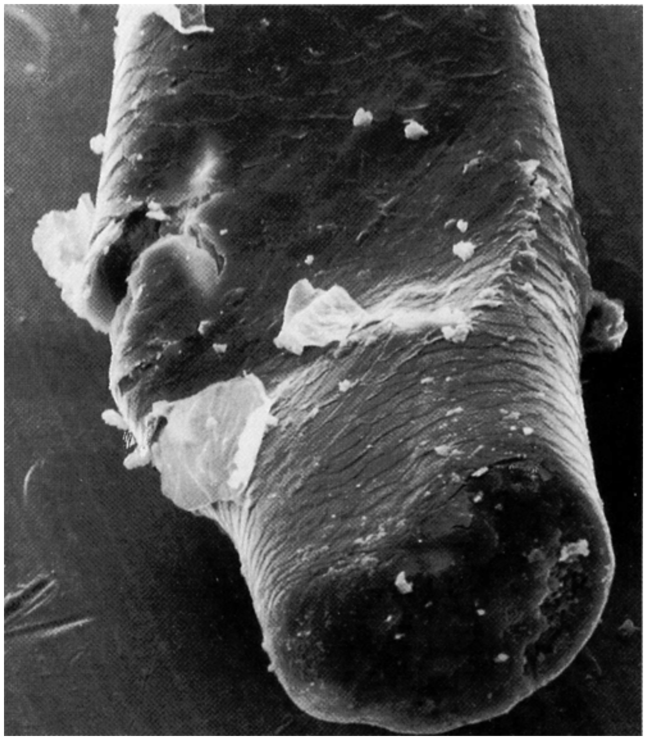

Fig. 12. End-on view of Huldremose scalp hair, showing intact cuticular scales and evidence of cleanly cut end. SEM. Approx × 1000.

of the scalp (together with a few longer hairs). The more this was discussed, the more difficult it seemed to explain. If the hair had been accidentally pulled off during the initial washing of the body, surely one would have expected either some ragged hairs of unequal lengths to have remained, or possibly there could have been no hairs at all if it was pulled out of the partly decayed hair follicles. But how could one explain a fine and generally similar length of bristle? Did the hair separate at the scalp surface at the post-exhumation washing of the body, and then with the drying and shrinkage of the scalp become extruded?

The problem seemed worth further investigation, and for this reason some short scalp hairs were plucked out for investigation by scanning electron microscopy. We had expected to find decomposed and longitudinally frayed hair ends, as a result of the separation of the main mass of hair from the scalp (as recorded in Steenberg's letters from 1879). But in fact the evidence did not confirm this. The SEM close-up view (as exemplified in fig. 12) of these hairs shows that the hair shaft is in good condition, with the cuticular scales undamaged and in good order. The limited squashing of the hair shaft is due to the tweezers we used to grip the hair. Most significantly, the hair end is not frayed or damaged, but shows what can only be interpreted as a clean cut from a sharp implement. It seems to us impossible that such a hair end could result from the breaking off of the degraded hair from the scalp. The internal micro-structure of the hair would have resulted in longitudinal splitting and fragmentation, not "clean" transverse breakage. An alternative explanation thus seems to be needed. This could explain why the hair seems to have come off so easily on washing. In contrast the hair of the Lindow II body was loose, but tended to come away in fine strands or clumps during cleaning and conservation when peat was being removed from the head region. It would certainly not have been possible to remove the head of hair of Lindow II in one self-contained "mop". What at first seemed unproblematic has thus turned into another enigma. It seems that it might be worth following this up by examining in the same way a few hairs from other bodies and the plaits found alone and attributed to the Bronze Age.

## CONCLUSIONS

There is a perennial need in archaeology to review and reconsider aspects of the subject, including bioarchaeological materials. Uncommon and unusual finds, such as bog bodies, can be expected to reveal additional information by re-examination, and this seems to be borne out by the present investigation. Even though this body was discovered a little over a century ago, it is clear that no significant deterioration has occurred since its initial drying out. It mày originally have been the best preserved prehistoric body ever recorded from a north European bog. The body was earlier best known for the complete clothing worn by it, showing what a fairly well-to-do woman in Jutland wore at probably about the time of Christ. Careful external and internal (radiographic) studies have raised some interesting questions. Evidence of injuries to arms and legs provides a case for serious trauma and blood loss as the cause of death. The interpretation of injury has demanded the careful differentiation of pseudo-pathology, due to the decalcification and pressure distortion of some bones, from recent peat cutters' damage, and the cuts likely to have been sustained at about the time of death. There seems little doubt that some cuts to the right upper arm, forearm, and both lower legs were made by a sharp metal instrument, not a relatively blunt peat cutting tool. Fine cuts on bone and the position of the cuts on the body would also argue against these simply being peat cutting damage. Though conforming to the general pattern of violence, the Huldremose woman is unique in the details of the injuries sustained. It can be expected that further studies could tell us still more about her and the times in which she lived.

Don Brothwell, Institute of Archaeology, University College London, London WC1H 0PY, England.
David Liversage & Birthe Gottlieb, The National Museum, Frederiksholms Kanal 12, DK-1220 Copenhagen K.

## NOTE

Since this article went to press a note has appeared (Brothwell *et al.* 1990) which specifically discusses the microsurgery undertaken to sample the food residue in the intestinal tract of the Huldremose woman. A further detailed note is in preparation on the results of the C.T.Scan.

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# Cats from Viking Age Odense

by TOVE HATTING

## INTRODUCTION

During the excavation of two late medieval houses in the centre of Odense on Funen, Denmark in 1970, a pit was found immediately to the east of the house foundations which contained the remains of at least 68 domesticated cats (*Felis catus L.*). As a consequence the excavation, which was begun by Odense Town Museum (Møntergården), was handed over to the Zoological Museum in Copenhagen. Further analysis revealed the find was both zoologically and cultural-historically unique.

## DATING

The position of the pit under the late medieval foundation gave a preliminary dating. A more precise dating was however desirable as bones of domesticated cats are known, albeit infrequently, from Denmark as early as the Roman Iron Age. Radiocarbon analysis of the bones carried out by the Copenhagen laboratory gave a date of 1070 ± 100 AD (K-1887), which means that the pit was in use in the Viking Age. Even though domesticated cats are known from the Nordic countries as early as the Roman Iron Age (Jacobsen 1972), this dating is remarkable, because it is normally first in medieval deposits that cat bones are found in such quantity. In Viking times cats were relatively rare, a much prized animal kept more for its fur that for its ability as a mouse catcher. At least this is the picture which emerges from a judgement in a Welsh legal document from 948 AD (Chadwick 1970). The punishment for the theft of the Prince's cat was a fine amounting to a sheep plus enough corn to cover the cat when it was held by the tail, with its head touching the ground. In medieval time cats became more common and their value decreased accordingly.

## EXCAVATION OF THE PIT

The pit was discovered when a trial trench, running east-west, struck its southern edge. As a consequence a field 1 × 1 m (Field I) was excavated to the north of the trench and this was found to contain the remainder of the pit together with its great concentration of cat bones. The pit was almost circular with a diameter of over a metre, of which 30 cm lay in the trial trench to the south. It was about 80 cm deep, narrowing towards the base, and had a volume of just less than 0,7 $m^3$ (fig. 2).

The layers in the pit were distinguished on the basis of colour differences which are probably due to their varying contents of organic material and chalk; an analysis of this relationship was unfortunately not carried out.

The uppermost layers comprised sandy clay and a c. 20 cm thick layer composed almost exclusively of charcoal. The latter was the remains of a fire which had been set on top of the actual pit fill. Under the "fire layer" there were a further two layers of clay and sand and under these lay a c. 30 cm thick clay layer which was rich in cat bones. The latter was labelled "the cat layer". At the base of the pit there was a c. 15 cm thick layer of very greasy, slightly reddish clay in which the cat bones were even more concentrated and also slightly better preserved than in

Fig. 1. Photograph of cat with forelimb bones: One of the best preserved skulls was found together with a complete forelimb in a clump of fly puparia at the base of the pit.

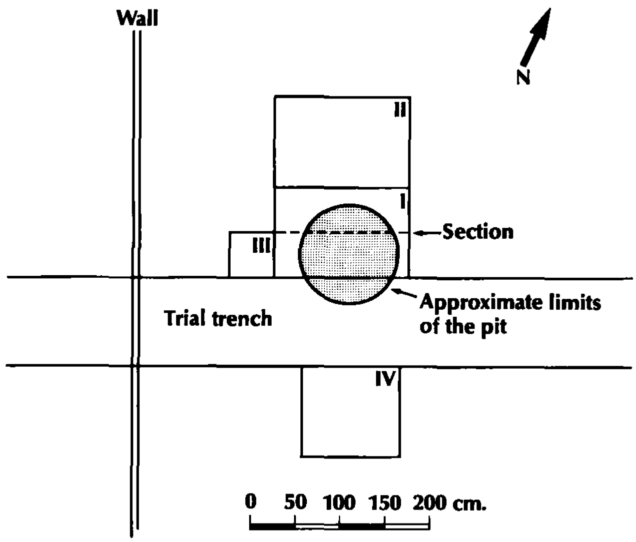


Fig. 2. Excavation Plan: The trial trench was excavated by Odense Museum, whereas areas I-IV were excavated by the Zoological Museum.

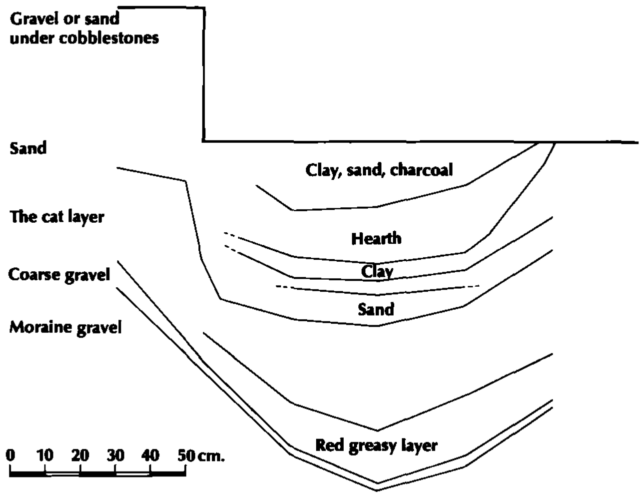


Fig. 3. The pit in section.

the other layers. This layer was given the name "red layer" (fig. 3).

Clumps of chalk were found spread throughout the pit. These were of various sizes, ranging from a few millimetres up to 10 cm in diameter. They were not analysed, but were thought at the time to be composed of pure slaked lime.

Similarly, small concentrations of fly puparia were found throughout the pit, although these were most abundant in the "red layer". Precise identification was not possible, but the majority of the puparia belong to the genus *Musca* (fig. 4).

In the area around the pit, there were scattered bone finds, mostly of cat. It was decided therefore to extend the area of the excavation and another 1 × 1 m field (Field II) was laid out to the north of Field I, a further smaller field (Field III) was opened up to the west and yet another field (Field IV) to the south of the trench. However, as can be seen from the find lists, cat bones from outside the pit were few in number.

## THE FINDS SPECIES LIST (FIG. 5.).

*Domesticated cat (Felis catus L.)*

The pit contained a total of 1783 bone fragments of cat, which, on the basis of a count of the singly-occurring bone in the roof of the cranium, *parietale dextra*, must represent a minimum of 68 individuals. Cranial bones were on the whole the most abundant, but the large bones of the forelimbs were also well-represented. There were 56 left elbows, *ulna sinistra*, and 56 left upper forearm bones, *humerus sinistra*. Rear limbs were somewhat less abundant. There were for example 40 right thigh bones, *femur dextra*, and 46 left shin-bones, *tibia sinistra*, whilst bones from the torso, such as vertebrae and ribs were remarkably few in number (fig. 6).

Only one animal, a six-month old kitten, lay virtually

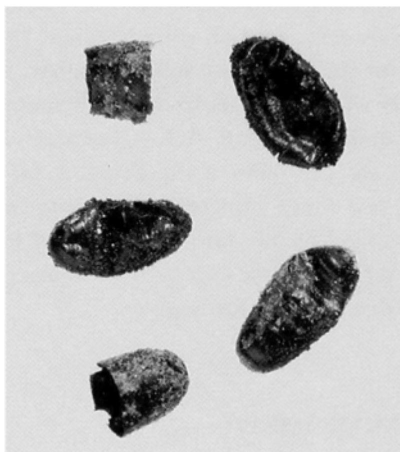

Fig. 4. Photograph of fly puparia: The best preserved fly puparia were identified as House Fly (*Musca domesticus*). 1:1.

undisturbed in the pit (fig. 7), although a number of crania were found intact. Some of the forelimb bones retained their natural relative positions, but the majority of the limb bones lay randomly scattered.

### *Other species*

Apart from cat bones, the pit also contained bones of the usual domesticated animals – cattle, pig, and sheep and poultry such as domesticated goose, hens, and a single thighbone of the long-tailed field-mouse *Apodemus flavicollis*. There were furthermore, a pair of almost complete skeletons of fox *Vulpes vulpes* (fig. 8), as well as a fragment of the upper jaw of a fox cub. The pit also produced most of the skeleton, plus a few loose bones, of raven *Corvus corax* (fig. 9).

Both foxes had complete sets of teeth, but one of them was a younger individual in which the proximal epiphyses of the upper forelimb had not yet fused (fig. 8). As was the case with the cat remains, there were numerous cutmarks both on the skulls and the lower jaws; the animals had clearly been skinned (fig. 8).

The bones of the ravens on the other hand, revealed nothing which might explain their presence in the cat pit. It is tempting to speculate that they were of cultic significance in association with one of Nordic mythology's main characters – Odin. Odin's companions were two ravens – Hugin and Munin. This possibility and the fact that the bones were found in Odense, which also brings Odin to mind, could mean that the ravens were not just ordinary refuse. Like all members of the crow family, ravens are easy to tame, and the possibility that these birds belonged to a flock of sacred ravens similar to that at the Tower of London is obvious (fig. 9).

In the lower levels of the pit there were several concentrations of fly puparia which in most cases were too degraded to permit identification. The few well-preserved examples proved to belong to the common house-fly *Musca domestica L.* (Werner Michelsen det.).

| SPECIES OF ANIMALS FOUND IN THE DITCH | | |
|---|---|---|
| **WILD SPECIES** | | **NUMBERS** |
| Insecta | Insects | |
| *Musca domestica* | House-fly | ? |
| Pisces | Fish | |
| *Gadus callarias* | Cod | 6 |
| *Melanogrammus aeglefinus* | Kuller | 1 |
| *Pleuronectidae* | Flatfish | 2 |
| Aves | Birds | |
| *Corvus corax* | Raven | 31 |
| Mammalia | Mammals | |
| *Apodemus flavicollis* | Field-mouse | 1 |
| *Vulpes vulpes* | Red Fox | 149 |
| **DOMESTICATED SPECIES** | | **NUMBERS** |
| Aves | Birds | |
| *Anser anser* | Geese | 23 |
| *Gallus domesticus* | Hens | 22 |
| Mammalia | Mammals | |
| *Canis familiaris* | Dog | 24 |
| *Felis catus* | Cat | 1783 |
| *Sus domesticus* | Pig | 46 |
| *Ovis aries* | Sheep | 141 |
| *Bos taurus* | Cattle | 140 |
| *Equus caballus* | Horse | 2 |

Fig. 5. Species represented in the pit.

## COMPARATIVE MATERIAL

### *Modern reference material*

In order to gain a qualified picture of the cats from Viking Age Odense, it was necessary to obtain and examine skeletal material from modern cats of known age, sex, weight, and size (figs. 10 a-b). To date 23 individuals have been collected with the following age and sex distribution: 4 adult males, 6 adult females, 9 juvenile males, and 4 juvenile females.

These cats are all ordinary Danish domestic cats. These are presumed to represent the original form introduced to the country, and have not been exposed to special selection. Pedigree cats such as Angora and Siamese have undergone changes, at least with respect to the proportions of the cranium. Body configuration is also different in these refined forms from that in the original domesticated cat and for this reason they have not been included in the reference collection.

### *Medieval material*

Finds of cat bones are known from medieval layers in the majority of Danish market towns. As an aid in working

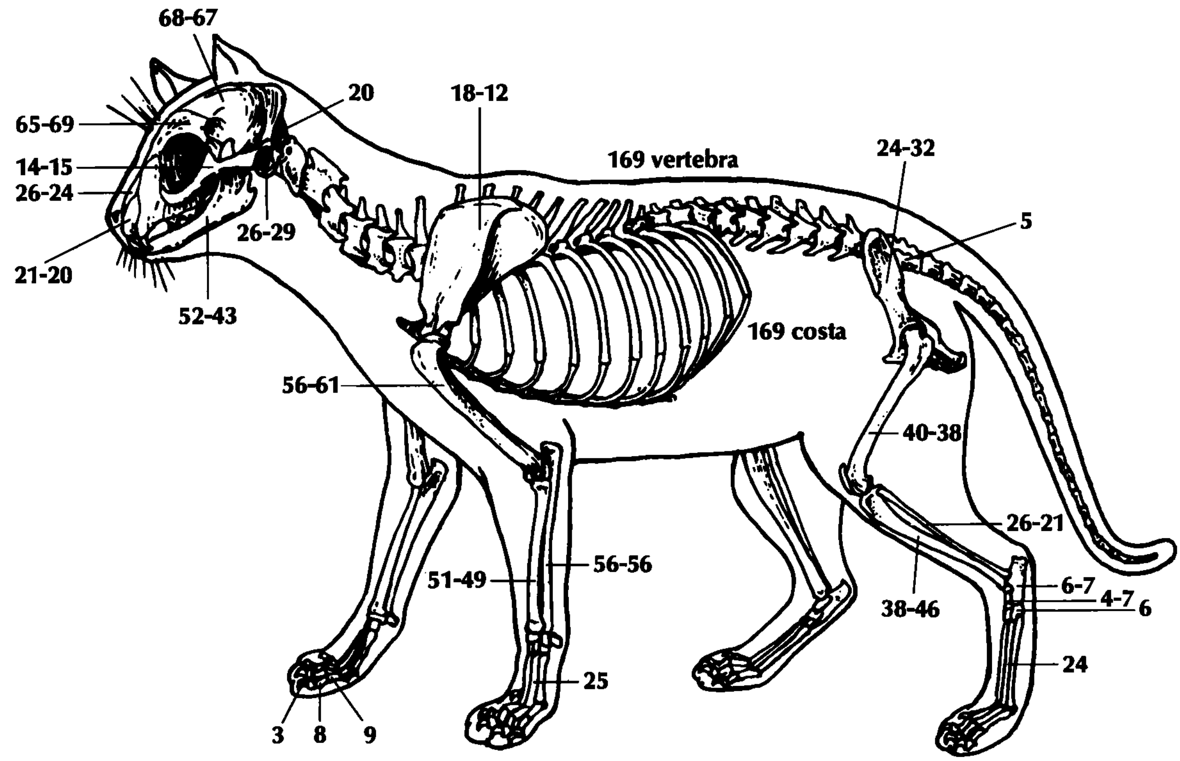


Fig. 6. Diagram of cat skeleton showing the number of fragments found.

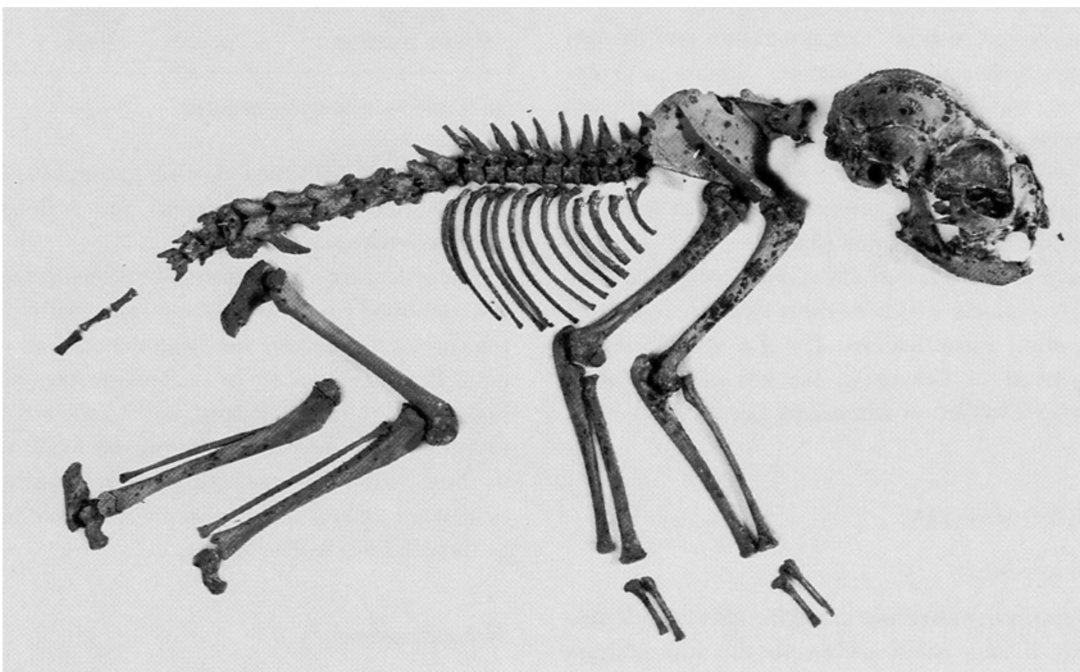

Fig. 7. Photograph of a complete skeleton of a c. six-month old kitten found deep in the red layer.

Fig. 8. Photograph of the skull of Fox (*Vulpes vulpes*).

out the bone diagrams for the Odense cats, measurements from sites in the town of Svendborg and Ørkild Castle, near Svendborg, on Funen have been used (material in UZM, excavated by H.M.Jansen, SOM). In individual cases the more extensive material from Århus in Jutland (Møhl 1971) and Gamle Lödöse (material in UZM, excavated by R. Ecre, Göteborg Museum), which is the medieval forerunner of Göteborg in Sweden, are also included in the diagrams. A more detailed treatment of these finds will however have to wait until a later publication.

As can be seen from the diagrams, cats from the Nordic Middle Ages are in general smaller than modern cats and cutmarks are evident on the skulls and lower jaw bones of nearly all of them.

## DESCRIPTION OF THE SKULLS

A total of 21 virtually intact skulls were recovered from the upper layers of the pit, whereas in the lower layer, the total was 17. In addition there were the disarticulated bones from 28 skulls.

Unfortunately the majority of the skulls were incomplete in that either the skull basis *occipitale* had been broken off or the front of the jaws *premaxillare* were missing. The majority also lacked the cheek-bones *jugale*. It has not therefore been possible to measure the cheek breadth (*zygomatic breadth*) which is a much-used measurement in determining cranial form. Only 3 skulls from the upper layer (K19,21, and 24) and one from the lower layer (R1) were well enough preserved such that the complete cranial length (*condylobasal length*) could be measured (table 1).

The fact that the *premaxillare* were missing must be due to some extent to the fact that it was not possible to sieve the soil during the excavation. These very small bones (c. 1 cm) were difficult to find in the clayey soil and it therefore likely that they were lost during excavation.

On the other hand the missing neck region is clearly due to the fact that the skulls were damaged before being thrown into the pit. In a remarkable number of cases the neck region was damaged such that the bones around the *foramen magnum* had been broken off. Ten otherwise well-preserved skulls lacked the neck bone *os occipitale* in addition to the bones in the region of the ear, *os bulla*, *petrosum* and the lower part of the *squamosum* (fig. 11).

All the skulls showed clear cutmarks concentrated around the snout, partly on the upper jaw, *maxillare*, over the canines and partly on the nose bone, *nasale*. Furthermore, cut and scrape marks, as well as holes made by the

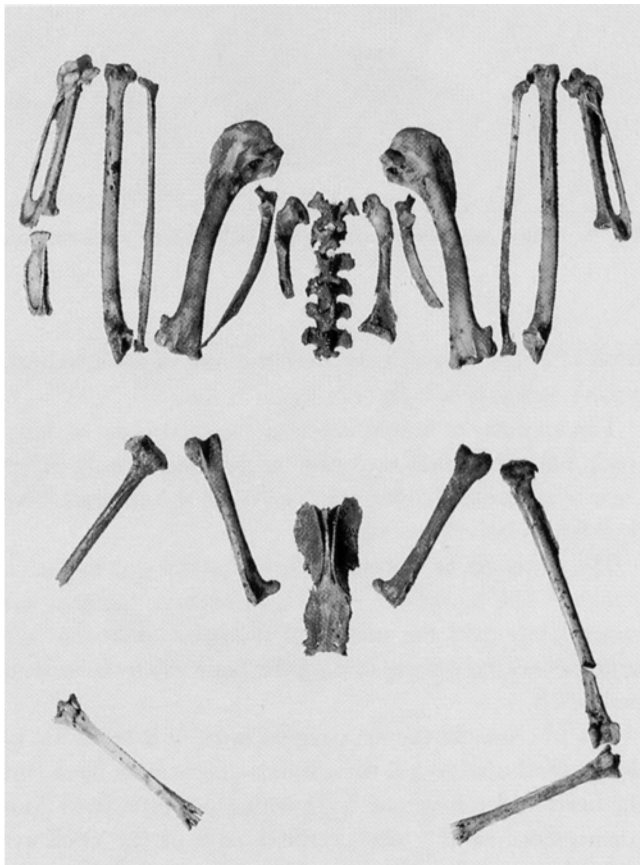

Fig. 9. Photograph of bones of a Raven (*Corvus corax*).

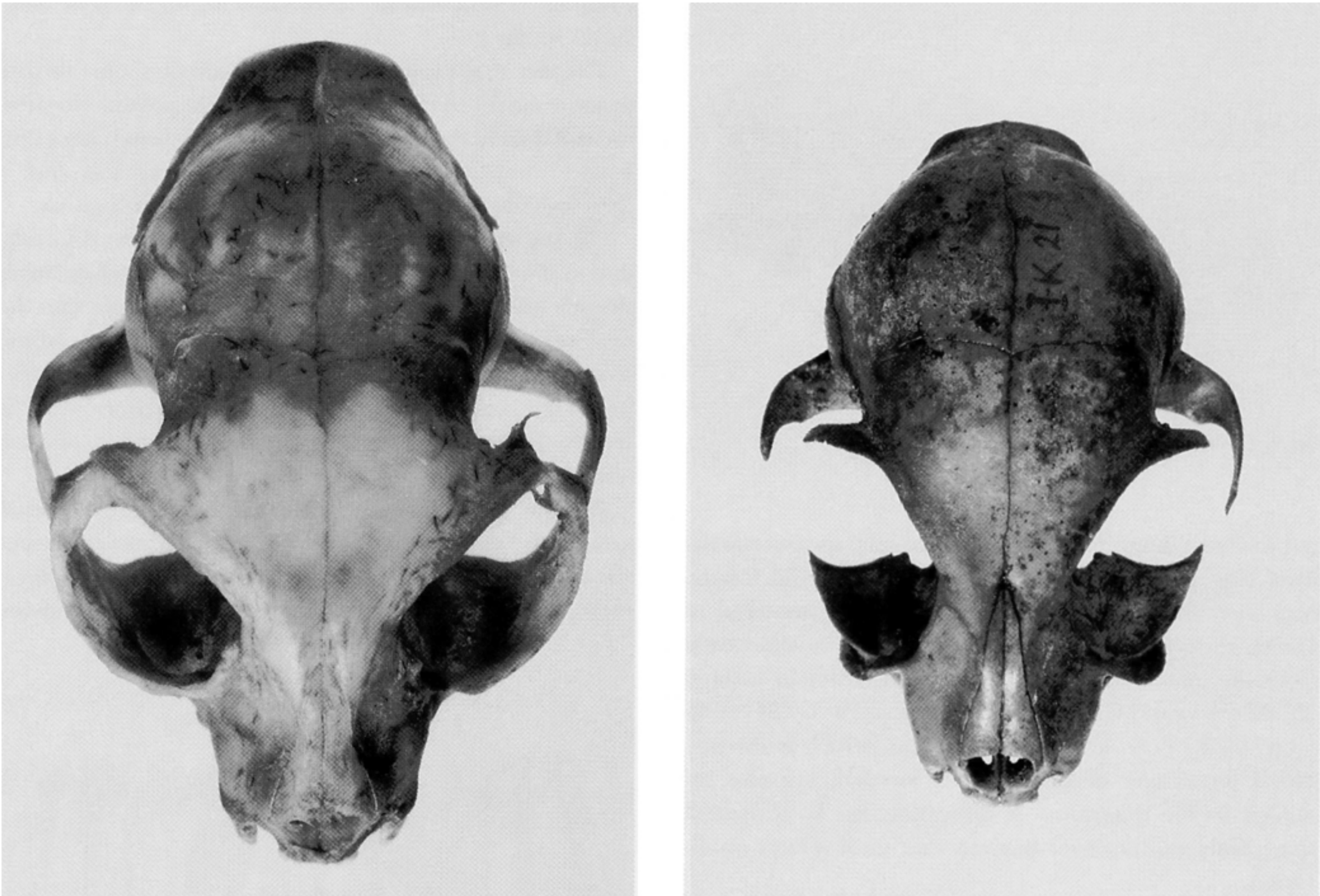

Fig. 10. Photographs of cat skulls: A: Recent female domesticated farm cat. B: One of the best preserved skulls from the pit.

teeth of dogs, were evident over the roof of the cranium, *frontale* and *parietale* (fig. 12).

The majority of individuals had a complete set of adult teeth, but the cranial sutures were most commonly either open or very clearly defined. Nearly all the animals were therefore relatively young.

The cutmarks on the snout show that the cats had been skinned. The marks are at the point where the skin lies immediately over the surface of the bone, such that the knife can scarcely avoid cutting the bone when the animal is skinned.

The fractures in the neck region must be a reflection of the method used to kill the animals. They must have had the head pulled from the body with a powerful jerk. As a consequence of this the occipital part of the skull remained attached to the powerful muscles which run between the base of the skull and the neck vertebrae.

As mentioned earlier, there were only 4 skulls which were sufficiently complete such that the condylobasal length could be measured. Of these four skulls, one (R1) was from a young individual which had just acquired its adult set of teeth – the root of the canine tooth on the lower jaw was still open. The same criterion shows that K21 is from an older individual.

Diagrams of the skull measurements (fig. 13) show that the Odense cats were smaller than recent cats. In particular K21 is remarkably small in the light of the fact that this is a mature individual – probably one of the breeding females. Other skull measurements, for example length and breadth and distance between the eye sockets (*interorbital breadth*) of which several are available for the Odense cats, are less than in modern cats, although the difference is not so marked as in the limb bones (see later). In the skull material both sexes are apparently

| | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 |
|---|---|---|---|---|---|---|---|---|---|
| Condylobasal length (2) | 76,7 | - | - | - | - | - | - | - | - |
| Facial length (9) | 32 | 27,1 | - | 31 | 13,6 | 30,1 | 29,2 | 26 | - |
| Length of $p^4$ (14) | 9,6 | 9,4 | 9,3 | 10,1 | 10,1 | 9,5 | 9,2 | 9,2 | 9,3 |
| Gr. breadth of $p^4$ | 4,9 | 4,7 | 4,7 | 5,2 | 4,8 | 4,4 | 4,5 | 4,6 | 4,6 |
| Mastoid breadth (18) | 38,5 | 35,9 | 37,1 | - | - | - | - | - | 34,8 |
| Breadth of condyles (19) | 21,5 | 20,1 | 20,1 | - | - | - | - | - | 18,4 |
| Interorbital breadth (25) | 15,3 | 14,5 | 15,2 | 14,9 | 13,9 | 16,2 | 13,2 | 13,6 | 13,8 |
| Breadth at the canines (27) | 23,5 | 22,1 | 22,9 | 23,1 | 25,4 | 25,6 | - | 22,7 | 21,4 |

| | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 |
|---|---|---|---|---|---|---|---|---|
| Condylobasal length (2) | - | - | - | - | - | - | - | - |
| Facial length (9) | - | - | 29 | 23 | - | 25,7 | - | 29,8 |
| Length of $p^4$ (14) | 9,7 | 9,2 | 9,8 | 9,8 | 8,6 | 9,7 | 10,3 | 9,7 |
| Gr. breadth of $p^4$ | 4,9 | 4,4 | 4,7 | 4,7 | 4,6 | 4,9 | 5,4 | 5 |
| Mastoid breadth (18: | 37,4 | - | - | - | - | - | - | - |
| Breadth of condyles (19) | 18,9 | - | - | - | - | - | - | - |
| Interorbital breadth (25) | - | - | 14,9 | ? | 14,4 | 16,2 | - | 14,7 |
| Breadth at the canines (27) | - | - | | 23 | 21,8 | 24 | - | 23 |

| | K16 | K19 | K20 | K21 | K22 | K23 | K24 | K26 | K28 |
|---|---|---|---|---|---|---|---|---|---|
| Condylobasal length (2) | - | 79,2 | - | 71 | - | - | 75,6 | - | - |
| Facial length (9) | 29,6 | 32,1 | 28,4 | 30,3 | 29 | - | 32,2 | - | - |
| Length of $p^4$ (14) | 8,9 | 9,9 | 9,3 | 8,6 | 9,9 | 8,5 | 10 | 9,4 | 9,5 |
| Gr. breadth of $p^4$ | 4 | 4,2 | 4,8 | 4,1 | 4,9 | 4,2 | 5 | 4,5 | 4,4 |
| Mastoid breadth (18) | - | 38,6 | - | 35,9 | - | - | 37 | - | - |
| Breadth of condyles (19) | - | 20.7 | - | 17,9 | - | - | 18,9 | - | - |
| Interorbital breadth (25) | 16,3 | 14,9 | 15 | 14,3 | 14,5 | - | 15,1 | 15,5 | 15,9 |
| Breadth at the canines (27) | 23,2 | 22,4 | 23 | 22,9 | 20,9 | - | - | 23,7 | - |

Table 1. Measurements of the skulls. R1–R18 are from the red, greasy layer, K16–28 are from the cat layer (see fig. 3).

represented, in contrast to the situation with the mature limb bones.

## DESCRIPTION OF THE LOWER JAWS

A total of 124 lower jaw halves were found either in or around the pit – 63 right halves and 61 left halves. The great majority were intact and 19 were found together with the skulls to which they quite clearly belonged (fig. 14).

Whilst only a few of the skulls showed signs of external violence, cutmarks were found on the outer surface of the majority. These cutmarks lie most commonly immediately behind the alveolus for the canine tooth.

As was the case with the skulls, most of the lower jaws were equipped with sets of adult teeth – however X-ray photographs of the canines showed that the majority of these had a large pulp cavity and in many cases the root was still open. This means that the individual has only very recently aquired its adult teeth.

The canines are replaced when a cat is about 6 months old and the change is normally complete at an age of about 7 months (Habermehl 1975). At first the canines are open at the root and they close in the course of the following few weeks, after which the pulp cavity also gradually closes.

One further age-determined feature should be mentioned. The two halves of the lower jaw fuse at the symphysis at the chin late in the cat's life. Apparently there is great variation as to the age at which this occurs. On the basis of the 10 recent adult skeletons (over 10 months) which were available for study, it can be concluded that an animal can be over 7 years old before the two halves of the jaw are completely fused.

Fig. 11. Diagrams of skulls seen from below: No. 1 is complete, the others lack the neck (*occipital*) region. The breaks are angled such that one earbone is partly preserved.

Of the many lower jaws found in the pit, only one was completely fused. It was found in Field II in the "cat layer" and with a sectorial tooth measuring 6,5 mm in length it must come from an old female.

The skull measurements show that the cats from Odense were small in comparison to modern cats and their lower jaws, in accordance, were also small. However if the length of the sectorial tooth in the lower jaw (first molar) is measured, it is evident that there is great variation in the size of this tooth. The largest of the Odense cats sectorial teeth are on a par with those of modern cats although on average they are smaller. Fig. 15 shows the relationship between the total length of the jaw and the length of the lower sectorial tooth M1. It can be seen that the larger modern cats have in many cases less well-developed teeth than their smaller Viking Age counterparts. The increase in size seen in modern cats, which is apparent in the bone structure and which must be largely due to more abundant food and better living conditions, is not reflected to the same extent in the teeth. As a rule tooth structure is a very stable characteristic. The opposite is true of newly domesticated animals, in which the jaw can be so weakly developed that the teeth are too big and are of necessity arranged in a staggered fashion in the jaw.

## BONES FROM THE BODY

Of the 606 fragments of large limb bones which were recovered, 351 were forelimbs and only 255 from hindlimbs. The great majority of these bones came from immature animals in that the *epiphyses* (points of articulation) were not yet fused. At birth, all epiphyses are free and there is a growth zone linking them with the shaft of the bone itself. This allows the animal to grow, whilst also allowing the joint to function.

The few limb bones in which linear growth had ceased, i.e. those with fused epiphyses, were all, without exception, very small. There were a total of 20 from the forelimbs distributed as follows:

2 right and 2 left upper forelimbs (*humerus*)
4 right and 5 left lower forelimbs (*radius*)
3 right and 3 left elbow bones (*ulna*)

A total of 17 bones from hindlimbs were recovered:

4 right and 5 left thigh- bones (*femur*)
2 right and 3 left shin-bones (*tibia*)
1 right and 3 left fibula (*fibula*)

In all the diagrams where the greatest length of the limb bones is plotted against the midbreadth of the *diaphysis*, i.e. the boneshaft, these fully adult Odense cats lie below modern cats for both of these measurements (figs. 16–18). If the measurements from medieval finds in the town of Svendborg and Ørkild Castle on Funen and the town of Gamla Lödöse in Sweden are included, this picture is not altered, i.e. they are also smaller than present day cats. The number of bones from the medieval sites is not great, but on the basis of the available evidence, it appears that the small bones from Odense come from female cats, whereas the other sites include remains of both sexes.

The table (fig. 19) shows the breadth distribution of distal end of the *humerus* from Viking Age Odense. Only four of these bones were fully mature, i.e. with the upper epiphysis fused to the shaft. Of the others, 17 were whole but lacked the upper epiphysis, i.e. they were less than 11 months old. The age of the remainder, a total of 31, could not be determined because the bone was broken in the middle of the shaft. The distribution shows that, whilst the undetermined and juvenile are spread over the whole range of variation, the four fully grown examples lie below the average. Accordingly it can be concluded that these four mature upper forelimb bones come from adult females, presumably breeding stock which were allowed to live for the sake of production. The young animals which were slaughtered comprised both males and females.

In many cases, the bones of the forelimb, the *humerus*, *radius*, and *ulna* had retained their natural orientation relative to each other as they lay in the pit; this was also the case for many of the skulls and lower jaws. Other bones were found less frequently in their correct positions (fig. 20).


Fig. 12. The majority of skulls show numerous cutmarks on the bones of the snout (*nasale*), upper jaw (*maxillare*) over the alveolus for the canine and over the bones forming the roof of the skull (*frontale* and *parietale*).

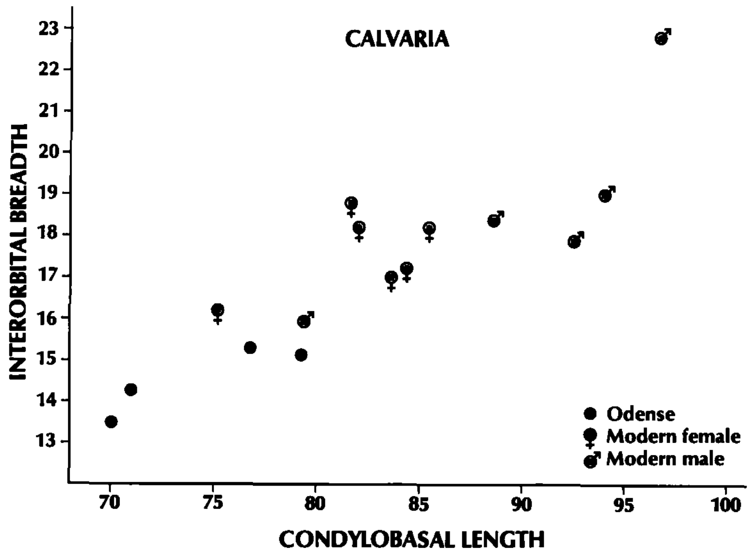


Fig. 13. Condylobasal length and interorbital breadth: The four complete skulls from the pit are all smaller that recent skulls.

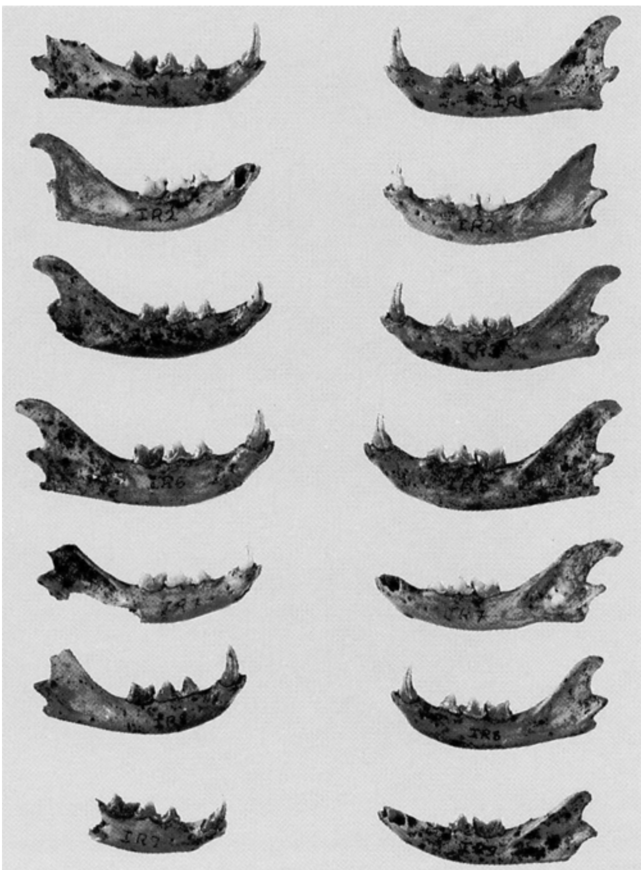

Fig. 14. Lower jaws (mandibula) from the red layer.

Many of the bones show evidence of gnawing by dogs and the discrepancy between the number of forelimbs and hindlimbs and the fact that many of the forelimb bones retained their correct orientation, could be due to the dog's liking for the more meaty parts of the cat carcases. Similarly, the obvious lack of vertebrae and ribs (see bone summary) could also be explained by scavenging dogs (figs. 21 a-b).

## AGE DISTRIBUTION

The majority of the cat jaw fragments, both from the upper and lower jaw, came from animals which had acquired their adult teeth. In modern cats, this transition normally begins at an age of about 7 months. It is thus relatively easy to determine the age of a kitten, but once the adult teeth have been acquired then age determination becomes more difficult.

Something which can be of assistance in this respect, is the fact that the roots of the teeth are not completely formed at emergence. The tooth is open at the root in the first few months, only then do the bases of the canines and molars close. An X-ray picture can show approximately how far advanced the tooth is in its development. X-ray pictures of the numerous lower jaw halves from the pit,

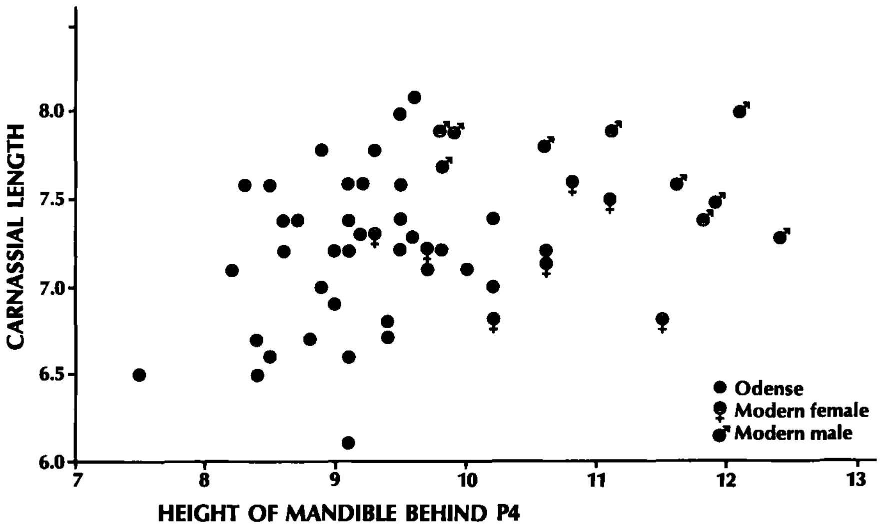


Fig. 15. Lower jaws: Jaw height and size of the 1. molar: Whereas jaw size in the Odense cats is less than that of modern cats, the size of the 1. molar is approximately the same. This means that the Odense cats had relatively larger teeth than recent cats.

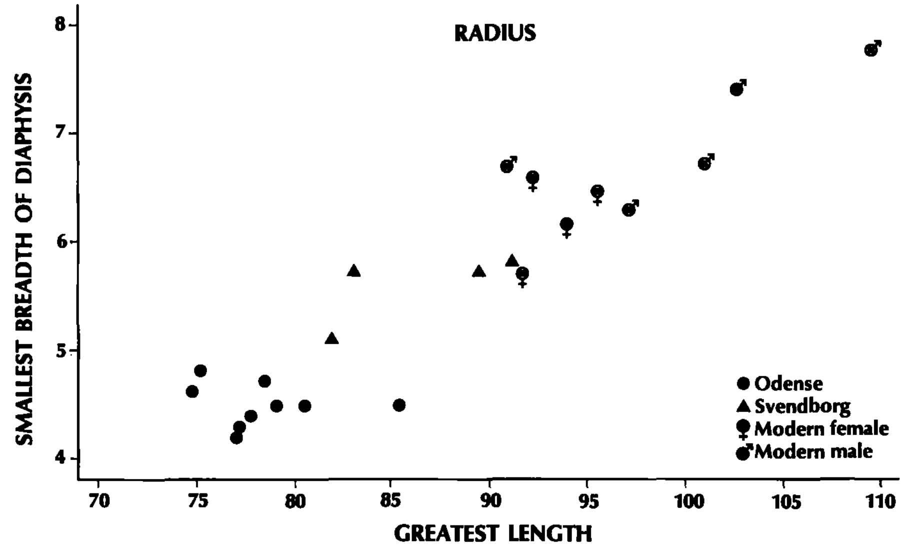


Fig. 16. Radius: Total length and breadth of the diaphysis. The few mature bones from Odense are from very small individuals, probably females.

which in the main have adult teeth, show that these have only very recently been acquired, i.e. the animals were just less than one year old at death.

From a total of 61 canines, only 4 can be said with certainty to come from mature individuals and there is some uncertainty with regard to a further 14. A total of 44 are definitely from various juvenile stages; only 4 of these individuals still have milk-teeth.

Although the material contains bones of both very young and fully mature (even old) animals, the majority were not fully grown at death. In most cases both the lower epiphysis of upper forelimb (*humerus*) and the upper epiphysis of the lower forelimb (*radius*) were fused. In present day cats this occurs at an age of 8.5 months. The upper end of the *humerus* and the lower end of the *radius* were typically unfused. In modern cats these epiphyses fuse when a kitten is about 11.5 months old. This gives a very precise age determination for the majority of the

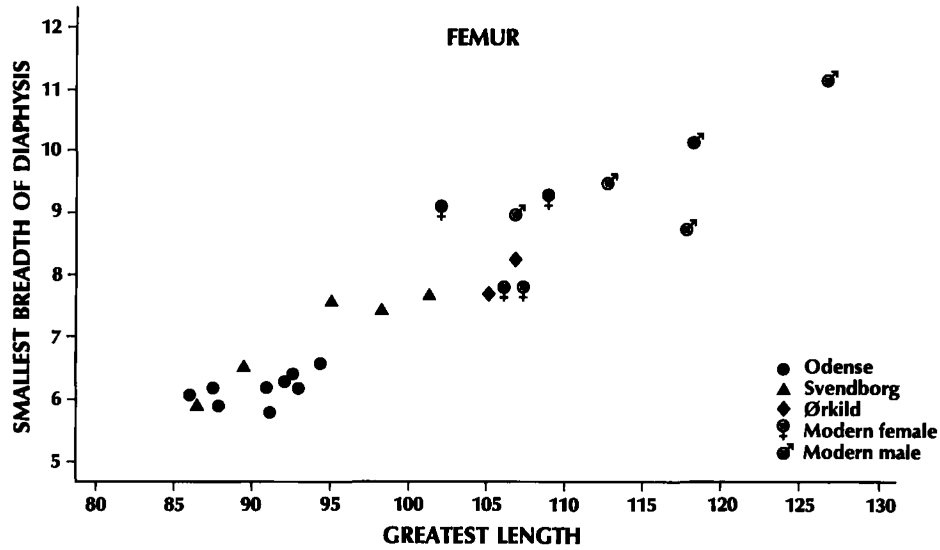


Fig. 17. Femur: Total length and breadth of the diaphysis (see fig. 16).

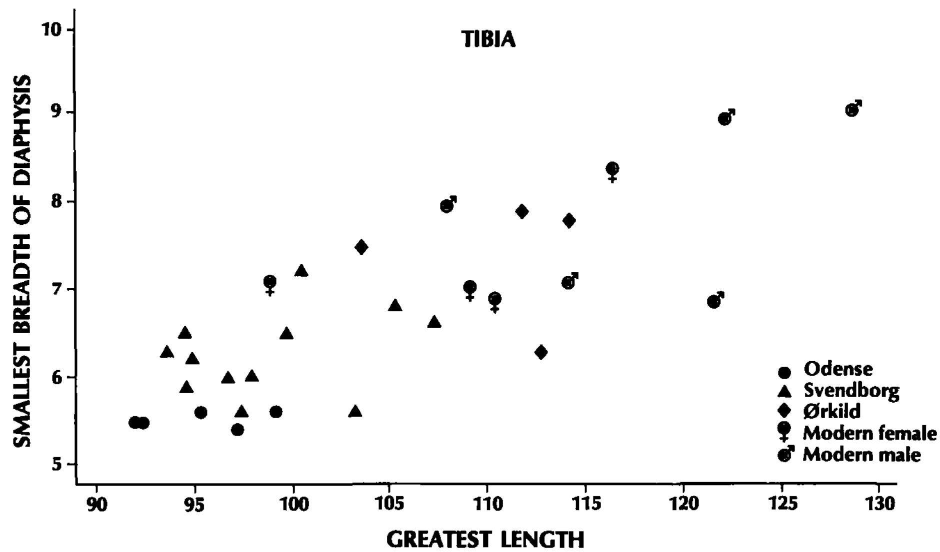


Fig. 18. Tibia: Total length and breadth of the diaphysis. (see fig. 16).

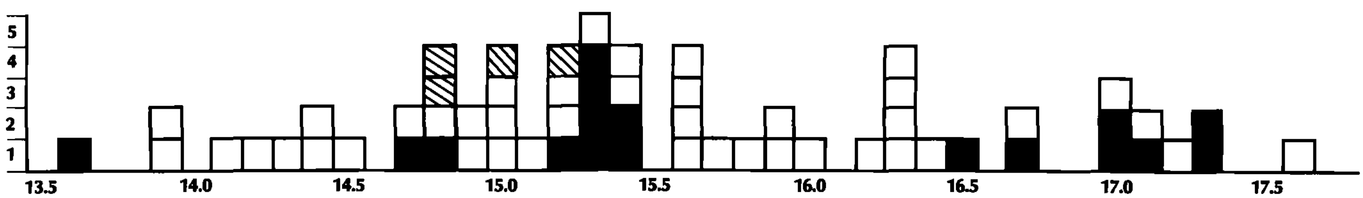


Fig. 19. Breadth of the lower end of the humerus: From a total of 62 lower ends of humerus in the pit, 4 were from adult animals and had fused epiphyses, 17 had unfused epiphyses and the remaining 41 were broken mid in the diaphysis. All the adults were relatively small and therefore probably females.

bones. By the age of c. 10 months a cat has almost reached full size.

## BODY SIZE

A comparison of the Odense cats with modern cats shows clearly that there is a significant size difference. This is not remarkable in itself, as remains from the large medieval urban excavations show clearly that the first cats introduced to the country were much smaller than today's ordinary farm cat.

The height at the shoulder is typically used as a measurement of size for a domesticated animal – for example with horses and cattle and also smaller animals such as dogs. With cats it is normally the weight which is used to indicate size, but as this is heavily dependant on nutrition, it is difficult to apply to skeletal material.

Shoulder height could of course also be calculated for the cat, but only weight and body length were measured on the modern reference material. This means that in

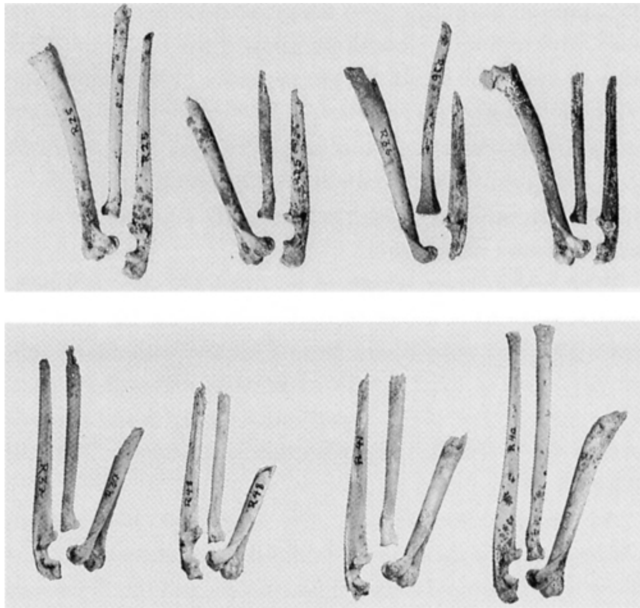

Fig. 20. Photograph of forelimb bones (*humerus, radius, ulna*): In many cases forelimb bones lay in complete sets, suggesting that the animals were thrown whole into the pit.

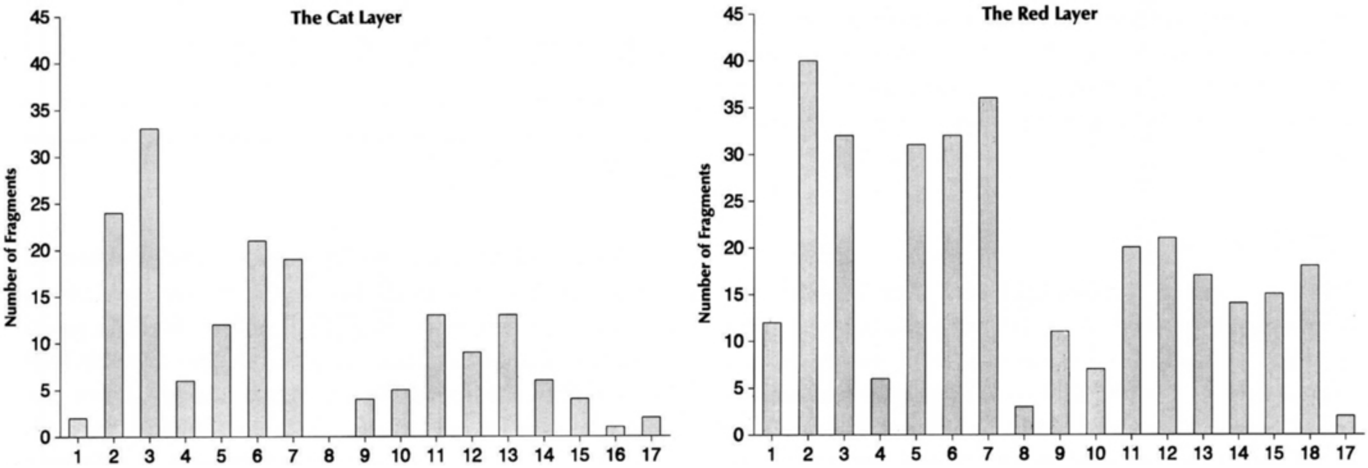


Fig. 21. Distribution of post-cranial bones in layer R and layer K. There are only a few bones from the torso, and hindlimb bones are poorly represented relative to forelimb bones.

1. DENS (Teeth)
2. VERTEBRA (Vertebra)
3. COSTA (Rib)
4. SCAPULA (Shoulder-blade)
5. HUMERUS (Upper arm)
6. RADIUS (Radius)
7. ULNA (Ulna)
8. CARPUS (Wrist)
9. METACARPALE (Metacarpal)
10. PELVIS (Pelvis)
11. FEMUR (Thigh-bone)
12. TIBIA (Shin-bone)
13. FIBULA (Fibula)
14. TARSUS (Ankle/heel)
15. METATARSALE (Footbones)
16. PHALANX (Toes)
17. DIVERSE

order to calculate shoulder height it would be first necessary to convert weight and body length to shoulder height using measurements of the limb bones. A constant would then be arrived at which could be used together with the limb measurements from the Odense cats to calculate their shoulder height. The many conversions mean however that any result arrived at by this process would have a great deal of uncertainty associated with it.

Body length (the distance from the tip of the snout to the anus) is normally used when measuring small mammals, and it gives a clear impression of the cat's size. This measurement is known for the majority of the cats in the reference material. The relationship between body length and the maximum length of the shin-bone is so constant that it is permissable to calculate the body length of those individuals which at Odense were only represented by a single mature shin-bone.

With a shin-bone length of between 112 and 129 mm, modern cats have a body length of between 480 and 575 mm. The five shin-bones from Odense with fused epiphyses, have a total length of between 92 and 99 mm. This means that these bones must come from animals with a body length lying somewhere betweeen 350 and 420 mm.

As already established, the complete bones from Odense come from females. It should be remembered that there is great sexual dimorphism in cats and the difference in the average body size is therefore not so great. If the material from the medieval excavations in Gl. Lødøse, Gothenburg (which contains both males and females) is combined with that from Odense, then the average difference between the Viking Age/medieval cats and the modern reference material is just less than 50 mm.

These conclusions must however be seen in the light of the fact that the sample size of the modern material available for study and comparison is small (10 individuals) (fig. 22).

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **RADIUS** | | | | | | | | |
| | Odense | | | | | | | | |
| GL | 85 | 81 | 79 | 78 | 78 | 77 | 77 | 75 | 75 |
| SD | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 |
| | Svendborg | | | | | | | | |
| GL | 91 | 89 | 83 | 82 | | | | | |
| SD | 6 | 6 | 6 | 5 | | | | | |
| | **FEMUR** | | | | | | | | |
| | Odense | | | | | | | | |
| GL | 94 | 92 | 93 | 93 | 91 | 91 | 88 | 88 | 86 |
| SD | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| | Oerkild | | | | | | | | |
| GL | 107 | 105 | | | | | | | |
| SD | 8 | 8 | | | | | | | |
| | Svendborg | | | | | | | | |
| GL | 101 | 98 | 95 | 89 | 87 | | | | |
| SD | 8 | 7 | 8 | 7 | 6 | | | | |
| | **TIBIA** | | | | | | | | |
| | Odense | | | | | | | | |
| GL | 99 | 97 | 95 | 92 | 92 | | | | |
| SD | 6 | 5 | 6 | 6 | 6 | | | | |
| | Oerkild | | | | | | | | |
| GL | 116 | 110 | 109 | 99 | | | | | |
| SD | 8 | 7 | 7 | 7 | | | | | |
| | Svendborg | | | | | | | | |
| GL | 107 | 105 | 103 | 100 | 100 | 98 | 98 | | |
| SD | 7 | 7 | 6 | 7 | 7 | 6 | 6 | | |
| GL | 97 | 97 | 95 | 95 | 95 | 94 | | | |
| SD | 6 | 6 | 6 | 6 | 6 | 6 | | | |

Fig. 22. Measurements of longbones. GL: Greatest length. SD: Smallest breadth of diaphysis.

## CONCLUSION

The first finds of domesticated cats from Denmark are from around the birth of Christ, but from the early Middle Ages onwards they are known from the majority of market-towns. The 68 (minimum estimate) cats found in the pit under a medieval house in Odense, Funen, dated to AD 1070 ± 100 were mostly young individuals, together with a few older females. They were killed by a powerful jerk of the head after which they were skinned. In comparison to present-day farm cats, they were small, although their teeth were relatively large.

Finds of fly puparia (*Musca sp.*) and the numerous teeth marks from scavenging dogs suggest that the pit stood open for an extended period of time. This also explains why bones from the cats' head and forelimbs are more frequent than those from the body and rear limbs. The latter are the fleshier parts of the carcase in which the dogs would be most interested.

The age distribution of the animals in the pit shows a predominance of animals just less than one year old; a number of bones were from small mature females, probably breeding stock. This suggests that the cats were kept in captivity. Cutmarks on the skulls and the lower jaw show that the purpose of this was fur production. Parallels for this activity are unknown from Denmark or adjoining countries, either from archaeological or historical sources.

As an indication of the value of cat fur at this time, a Welsh law from 948 can be quoted. The so-called "King Hywell Dda's Law" gives the following punishment for theft of the prince's cat: as much corn as is needed to cover the cat when it is held by the tail and its head touches the ground.

*Translated by David E. Robinson*

Tove Hatting, The Zoological Museum, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen Ø.

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# *Viking Age Buildings*

by HOLGER SCHMIDT

Extensive excavations during the last 15 years in Denmark have proved that the change from the prehistoric longhouse-farm to the much more scattered medieval farm gradually took place during the Viking Age (i.e. about 800–1100 A.D.). In the same period also the modes of building-construction were drastically changed, as the traditional and stable two- or three- aisled bay-structure was given up in most buildings, and the medieval timberframed system with sillbeams and trussed rafter roofs developed. As apparently the general development of the house-structure also took place very gradually, if not more or less accidentally, and as moreover the principles of different building-constructions are often mixed up in the houses, the typology of Viking Age houses is in many respects uncertain. The director of the Hedeby excavations, Kurt Schietzel, even describes the houses as being apparently never quite like each other and classification for that reason very difficult (Schietzel & Eckstein 1981 p. 43). In this period, therefore, most houses must simply be characterized as typological hybrids. So the theory of general evolution is then probably the best approach to an understanding of the many problems ensued.

In the Iron Age longhouse (fig. 1) man and cattle lived together under the same roof. The farmer and his family

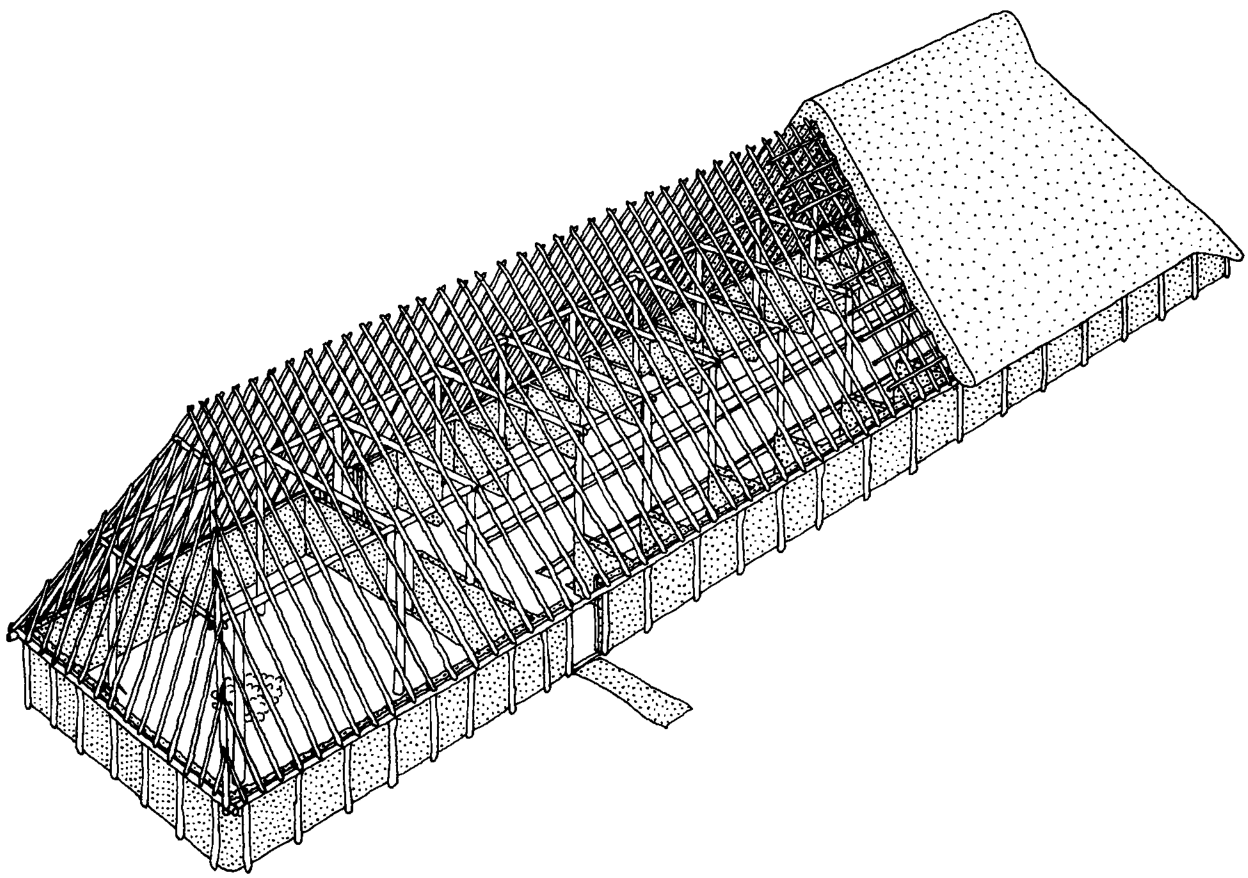

Fig. 1. Reconstruction of a longhouse from the Roman Iron Age. The roof, the walls, and the stalls are supported by the internal framesystem. H. S. 1984.

dwelt around the hearth in the middle of the floor in the west end of the house, while during the winter the cattle was stalled in the east end. The building was made to measure in the sense that the number of cattle belonging to the farm more or less determined the length of the house (the dwelling-part varied less in size), and the width of c. 5 metres was also very appropriate for the byre. The structure made it easy to add more bays if necessary. Certainly these houses for cattle-breeders were improved during the many centuries when they were the ruling type in NW-Europe. This development has been proved by excavations in Vorbasse and in many other deserted villages (Hvass 1983). But the flexible and stable structure remained amazingly unchanged until the Danish rural society during the Viking Age was changed – apparently in very much the same way as society had been changed centuries before in Central Europe (Donat 1980).

The main elements of the structure were the internal roof-supports. In the Old Norse texts these posts are called *suler* (Jensen 1915 and Stoklund 1969 p. 38), and archaeology has proved that they were often of triangular section, as a consequence of the splitting-technique used on the oak-trunks. In which case they were always put up with their bark-sides against the middle of the house and the sharp edge against the longsides (Trier 1969, p. 126). Accordingly the biggest dimension of the posts was across the house. For this reason, and also because they were usually put up in pairs, one must assume that the *suler* were joined together at the top by horizontal timbers across the house, i.e. tie-beams. As the inner uprights were also put up in rows lengthwise in the house, they must also have carried horizontal timbers lengthwise (above or at the same level as the tie-beams), so-called *åse* (side-purlins), which again carried the light rafter roof. This internal rigid frame-system was crucial for the stability of the Iron Age longhouse, especially during the erection.

Usually the bay in which the hearth is placed is slightly bigger than the other bays in order to obtain as much free space as possible in the central part of the dwelling. During the Viking Age we shall see that the builders' aim was to get rid of all the free standing inner uprights in the dwelling, although for some time they remained part of the structure of partition-walls, gables, and stalls – if these were still part of the house. The good stable traditional structure was thus partly abandoned to oblige the demands of function.

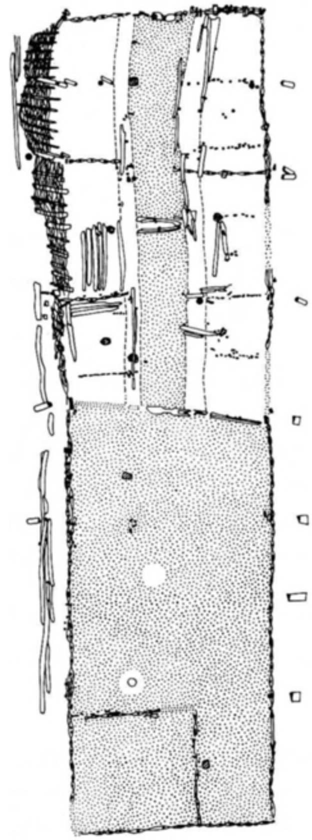

Fig. 2. Longhouse from the marchvillage Elisenhof, 9th century. The byre was extended when the number of cattle increased. Plan, scale 1:200. H. S. 1980.

Traditional longhouses were still in use in most early Viking Age villages. The extremely well preserved 9th century houses in the marshvillage Elisenhof are for instance of this type (fig. 2). This is easy to explain by the fact that the economy here totally depended on the breeding of cattle, but even in the town of Hedeby, where the economy did certainly not depend on the breeding of cattle but on trade, small "longhouses" have been excavated. However these houses are less characteristic, as for instance in the example shown (fig. 3, top) the single cow had to pass through the dwelling in order to be stalled – great quantities of preserved cow-dung in the small gable room leaves no doubt at all as to its function (Schietzel & Eckstein 1981, p. 44).

Another Hedeby house (fig. 3, bottom) was even better preserved than the small longhouse. Besides the post ends in the ground also the wattle panels were preserved, re-

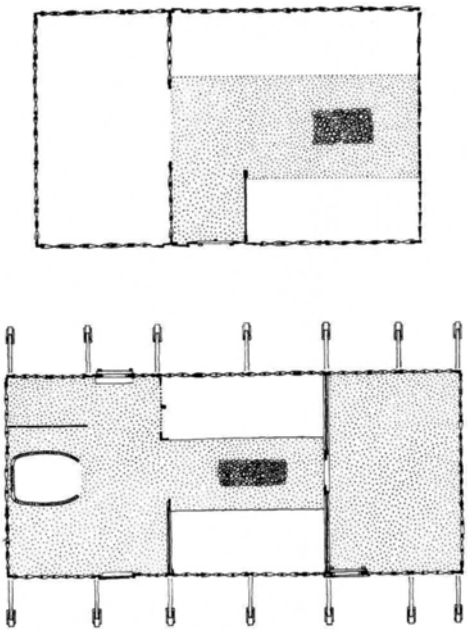

Fig. 3. 9th century houses from Hedeby. Plans, scale 1:200. H. S. 1984.

used as filling in the wet soil for the next house on the site (in Hedeby it has been proved by dendrochronology that houses were in use for only a very short period, they were then replaced by others built on top of the old ones). The house has been dated by dendrochronology to A.D. 870, and it is by far the oldest example of the later so well-known medieval *salshus* (dwelling-house) which was used practically unchanged until the stonebuilt chimney in the 17th century became common in rural buildings. In these houses *stuen* (the living-room) – with the hearth or an oven – is situated in the middle, *herberget* (the unheated room) in one end – mostly used as a magazine but also often as a lobby or workshop (or both), while *stegerset* (the service room) with the bake-oven etc. is in the other end. The Danish plantype is thus closely related to the medieval English house. In this Hedeby house the service room was apparently more or less consequently separated from the living-room. The partition between these two rooms was less substantial than the partition-wall which separated the other gable room from the living-room. Anyway, the functional separation was from the beginning evident in the house. It is therefore very interesting, as well as also a bit confusing, typologically speaking, that the excavator, Kurt Schietzel, states that after 12 years the service room was apparently converted into a small byre, as the bake-oven was demolished and a wooden manger (dated A.D. 982) was put into the room instead (Schietzel & Eckstein 1981, p. 44). The dwelling-house thus became a "long-house" – almost without any change of the planscheme. If this was the case it has been demonstrated that in this period the dwelling-house with well defined and separated functions, in great contrast to the later houses, could be changed into a completely different house-type.

However, apparently the construction of the house has also been changed. Judging from the preserved wattle-panels of the gable, the relatively low-pitched roof had originally a ridge-piece. It was supported by kingposts placed on top of the gable-wall-plates, and presumably also by kingposts placed on the tie-beams over the partition-walls (fig. 4). Theoretically a ridge-piece roof produces no horizontal thrust whatsoever or very little, but apparently the structure proved to be so unstable that it became necessary to support it with heavy buttresses (proved by dendrochronology to be secondary to the house, Schietzel & Eckstein 1977, p. 153 and 1981, p. 64).

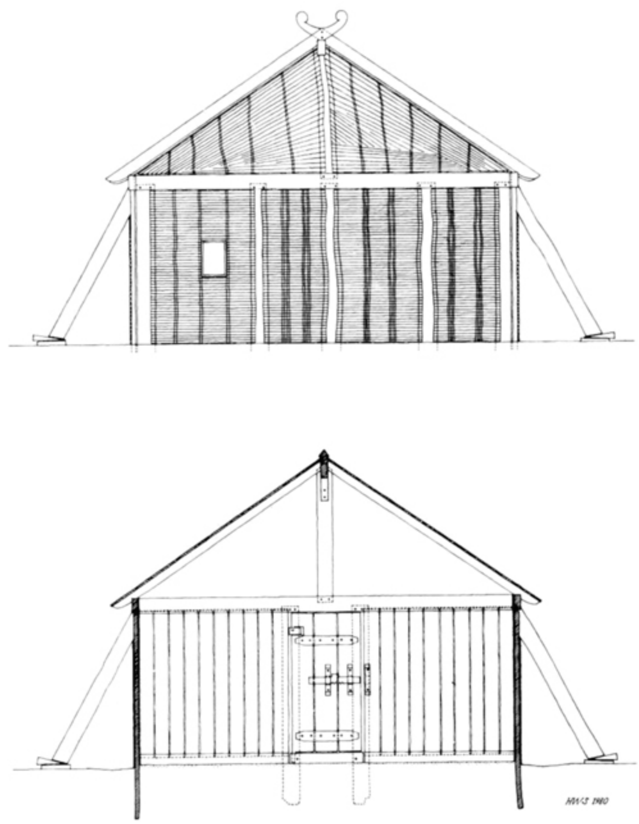

Fig. 4. Reconstruction of a Hedeby house built A.D. 870. A window-frame was preserved with the wattle-panels of the gable. Elevation and section, scale 1:100. H.S. 1980.

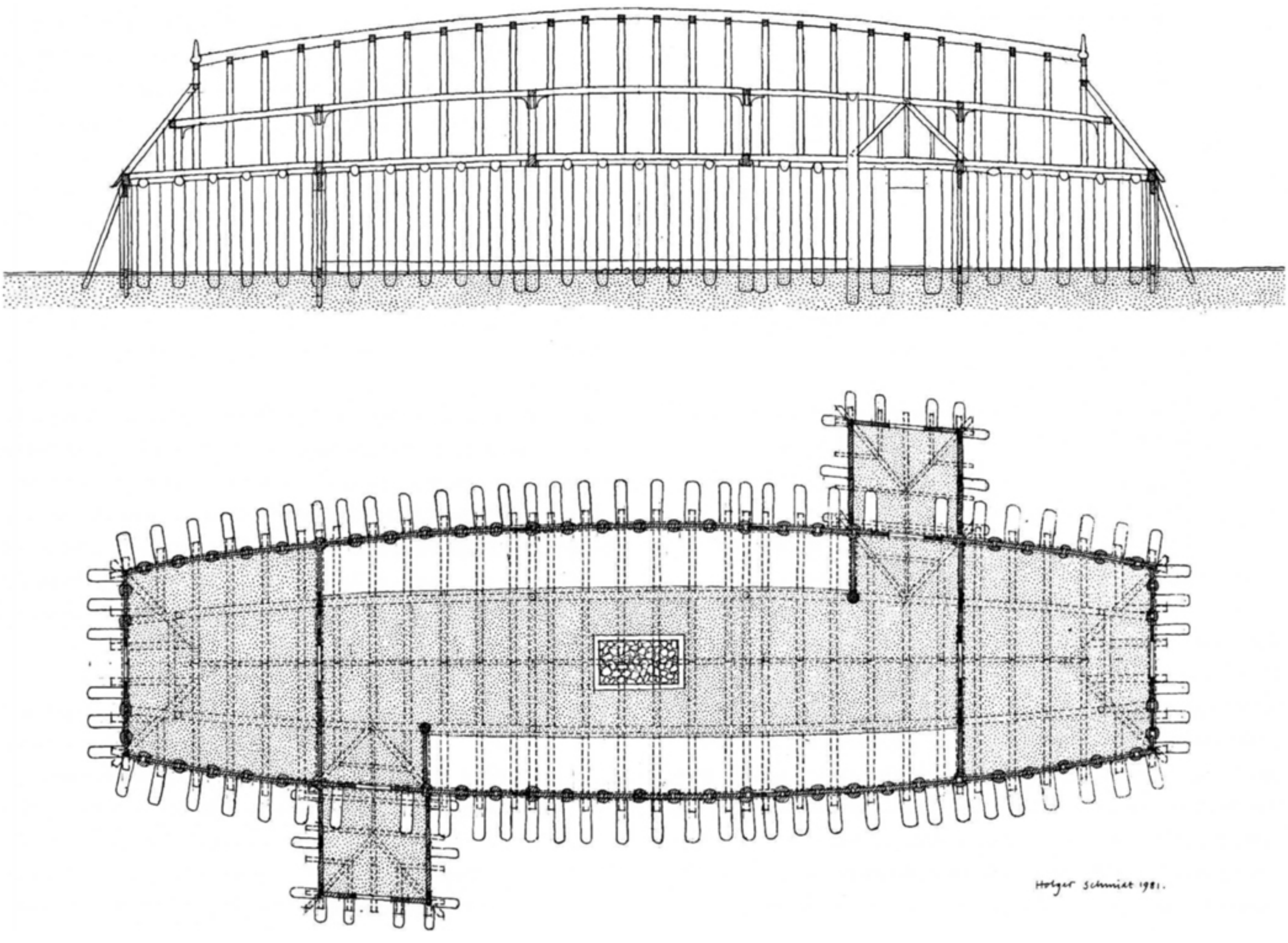

Fig. 5. Reconstruction of a house from the Fyrkat fortress built about A.D. 980. Section and plan, 1:200. H.S. 1981–82.

A stabilisation of the relatively light structure by means of braces or struts is unlikely. At such an early date the lateral stability in the houses could only be obtained by external buttresses, by the overdimensioning of the timber, or by the traditional *sule* structure. In any case it is evident that it was of little use to the upper part of the Hedeby house that all the wall-posts were firmly stuck into the ground – unless the (unlikely) explanation of the added buttresses simply is that already after a few years the house suffered from dry rot where the posts met the ground (below this level the timbers were preserved when excavated). Moreover, it is evident that this Hedeby house proves that the presence of buttresses (or postholes from buttresses) outside the walls of a housetomb does not necessarily mean that the roof can be typologically classified as a trussed rafter roof.

Caution against a heavy-handed typology concerning Viking Age houses is also justified by the very mixed up wall-construction in this and in many other Hedeby houses. As has already been stated, the walls were made of post-and-wattle dug into the ground, while the staves of the partition-walls were put on sills, as in some of the contemporary houses from Elisenhof. From the evidence of these houses it may therefore well be claimed that the introduction of the sillbeams was no "revolution" really in house structures, but rather an evolution which started inside the early Viking Age houses. The screenwall inside the door of the small Hedeby longhouse (fig. 3, top) was built of horizontal boards mortised into uprights (bole technique), while the other walls were made from post-and-wattle, except one of the gables which was made from coarse split staves well dug into the ground. But in all

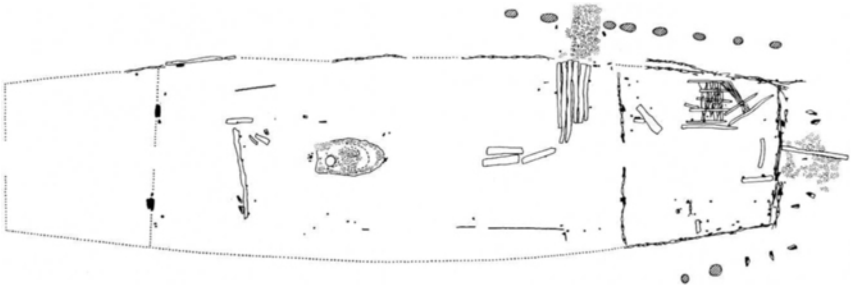

Fig. 6. House from Lund built about 1020. Plan, scale 1:200. H.S. 1984.

probability very little of this mess was clearly visible when the houses were still in use. At that time all the walls (except the bole- or stavebuilt partitions?) must have been heavily daubed with clay and cow-dung etc.

The houses from Elisenhof (fig. 2) more or less tell the same story (Bantelmann 1975). According to the fact that some of the houses have internal uprights as well as external buttresses, also here the roofs must have been typological hybrids. It is characteristic, although, that in these houses the *suler* have been more or less consequently replaced by external buttresses in the dwelling part, while they were preferably preserved in the byre, where they served also as stabilizers for the stalls. The traditional *sule* structure, which was so stable also because the uprights were stuck deeply into the ground, was now gradually given up in order to obtain a post-free living-room. The removal of the *suler* may well have been a useful improvement in the houses, however, the construction was very much weakened and therefore much more unstable until the trussed rafterroof with uniform scantling (and tie-beams for each pair of rafters) was introduced.

During the 10th and the 11th centuries large dwelling-houses detached from the byres gradually replaced the longhouses in the middle of the village tofts, while the byres were put up close to the barns by the fences (Hvass 1980). At the same time the quality of the houses generally improved, and the unique convex house shape, which had certainly started much earlier, flourished to a climax and became more or less universally used. Since such houses became known from the excavation of the great Trelleborg fortress (Nørlund 1948) much speculation has been put into words to explain why this complication to the structure, which must have been a great challenge to the carpenters, was introduced. Probably it became popular in use because the passing of the fireplace, which was now placed exactly in the middle of the houses, became much easier, but primarily the reason must have been to give the houses an aerodynamic shape which made them stronger and more resistant to the high winds – also the vikings' taste for the convex shape may have been of some influence (Schmidt 1973, p. 60). The greater number of the excavated houses of this convex shape are represented only by the evidence given by the ghosts of the timbers which were once dug into the ground. However, it is evident that during the two centuries an increasing, number of solid oak timber became part of the wall construction (Nielsen 1980). Actually some of the houses were entirely timber built as it has been attemped to show in the two stave built modelhouses at the fortress of Trelleborg and the similar fortress of Fyrkat (fig. 5) (Schultz 1942 and Schmidt 1981, 1985). Recently both fortresses have been dated by dendrochronology to about A.D. 980.

In the large houses of the fortresses the hall has no free-standing posts. And as it was much bigger than the humble three-room house from Hedeby, it was certainly impossible to span the length without some support from small (queen-)posts placed on tie-beams. The presence of purlins is indicated by the gigantic postholes for the *suler*, which were incorporated in the partition-walls, as well as by the postholes inside the main entrances, which were part of a screen wall in the Trelleborg- and Fyrkathouses. Some of the houses outside the circular rampart of Trelleborg, which were not used as dwellings, even had ghosts from the traditional inner uprights, but in all other respects they were similar to the other houses at the fortress. So it must be assumed that in the houses used as dwellings the framesystem was "lifted up" and partly carried by two tie-beams spanning across the hall. The thrust from the roof was then – by way of the tie-beams – transmitted to the substantial timberwalls, which thus became the most important element of the housestructure, while the purlins were now primarily kept to give longitudinal stiffness to the roof (Olsen & Schmidt 1977, p. 126). This roof, presumably without any great number of braces or studs, was anyway so unstable that from the beginning it was necessary to add a great number of buttresses to the structure. Judging from the observed strengthening of the longwalls in certain points, as well as from the *sule* postholes in the houses outside Trelleborg, the houses from the fortresses, and many similar houses, consisted of five bays of which three in the middle formed the hall.

As did the Hedeby house, these dwelling-houses consisted of three rooms – and sometimes one or two porches in front of the main entrances – but only the hall could be heated. The two gablerooms probably served as *herberger* (magazines and lobbies) – in a gableroom in one of the Fyrkathouses carbonized rye grain was found (Olsen & Schmidt 1977, p. 189). The great hall had a passage in the middle where also the hearth was situated, and an area of residence, which was slightly raised, towards the sides. This is probably valid for most of the barracks of the fortresses as well as for the *salshuse* (dwelling-houses) of the farms (cf. Vorbasse), but curiously enough similar three-room houses were used as workshops, and in 11th century three houses on the main farm in the Vorbasse village, which were almost identical in size, form, and room-arrangement, were used as 1) dwelling-house, 2) workshop and byre (the latter in one of the gablerooms) and, 3) byre (in the big room in the middle of the house) (Hvass 1980). From this example it may be seen that in the late Viking Age "boatshaped" houses with three rooms were used almost universally, in fact, they became a fashion, even if this housetype was originally created to comply with new demands to the dwelling. It might, therefore, rather be called a new building-system.

It is interesting to note that also in the rising towns this housetype was used in the 11th century. Examples have been excavated in Viborg and in Lund (Nielsen 1968 and Mårtensson 1976). The very lightly constructed house from Lund, built at about A.D. 1020 (fig. 6), had a hearth – which was later on replaced by an oven – not exactly in the middle as usual, but placed so that it indicates a "medieval" screen-passage inside the entrance close to the partition-wall.

Besides the more developed houses the traditional type survived in a more or less rudimentary state. A fine example of inner uprights of "prehistoric" plankshape may be seen in a barn built as late as 1629 on the farm Biskops in Gotland, Sweden (fig. 7) (now in Bungemuseet). But the general development of the Danish roof is quite different. As far as may be judged now the structural problems of the viking houses (without *suler*) were solved only when the trussed rafter roof of uniform scantling was intro-

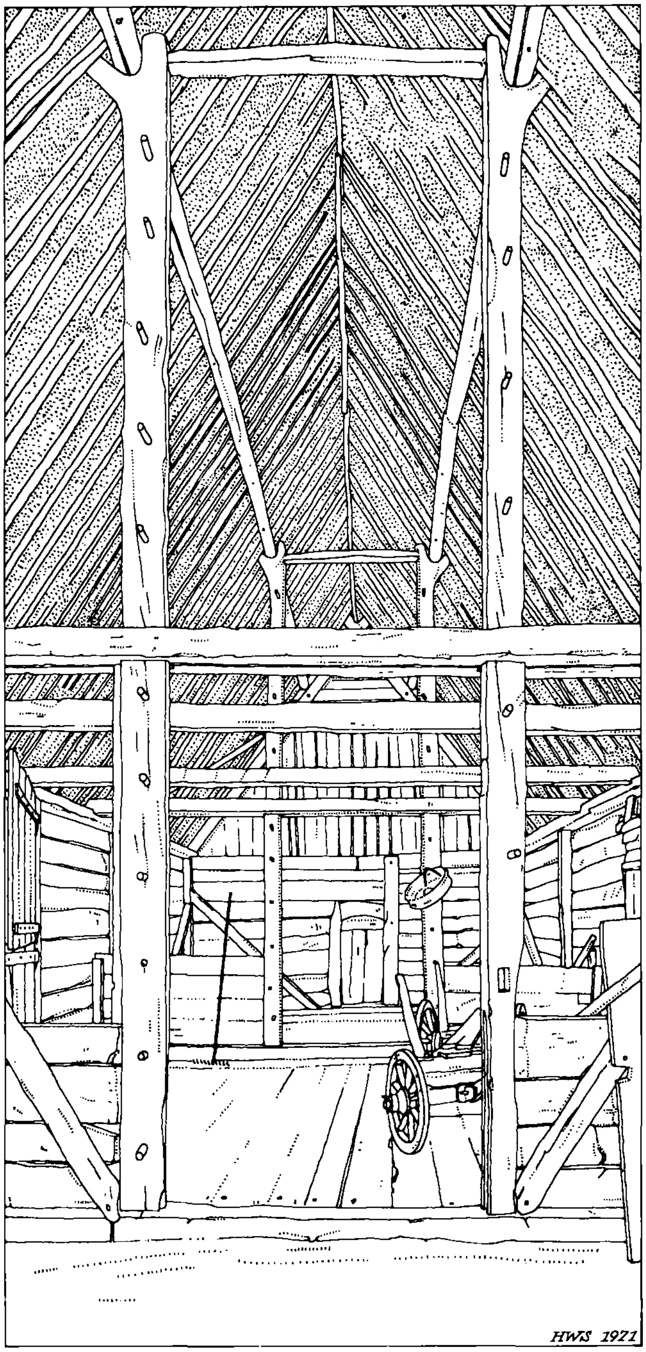


Fig. 7. A barn built 1629 on the Biskops farm in Gotland, Sweden. The *sule* structure is closely related to the structure of the Iron Age long-house. H.S. 1971.

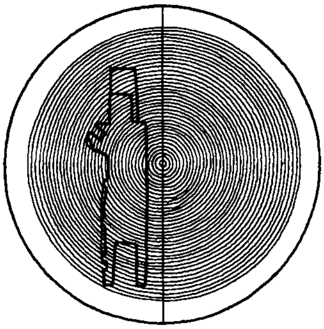

Fig. 8. Wall-plate from the stave-church at Nr. Hørning built near the end of the 11th century. Two wall-plates of this type could be made from the same oak trunk. The upright stave planks were secured in a groove in the underside of the wall-plate. The edge of the roof was finished by a horizontal board fixed to the groove at the top of the wall-plate. The trenched tie-beams ride over the top of the wall-plate. Scale of the section 1:20. H.S. 1977.

duced. This type became dominant in traditional Danish house-building forever after, and in this roof all trusses – usually placed at an interval of about 90 cm – form a stable triangle and therefore produce only a vertical thrust on the wallstructure below. It is very tempting indeed to see the termination of the curved houseshape as closely connected with the introduction of the trussed rafter roof with uniform scantling. The new roofconstruction came to Denmark from the South, and the oldest example, of which we have evidence, belongs to the stave-church of Hørning – built near the end of the 11th century. The wall-plate has been partly preserved (fig. 8), and traces show that the trenched tie-beams (being part of the rafter trusses) ride over the top of the wall-plate. However, it is in the more or less preserved original roofs of the stonebuilt Romanesque churches that the technique of the early medieval carpenters may still be studied

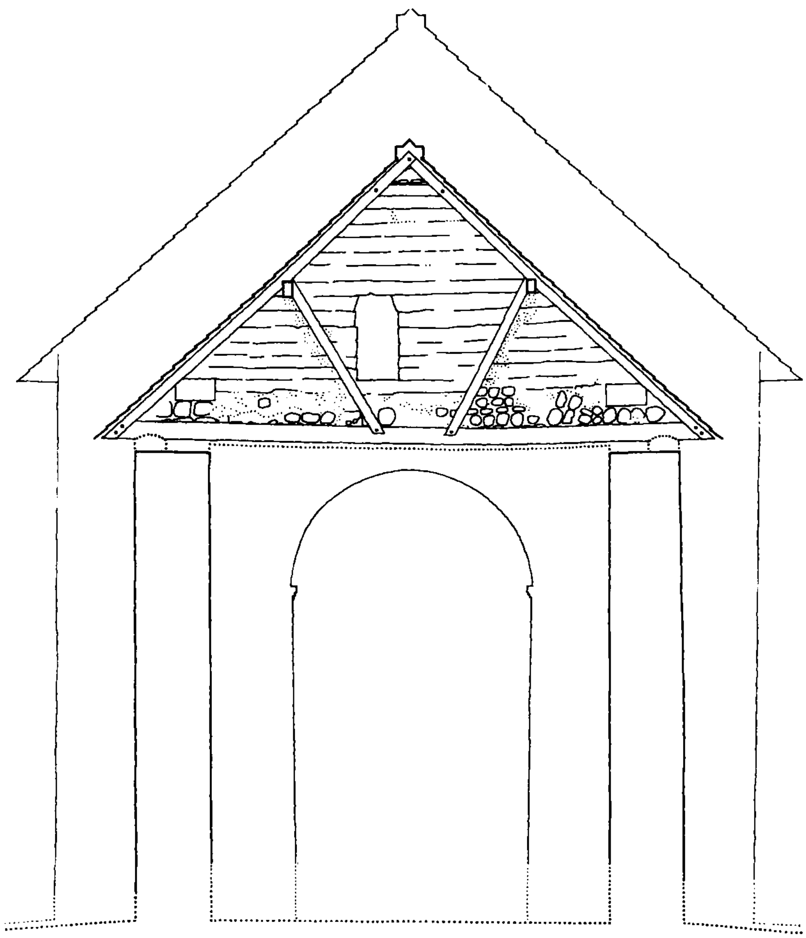

Fig. 9. Reconstruction of the original chancel-roof in Horbelev church, built in the late 12th century. Two purlins, which reach between the two stonebuilt gables, were used to provide the lengthwise stability for the Romanesque roof trusses. Section, scale 1:100. H.S. 1984.

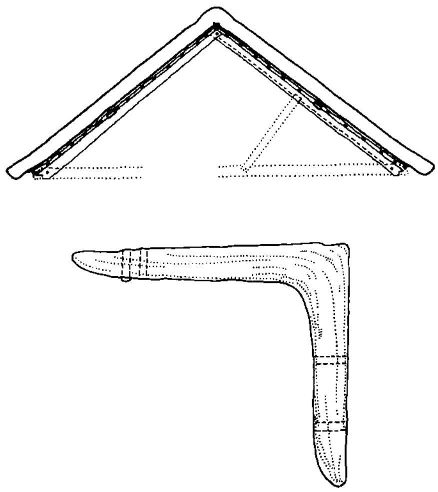

Fig. 10. Reconstruction of a reused Romanesque roof truss from the 14th century Hedegård farm by Halkær. Wind-braces on the upper side of the rafters provided lengthwise stability to the roof. Section, scale 1:100. Naturally grown brace from the reused Hedegård timbers, closely related to the "knees" in the Viking ships. Scale 1:20. H.S. 1984.

(Møller 1953). In a few examples, which characteristically belong to the oldest churches of the respective local groups, purlins were still used to provide the longitudinal stability for the trussed rafter roofs (fig. 9) (Roussell & Norn 1951, p. 1435 and 1570). Even if such hybrid roofs are very rare they may suggest that the new principles of construction in a way also constitute a continuation of the tradition, i.e. a development, or at least that a mixture of structural types still remained acceptable. But in most Danish Romanesque roofs the lengthwise stability was provided by wind braces only, exactly as it is today in traditional carpentry.

The excavation of Hedegård farm by Halkær, built in the 14th century, revealed a quantity of building-timbers re-used as filling in the wet ground (Roussell 1939, 1947). Among these were rafters made from pine wood comparable to those made from oak wood in the Romanesque church roofs (fig. 10) (unpublished). The struts support the middle of the rafters, and are themselves supported by the tie-beam. At the same time the triangle becomes more stiff. On the upper side of the Hedegård rafter there is a scarfed joint where the wind-brace passed. The pitch of the roof is low (about 38°), but the dowels for laths have such a varied spacing that a thatched roof is clearly indicated. Also a naturally grown brace has been found at Hedegård, much like the "knees" used in Viking ships (fig. 10, bottom).

Summing up: The development of the house structure during the Viking Age and the Middle Ages in Denmark by no means meant that the traditional types were entirely given up, and many houses and building-constructions must be classified as typological hybrids. Presumably the development took place primarily in the architecture for the upper classes (and for the church), while the vernacular buildings remained much more conservative. An outline of the general development of the house structure may be suggested as follows (fig. 11):

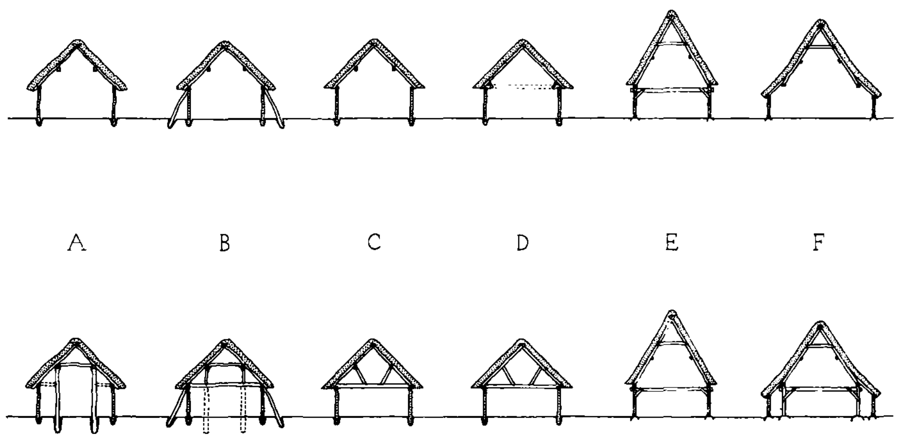


Fig. 11. Suggested general development of the housestructure in Denmark during the Iron Age, the Viking Age, and the Middle Ages.
A: building with *sule* structure. B: building with queenpost-structure. C: building with trussed rafter roof combined with purlins. D: building with trussed rafter roof. E: timberframed building with collar rafter roof. F: timberframed building with collar rafter roof and outshorts (*højrem*house related to the Saxon house). Sections (top), trusses (bottom), scale about 1:500. H.S. 1984.

In the *sule*house (A) the internal frame-system gave support and stability to the roof as well as to the walls and stalls – also during the building of the house.

When the inner uprights were lifted up upon the tie-beams (B), the "frame" was still providing some support and stability to the roof. But the walls, which now had to carry the entire thrust, needed strengthening and the structure needed stability, even if, in theory, there was little or no lateral thrust. Therefore the added external buttresses and the stronger aerodynamic shape.

The rigid trussed rafter roof was a solution to the problems of lateral stability. At the beginning the lengthwise stiffening was provided by purlins (C). Windbraces on the upper or, more often, on the lower side of the rafters were introduced later on (D). At about the same time the convex shape of the house was given up.

The further development consisted in putting up the posts on stones or sill-beams (E). By then it became necessary in most houses to brace the wall structure, as the wall-posts were no longer fixed into the ground. Firstly it was done by long braces at the inner side, later on with struts properly worked into the structure, which now also included *løsholter* (horizontal timbers between the posts about halfway up the walls). The uniform scantling of the timber-framing made it possible to join the tie-beams directly into the wall-posts, while the simple collar-rafters above the wall-plates were fixed to the tenons in the upper ends of the respective wall-posts. In this way a complete transversal frame could be joined together on the ground before the erection. It might be argued that the principle of the trussed rafter roof with uniform scantling was by then carried through right to the sill. The traditional Danish timberframed house was a reality.

If more space was needed outshots or lean-to-extensions were added to one or two sides of the house (F). When the house was consistently made wider in this way, a structure with a nave and one or two aisles emerged. The traditional timberframed structure remained inside the house and became the principal part of the so-called *højrems*-construction (which is closely related to the structure of the Saxon house) while the walls were quite simply moved outwards and the roof extended in an equally uncomplicated way. This new structure was almost as nice and effective as the good old *sule*house.

Holger Schmidt, Tranemosevej 4, DK-2600 Glostrup.

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# *Prehistoric Glass Technology*

## – Experiments and Analyses

by TINE GAM

## INTRODUCTION

There can be problems of definition when using a craft skill to spread light on aspects of prehistory. Is a "smith's grave" a buried smith or merely someone with the appropriate tools with him in the grave? Can one assume that it was the smith himself who was given the tools for the last journey? The difficulty in interpreting the finds can be that one does not know enough about the materials used. This can mean knowing too little about their chemical and physical behaviour and about the work processes involved. Practical experiments have long been a way getting to understand better both the technology in the narrow sense and the socio-economic context. Glass is a common archaeological find, but it has not often been made the subject of experimental trial. This may be because it is uncommon. The only glass objects known to have been made in 8th-9th century south Scandinavia were beads. Such things as beads, raw glass, trailers, millefiori rods, waste glass, dribbles of melted glass, and even tools have occurred at the seven sites of Ribe, Hedeby, Åhus, Paviken, Helgö, Birka, and Kaupang, leading to various views on the beadmaker's craft (see Callmer 1982 & 1988, Dekówna 1978 & 1990, Frandsen & Jensen 1988a, 1988b, 1988c, Hougen 1969, A. Lundström 1976, 1981, and Näsman 1979).

Probably for most people the techniques of working with glass, whether cold or hot, will be a somewhat recondite subject, and as the making of beads, in the present case by the winding technique, has to the best of my knowledge not been tried experimentally, it seemed a possible way to reach new knowledge of a fascinating subject.

## THE SOURCES

A glassmaker's workshop was reconstructed from a combination of archaeological information and present knowledge. The project was to include the production processes themselves in their totality, and the detailed study of tool traces and waste products. Pyrotechnical studies and material analyses are also essential for understanding the technology and for identifying it archaeologically.

The largest part of the material is the glass itself. For information about the actual finds the reader is referred to the literature cited. The finds of glass consist essentially of different types of whole or half beads, by no means all of which can be regarded as locally made. There are also monochrome and polychrome glass threads, raw glass, millefiori rods, waste glass, and lumps of melted glass as mentioned above. Only a few tools have been found. From Paviken there is a metal point 20 cm long with hollow socket and square section. Also fragments of glass with fired clay attached are interpreted as showing that crucibles were used at Paviken (P. Lundström 1981:100). From Paviken there is a metal point 10 cm long with hollow socket and square section. Also fragments of glass bles with green glass (ibid., 17). All the other possible tools are from Ribe. There is a metal rod about 20 cm long with a tapering point and about 10 cm of wooden shaft preserved. There is also a spoon-shaped fragment of antler, a stone with concavity, and at least three furnaces, in the lowest of which was found a little pan of iron (Näsman 1979:131). Four crucible fragments with respectively yellow, red, and green glass on them are not directly connected with any workshop (Näsman, personal communication). In many ways the material from Ribe is the most informative, and it has been the main model for the experiments.

The following description of the present state of research into production methods, the form of the furnaces, the annealing of the beads, the use of crucibles, and the composition of the glass, should not be taken as more than a contribution to the discussion.

## PROCESSES

Glass beads can be made by melting fritted glass in a

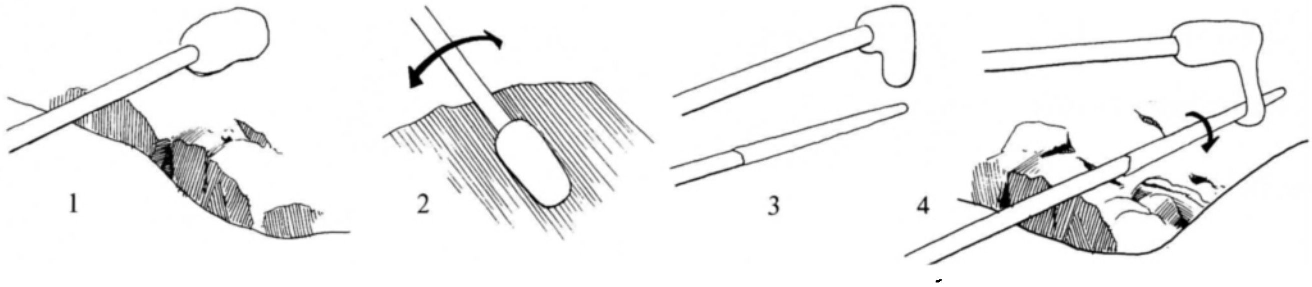


Fig. 1. The hot glass on the pontil being wound around the bead mandrel. Drawing by F.Bau, FHM.

mould, drawing out long tubes which are then broken into suitable pieces, boring a hole through a piece of glass – to mention only some of the possibilities. Here we will describe a technique in which the melted glass is wound around a conical point called a mandrel (see fig. 1). The original lump of glass or the "gather", as it is called among glassmakers, is put on an iron rod, called a pontil. The glass that remains behind when no more beads can be made cannot be re-used because it has fused completely with the pontil. If it is removed, attached oxide scale will be found on the concave side of the glass removed. This was identified in the Ribe material (fig. 2). If monochrome beads are being made the process can in theory be ended here by pushing the bead off the bead mandrel point and letting it cool. Simple beads like this are common, and some were found at Ribe (fig. 3a). The ribs of melon beads were made with a knife. On several melon beads from Ribe the incisions become progressively weaker, which must mean they were made in a single process. The last incisions are therefore made in much colder glass than the first. With a straight-edged knife the bead is given a cylindrical shape, while a semi-circular incision in its edge will give it a round shape. Other ways of shaping are by marvering (rolling) to a *barrel*, *biconical*, or *cylindrical* shape (figs. 3b & 3c). Only the last of these has been tried experimentally. The marver stones used have not so far been recognized among the archaeological finds, and in the experiments a piece of polished granite was used. Any flat surface, for instance part of the tools, could be used. When hot the bead can also be pressed to a polyhedric shape like fig. 3d.

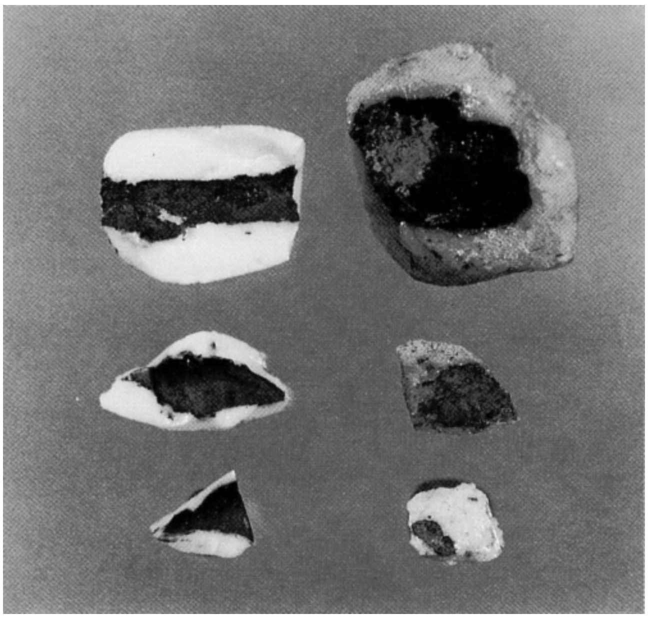

Fig. 2. Pontil glass with attached iron oxide scale from the pontil. Left experimental sample, right from Ribe. Photo H. Strehle, FHM. 2:3

*Polychrome beads* can be made in many ways, of which we will describe those commonest at Ribe. Some polyhedric beads have been given "eyes" of red or green glass, but the most usual decorative element was threads of white, yellow, or red glass. The threads can be applied singly, or in zig-zag, wavy or straight lines (fig. 3c), or they can be combined in trailer bands and applied to the bead. Finally they can be wound together, making what are called *reticella* beads (fig. 3f).

At Ribe millefiori beads have also been found, and also *half* mosaic beads (fig. 3h), which may show that this technologically quite different type of bead was also being made in south Jutland. The experimental work has not yet included millefiori beads.

Blue is the predominant glass colour in Ribe, followed by green, red, and white. The rest consists of yellow, orange, black, purple, and turquoise glass.

Beads decorated with threads were made using a little plug of glass of the desired colour. When its point was

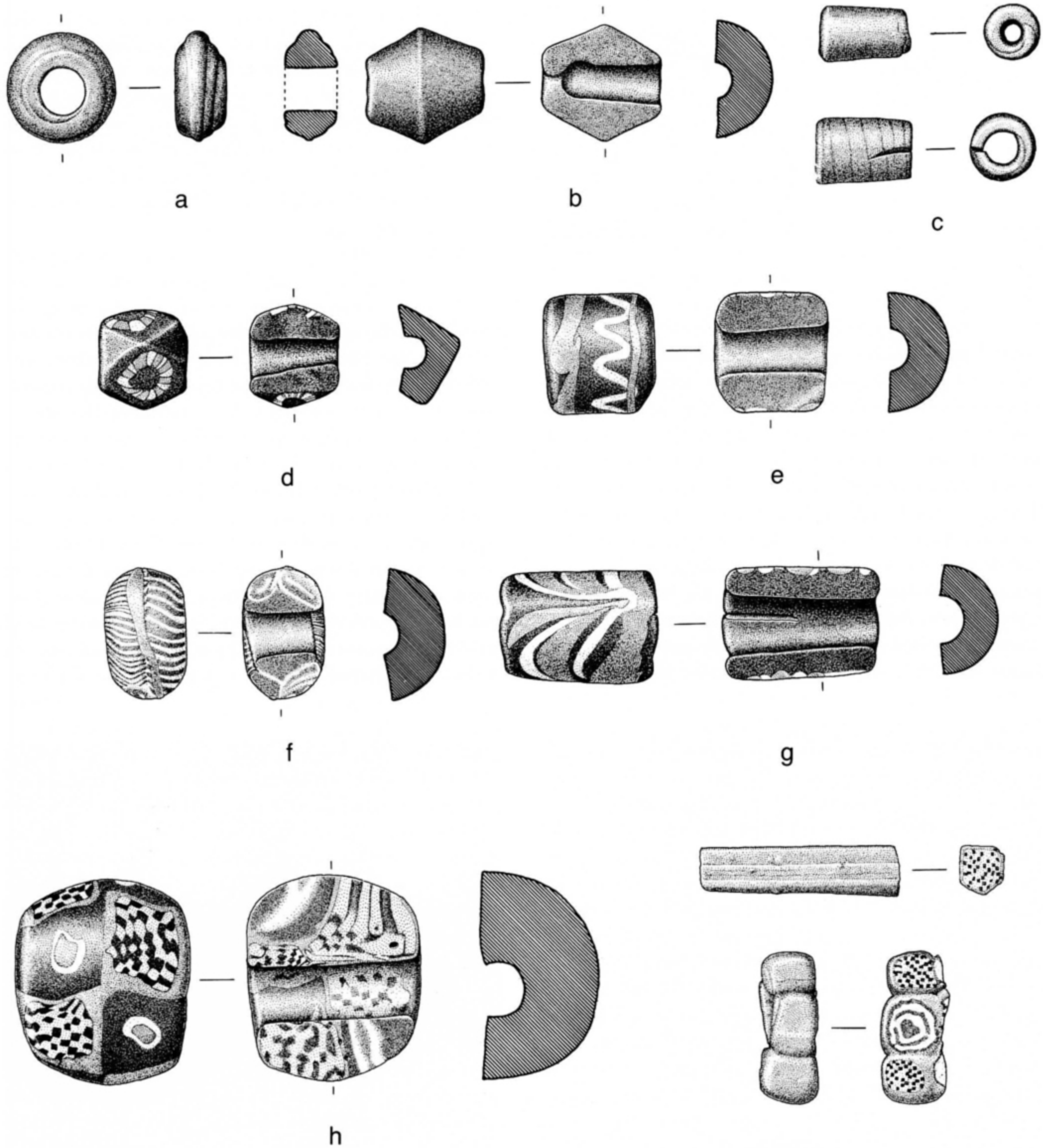


Fig. 3. Beads from Ribe, 2:1. Drawing P.-O. Bohlin, ASR. a, annular blue monochrome bead. b, biconical blue bead. c, cylindrical red bead. d, polyhedric blue bead with "eyes". e, cylindrical blue bead decorated with red and white threads. f, reticella bead. g, cylindrical blue bead with combed pattern of red and white threads. h, millefiori bead, millefiori rod, and flat millefiori piece.

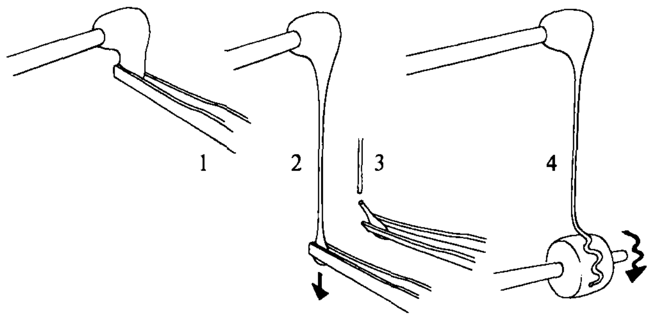


Fig. 4. Tweezers can be used to draw out a thread. Drawing F. Bau, FHM.

heated and melted on to the bead it was only necessary to move the mandrel back and forth to make a zig-zag, or simply turn the mandrel to give a straight trailer. First the tweezer was used to draw out a thread, then the bottom, drop-like piece of glass with the mark of the tweezers had to be nipped off before the thread was reheated and fused on to the bead (fig. 4). This gave a particular waste product, the tweezer mark, which was clearly parallelled in the finds from Ribe (fig. 5), also in having the same characteristic fracture resulting from the cooling effect of the tweezers. But the colours of the pieces with tweezer marks from Ribe do not show unambiguously that they came from the production of beads decorated with threads. If they did, one would expect the usual thread colours to dominate, and these were white, yellow, and red. Instead a majority of the monochrome tweezer marks are blue and green, and they may only show rescue operations when the glass had to be quickly pinched.

When a thread has been freshly wound around a bead it still stands in relief, which can itself be used decoratively. From Ribe there are black and red beads with three yellow threads in relief on them. They can be drawn up as a crest using a pointed tool (fig. 3g), which can also be used to improve the zig-zag of single threads or trailer bands. This is seen when the threads or bands get narrower at the corners of the zig-zags. It can also be seen under the microscope that the air bubbles in the bead itself are elongated or aligned so they follow the angles of the zig-zags. In the experiments a little hook with handle was used, so that the operation could take place as close to the heat as possible. The best result was achieved when the bead with the still plastic threads on it was heated until only the threads were softened. If the bead was heated too much it would be deformed when the threads were pulled. Finds of loose bands of white, yellow, and red threads fused together in parallel, sometimes with a thin layer of blue glass on the back, seem to show how beads with thread band decoration were made. In the experiments the loose threads were put together with a little blue glass on a pontil and then drawn out to a band that could be fused on to the bead (figs. 6 and 7). On the beads from Ribe with band decoration the threads run parallel, but on the experimental beads they turn over at the angles so the back is foremost.

At Ribe we also have *reticella* beads and signs of their manufacture. It can be seen how the reticella threads are put on to a blue bead. Most of them are also decorated with a red thread covering the join of the two reticella threads. Also loose threads, loose reticella trailers, and polychrome pincer marks have been found. The reticella threads consist always of a blue thread in the middle together with thinner white, yellow, or red threads. A number of methods were tried out, but not all aspects of the process are clear. To get the decorative threads on to the blue central thread marvering was first tried. The threads had to be pre-heated and were therefore placed in the pan. Ideally the marvering should be done flat – at an angle of zero degrees. This is hindered by the sides of the pan and was only done for want of anything better. Roesdahl's suggestion that pans were used for rolling must be disputed (Roesdahl 1980:115). A metal sheet would be

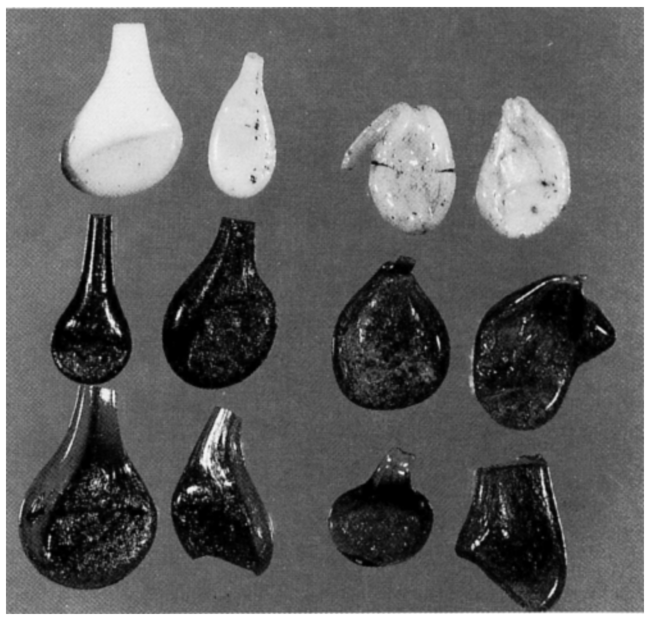

Fig. 5. Glass with impressions of tweezers – tweezer marks. Left, trial piece, right Ribe. Photo H. Strehle, FHM. 3:5.

Fig. 6. Two white and a red thread being joined on blue glass as a thread band. In the pan are two further white and a red thread, and two finished beads being annealed. Photo S. Heinesen, HAF.

Fig. 7. A thread band being put on a bead. Photo S. Heinesen, HAF.

Fig. 8. White threads being rolled on to an end of blue glass. Photo H.S. Rasmussen, HAF.

Fig. 9. White threads being melted directly on to an end of blue glass for reticella beads. Photo S. Heinesen, HAF.

ideal for hot marvering. We may here call attention to a little oval plate with projections at each end found in a pit with "glassworking debris" in Ireland, and was dated to the 6th-9th century (Youngs 1989:204). It may have been used for rolling glass. From Ireland come also a number of iron pans like the one from Ribe, some much more elegant with long thin handle with terminal spirals. These pans are either stray finds or come from sites where glass materials were also found, and are thought to have been used for melting glass (Youngs 1989:204). Although there is no doubt about their connection with the beadmaker's craft, their precise function is open to discussion. There

Fig. 10. White thread being cut with scissors. Photo S. Heinesen, HAF.

Fig. 11. Making reticella thread. The end is rolled forwards while being held and pulled at the point with the tweezers. Photo H.S. Rasmussen, HAF.

Fig. 12. Reticella thread being wound on to a blue bead. Photo S. Heinesen, HAF.

Fig. 13. Reticella thread being cut away with the scissors. Photo S. Heinesen, HAF.

would be no reason to heat the glass to the melting point, when in any case it would fuse with the iron. To fuse pieces of glass together it is enough to heat them to a little over 300°C. It would be quite superfluous first to draw out the threads and then re-heat them for rolling on. Also the glass would be deformed and cooled during the rolling process (fig. 8). Shearing on the threads was therefore tried (figs. 9 and 10). The reticella thread was twisted by holding the point with the tweezers while rolling the thread away from you (fig. 11). On both the original and the replica threads the decoration stands in relief, which it never does on the finished beads. This is the result of the

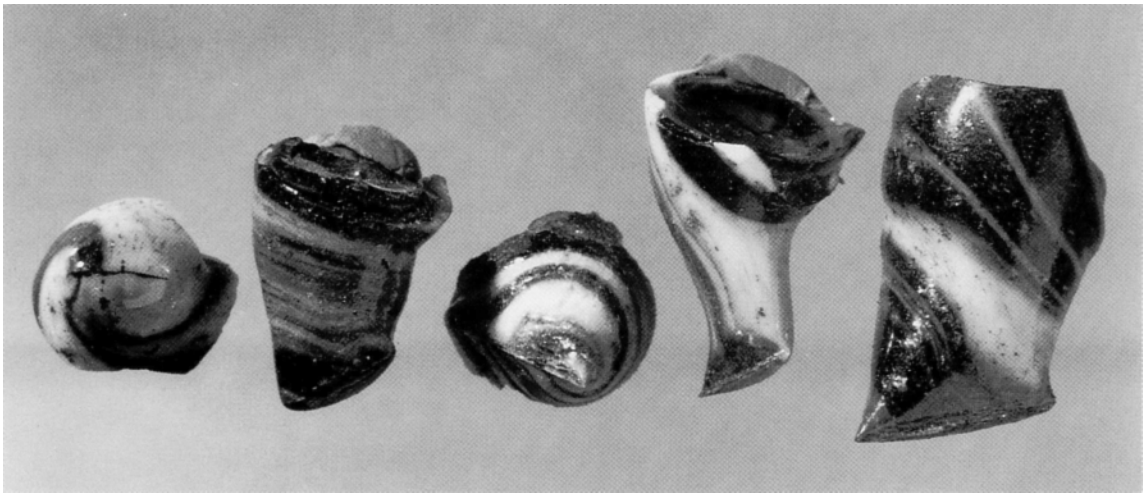

Fig. 14. Ends of reticella glass (the last unusable bit) with cut-marks. Photo S. Heinesen, HAF. 2:3

later heating that is necessary when the threads are to be wound on to the bead. Here also the shears are necessary. If the reticella thread is not cut after one revolution it will have to be wound around several times until it becomes so thin it breaks. There will then be an overlap which interrupts the pattern and is not found on any of the Ribe beads. These have a join of more equal width, because the thickness of the reticella thread is the same all the way around. Such joins occurred in the trials when the shears were used, see figs. 12 and 13. There are still disagreements between the replicates and the originals, as reticella threads with cutting marks have not yet been identified among the latter (cf. fig. 14), on the other hand the archaeological finds are only a small fraction of the original waste products. It was also a problem to make the threads run across instead of along the beads, but it is hard to say whether this was due to lack of experience or to the difference between the original glass and the glass used in the trials.

## THE FURNACE

This was the centrepiece of the workshop, and the study of furnaces and pyrotechnology is of central importance. The archaeological evidence is rather weak on this point. The hearths found in Kunstmuseets Have in Ribe were described as concentrations 25–30 × 50–60 cm in size of reddened clay, charcoal, and glass (Näsman 1979:125). For the trials a simple, open construction of stones the size of a fist was used, plastered with sandy clay. The dimensions were the same as in Ribe and the depth was ca. 15 cm. All had the blow-hole at floor level and either manual or electric bellows. Deciduous charcoal was used as fuel. It was easy to reach a temperature of 1000–1100° C in the hottest part of the furnace – even 1400°C – but was hard to hold the glass there without getting it contaminated with charcoal powder and ashes. Heat loss is considerable in an open hearth, and in an attempt to reduce this a board was placed over its back. With this the maximum heat was shifted to directly *above* the charcoal. It was on the whole difficult to avoid contaminating the glass. Although some of the beads from Ribe show this too, the majority have a smooth and shiny surface. Contamination can be reduced by increasing the distance between the charcoal and the glass, i.e. by using a taller and more enclosed construction in which the heat gathers at the top. In the present century a kind of shaft kiln was used to make beads and rings at Bida in Nigeria. Up to five men worked around the hole at the top. The kiln was about half a meter high (Dubin 1987:123, Gardi 1974:87). In Turkey they still wind beads using a kiln with two chambers and built-in "pockets" for annealing the beads (Kükükerman 1988).

There is however one thing that argues against the theory of the shallow hearth. In all the experimental hearths the floor close to the blow-hole and the sides near it became strongly vitrified (fig. 15). As this was not found in the Ribe hearths one can perhaps suppose that the blow-hole, and with it the hottest part of the hearth, was

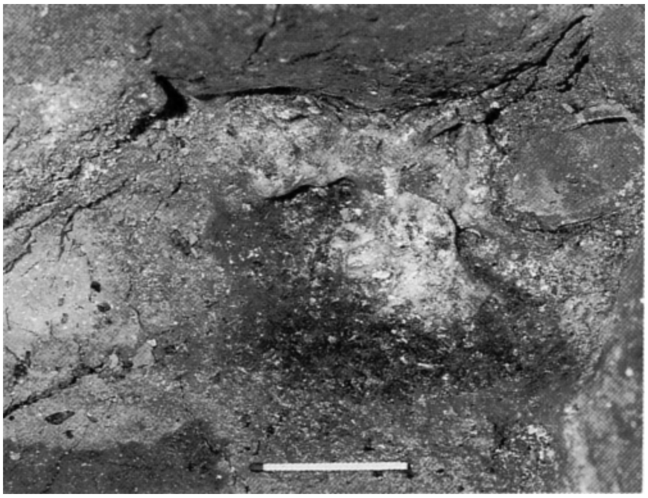

Fig. 15. The hearth showing blow-hole and strongly vitrified bottom and sides. Photo H.S. Rasmussen, HAF.

located a little above floor level, which would be a further argument in favour of a much taller construction. Unfortunately there seemed to be no sign of either cover or sides (Näsman 1979:125), but it is a question whether this is to be expected at a site that has so clearly been cleared and levelled several times.

## ANNEALING

After being heated to over 500°C glass must be cooled down uniformly. Otherwise there may be internal stresses in the glass and fractures can occur. Air bubbles hinder an even cooling, and can be especially harmful in small objects like beads. When crucibles are used the cause of the bubbles is that air is caught in the frit. The same can happen if cullet is used. Air can also be caught in the process of winding. It is therefore difficult to evaluate precisely the methods of annealing tried out.

In the first a copy of the iron pan was placed on the edge of the hearth above the blow-hole, where the temperature was c. 300–400°C. After being finished the beads were placed on it, using an annealing tongs based on the one piece of antler. When the fire had been brought up, the pan with the beads was placed directly in the hearth, bringing the pan's temperature up to c. 500°C, cooling slowly as the fire died down. This form of annealing seems at first to be effective, but being on the rim of the hearth gave too much variation of temperature, and as an alternative it was tried annealing the beads in ash and sand. Here ash was preferable, as sand gave too much resistance when the beads were being inserted. They lay only in the surface layer and far more of them broke in the sand than in the ashes. First a fixed "annealing corner" was tried in the form of a little clay pocket in the hearth. As it was beside the blow-hole it was impossible to regulate, and the temperature was too high in its lower part. This was shown not only by the pyrometer, but also by the beads. The lower down they had been, the more ash had fused on to them (fig. 16). The best method was a movable container in the form of a clay pot filled with ash placed in the hearth opposite to the blow-hole.

## CRUCIBLES

Despite the limitations of the archaeological evidence, descriptions of bead- making in Iron Age and Viking Scandinavia nearly always mention the use of crucibles for melting the glass (i.a. Callmer 1982, Jørgensen 1982, A. Lundström 1976, P. Lundström 1981, Näsman 1979). After experimenting with crucibles I will here propose a number of practical arguments against their use. The consumption of both glass and fuel would be greater. Energy would be needed not only to melt the glass, but also to heat the crucibles. After use some glass will always remain behind in the crucibles – glass that can never be wound on to a pontil. The proportion of the glass that can actually be used seems therefore unnecessarily low, considering the supply of raw materials and the value of glass. Not only would there be a layer of glass inside the crucibles, but also the outside gets glazed as a result of the high temperature. This means they are easily preserved, and if used they should be found whenever other remains from glass- making are found. Crucibles are *not* necessary to make a gather – which is the first stage in the process of

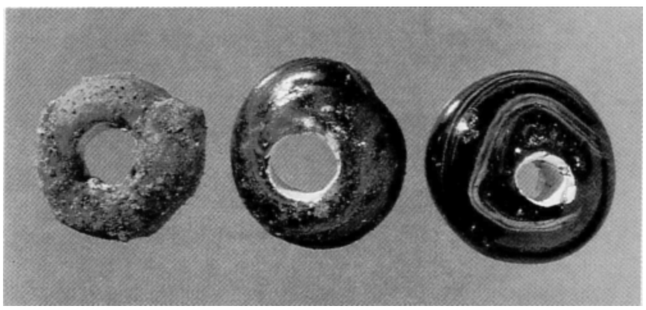

Fig. 16. Annealing of beads in hot ashes. At temperatures below 500° the ash does not attach itself to the beads.

winding beads. When the pieces of glass are being preheated, in this case on the pan, which is now being used for something different from annealing, pieces of increasing size can be melted directly on to the pontil, making the use of crucibles unnecessary. This is not saying that crucibles were never used in the production of glass beads, but it emphasizes how important it is to examine both the crucibles and the glass to determine whether the vitrification was deliberate or only accidental, and to compare the elemental composition with that of other locally produced glass.

But one question is whether glass was being melted or even only heated in crucibles, and another is whether it was being made from original materials. At Dunmisk in western Ireland there have been found a number of crucible fragments with glass attached, and further waste from glass working (Henderson 1988:145). One of the pieces was analysed using SEM and EPMA, and Henderson was of the opinion that half-fuzed raw materials could be found in the glass mass, which was interpreted as showing that the glass in the crucible was from the deliberate production of glass. From this one might be able to envisage different types of glass-making, in which the use of raw glass, tesserae, and perhaps cullet occurred alongside actually making glass. This may have happened in the context of certain centres, perhaps monasteries. Henderson points out that there were monasteries near Dunmisk and Armagh (Henderson 1988:146).

It is also worth while to examine the elemental composition of the crucibles and see if it is possible to determine whether it was local or imported raw materials that were used. Freestone and Tite have examined the composition of material from crucibles and hearths and found that refined local materials were chiefly used (Freestone & Tite, 1986, 56), but the possibility that clay from northern Germany or Holland was used in Ribe to make the moulds for bronze brooches cannot be excluded (Brinch Madsen 1984:32). Finally it may again be stressed that crucibles do not *have* to be used for making glass beads by winding.

## GLASS

Glass contains three main components – a glass former, a flux, and a stabilizer. The first is a mineral silicate, usually quartz sand. Pure sand has a melting point of over 1700°C, but when the oxide of the base sodium or potassium is added as a flux, the melting point can be reduced to c. 1300°C (Frank 1982:10). As the product of the reaction between these substances is water soluble, calcium is added. Metal oxides can under different firing conditions be used to alter the colour or opaqueness the glass. The quantity and character of the flux will determine for how long the glass can be shaped before it has to be re-heated. Lead, which can function both as flux and stabilizer, makes the glass "longer" (Schlüter 1979:397). So far only a few glass analyses from Hedeby and Ribe have been published, and they suggest that the common use of a soda glass with 10–15% Na but only 0.5–1.5% K (Dekówna 1990, Henderson & Warren 1983). This is characteristic of most glass until the Middle Ages, when it was replaced by a glass with more potassium. Soda glass is relatively "short", and therefore different to work with than the glass used for most of the trials. This was modern glass, and therefore purer, and it also had a much higher content of lead and potassium (Gam 1989). In some respects its tolerance was greater than that of the original glass. Unfortunately it was not either practical nor economically possible to make glass like the original one for use in the trials, and it is open to question whether it ever will be possible. Analysis gives some indication of the raw materials in glass, but exact determination of the raw materials and their origin is unattainable.

The latest part of the experiments was focused especially at the types of glass, for we succeeded in obtaining a soda glass that agreed with the prehistoric one at least as far as the flux was concerned. The first results confirmed expectations that it was a "shorter" glass, and its tolerance of annealing temperatures was far less. This glass could not have been annealed so well on the pan, though of course it is difficult to know which factors are the most important. One should always bear in mind the effects of different kinds of glass when discussing early manufacturing methods.

Nor has it been possible to find experimentally whether there was any reason behind the use of particular colours at Ribe. When red, white, and yellow are often used to decorate blue beads but not the other way around, is it only a matter of fashion, or are there good technological reasons?

## THE FUTURE OF EXPERIMENTAL STUDIES

Experimental work can never be seen as finished, but there is already ground for revising the way the craft has been described theoretically. The workshop is equipped with much more than "a hearth, a crucible, a tongs, and a metal rod" (P. Lundström 1981: 100). Separator, marver stone, hearth tongs, bellows, a holder for pontils and bead mandrels, something to pulverize with, containers, and people to help, are seldom mentioned in the archaeological literature, but were an important part of the trials. Descriptions of processes also become much fuller when based on methods that have been tried out. The study of the work processes is not an end in itself, but is a necessary precondition for the comparison of waste products and gives clues to the methods followed. It is therefore essential to the correct identification of archaeological finds. Interest is often concentrated on the question whether production actually took place at the site, and unless the workshop area itself is found, containing the hearth or kiln, judgement can only be based on the other material. Glass is often only treated quantitatively. It is only asked what is present. A more differentiated approach is needed, for some of the finds may have circulated as trade goods, which means that their mere presence does not show that production was carried out. This applies in general to any pure glass suitable for melting down – i.e. monochrome threads and tweezer marks, lumps and dribbles, and raw glass. On the other hand polychrome threads and pincer marks, pontil residues, broken beads, and pieces that have been contaminated in one way or another cannot be recycled. This can make them an important source of information, for there is no reason to remove them from the production area. The Scandinavian material comes from sites where there are also indications of trade and of the performance of other crafts. The question of the tools has not been fully solved, but we now know more after the trials. The precise design of the tweezers, for example, is not of great importance, as the tool used in the trials left the same marks in the glass as the original one did. Similarly the exact form of the mandrels is of secondary importance, while the basing of the annealing tongs on the spoon-shaped piece of antler is so slender that there would be no point in looking for that tool and the trials have only shown a *possible* use. As for assistants, at least one is necessary for blowing the bellows. So far it has been impossible to make reticella beads without a helper, and if shears were used there was probably always a need for an assistant. Other types of beads, for instance millefiori, are likely also to require a number of assistants. The living reconstruction of the workshop environment showed the obvious advantage of involving a number of people in the work processes. The trials thus provide a basis for estimating the craft's social organization and socio-economic integration.

By no means all sides of the beadmaker's craft have been illuminated. This applies to pyrotechnological aspects and to types of glass, but also processes involved in making the individual types of bead still need to be tested. There are also more general aspects of glass technology, where questions involved in bead- making have a wider application in glass- blowing. Why is a beadmaker's workshop in Ribe the earliest indication of glass working in Scandinavia, when workshops producing blown glass existed in a wide belt over the continent from the British Isles to the Black Sea? Part of the answer is no doubt to be sought in social relations, both at the internal national level, and in contacts between the larger regional areas. These are all stimulating perspectives in a fascinating subject.

*Translated by David Liversage*

Tine Gam, Gyldenløvesgade 4, 2.tv. DK 8200 Århus N.

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NOTES

1. The experimental work began in 1988 at Moesgård, Institute of Prehistoric Archaeology and at Lejre Historical-Archaeological Experimental Centre.
2. Once the temperature exceeded the pyrometer's maximum limit of 1370°.
3. Glass from Friedrich & Scheibler GmbH – Kugler Colors.
4. Glass made by Mark Taylor based on glass from the 2nd-3rd century (Forbes 1966).

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# Debate

## Migration Revived

by TIMOTHY CHAMPION

After a lengthy period of time in which migrations have been out of fashion in archaeological literature they have suddenly come to life again. Kristian Kristiansen (1991) and David Anthony (1990) have recently raised once again the question of migration as a serious problem for archaeologists. Much of Kristiansen's discussion is concerned with the specific cases of the Single Grave and Corded Ware Cultures and the possible value of the concept of migration as an explanation for their development but he has also opened up a number of much more general and theoretical questions; in particular he has posed questions about the very varied nature of population movements, the identification of such movements in the archaeological record, the role of migration as an explanation of observed culture change, and the reasons why migrations have played a significant part in the reconstruction and explanation of the prehistoric past by some archaeologists, and have been ignored or specifically rejected by others. Anthony is likewise concerned with the specific example of the expansion of Copper Age horse-using societies from the grassland steppes north of the Black Sea westward into Europe, but as a case study in the application of ideas derived from recent work on the nature, causation, and social and economic context of migrations.

I would like to take up some of these general points, especially the question of the explanatory role played by migrations, and the popularity that migration explanations have enjoyed at certain times in the history of archaeology. Before that is possible, however, it is first necessary to make some preliminary comments on problems of concept and terminology.

### DEFINITIONS

One of the main problems in any attempt to focus discussion on the details of social change or population movement is the very ambiguity of some of the terms commonly used. Thus the term "diffusion", for instance, can mean simply the static pattern of culture traits in space, or it can mean the dynamic processes which produced such a pattern from a single origin; or again it can refer to a particular sub-set of such processes, specifically those which did not involve movement of large numbers of people or movement over long distances. The term "migration" has sometimes been used to refer to any movement of people, even of small numbers or a specific sub-group, in opposition to diffusion; sometimes as merely one specific mechanism of diffusion, in opposition to acculturation; sometimes to a particular type of population movement, for instance a predominantly peaceful one, in opposition to an invasion. Kristiansen (1991) has quite rightly pointed out the very great variety of population movements that could be subsumed under the term migration, and has indicated some of the main parameters of such variability. Some of these are characteristics of the group concerned in the movement or of the actual movement undertaken: size (involving relatively larger and co-ordinated groups or smaller groups or individuals), social composition (the whole population or only some subset), speed of movement, and intentionality of direction. To these we should surely add other important factors, such as the distance involved, whether the movement was designed from the outset or achieved without deliberate intent, and the existence or not of any return movement.

Perhaps one of the most critical variables of all is the degree to which the relevant movement is a regular or integral part of the social group's organisation, or alternatively is an unusual episode representing a major disruption to that organisation. Terms such as "normal" and "abnormal", "usual" and "unusual", or "regular" and "irregular" clearly have no absolute meaning in such a context, but will vary with the particular scale of analysis; they are not opposites, but either end of a spectrum of possibilities, and need to be applied with appropriate sensitivity to the specific cultural circumstances of the cases in consideration. Nevertheless, we ought to be able to distinguish, even in the most general way, between "regular" and "irregular" activities, whether involving the movement of some or all of the population: "regular" activities might include, for example, hunter-gatherer mobility, nomadic pastoralism, exogamous wife-taking, seasonal transhumance, kula rings, Greek and Phoenician colonisation, Near Eastern caravan trade, Roman or Inca imperial expansion, or the leap-frog migration generated by the segmentary lineage organisation of the Postclassic Maya (Fox 1987), while "irregular" movements might be thought of as isolated episodes, such as the migration of the Helvetii in 59 BC described by Julius Caesar, or the population movements of the European Migration Period.

This distinction is particularly important when it comes to explanation, since "regular" migration could be regarded as a process, while "irregular" migration is more akin to an event. The former lends itself to uniformitarian explanations in terms of social processes; as examples of this, we might suggest our normal understanding of the expansion of urban societies in the Mediterranean through the mechanism of Greek and Phoenician colonisation, the wave of advance model for the introduction of agriculture to Europe, Childe's explanation of the spread of metalworking in prehistoric Europe through his concept of detribalised bronzesmiths in search of raw materials, or Fox's account of the leap-frog migration stimulated by segmentary lineage organisation as the critical factor in Maya post-classic state formation. "Irregular" movement on the other hand, is more suited to "historical" explanations in terms of individual events. Such explanations are common in mythological and legendary accounts of the past such as the medieval Irish *Book of Invasions*, which lists four successive waves of migration into Ireland each accounting for some features of the landscape, economy, or social organisation of the country before the people were destroyed by disasters such as plague or flood, but similar explanations are also to be found in more modern archaeological writing; it would be easy to list many examples, such as the Beaker Folk or the Urnfield People.

## EXPLANATORY ROLE OF MIGRATIONS

We can now turn to some of the problems regarding the role played by migrations in the accounts that archaeologists have given of the past, and in the first place to the limited epistemological question of their explanatory role. It is important here to realise that different archaeologists have set themselves different tasks, and have therefore taken different views of the logical relationship of the concept of migrations to their particular aims. We might distinguish two different types of approach to the past, which do not exhaust all the possibilities but are characteristic of much recent work. The first would be that of the New Archaeology, or processual archaeology: it emphasizes explanation of the variability of the material record, the testing of hypotheses, the invalidity of hypotheses which cannot be tested, and the role of social processes in our understanding of past social change. The second would be more suited to post-processual archaeology: it emphasizes a more narrative and historically specific account of past societies, the role of individual actors in society, and the importance of events as much as processes, and is more concerned with giving meaning to the past than with testing valid hypotheses.

For exponents of the former approach, processual archaeology, the concept of migrations has a limited but vital role. The many types of movement described above as "regular" are precisely the type of processes favoured as explanations by such an approach. Though they would fall into the definition of migration discussed by Kristiansen and Anthony, they would not normally be referred to a such. In such a context, migration would refer to an "irregular" movement, or a specific event rather than a process. For the prehistoric period it is notoriously difficult to find evidence for such events independent of the observed changes which the migration is supposed to explain (though it is quite possible that research in physical anthropology or DNA might produce such evidence). All prehistoric migrations, in the narrow sense of "irregular" events, are therefore entirely hypothetical, with the obvious exceptions of the initial human colonisation of an area, or recolonisation after abandonment (though even these movements might be classed as "regular" parts of human mobility if the scale of analysis is large enough).

To give a specific example, a recent book on the prehistory of Europe (Champion *et al.* 1984) did not use the concept of migrations to explain the past. It did, however, put great weight on many forms of movement of people, either explicitly or implicitly, as explanations of prehistoric change: examples would be hunter-gatherer mobility, exchange of raw materials and prestige items, expansion of early agriculturalists, Mediterranean colonisation. All of these can be supported to some extent by empirical or historical evidence or ethnographic analogy, and all are essential processes rather than unique events.

Hence we can understand the rejection of migrations in such an approach. Migrations do not fit with the emphasis on process, it is difficult or impossible to find evidence to support them, and such a concept is not an appropriate hypothesis for use as an explanation. We can also understand the apparent paradox that processual archaeology, having rejected the correlation between human groups and material culture assemblages ("cultures") and thus removed one of the major empirical objections to migrations, nevertheless did not accept the opportunity to adopt such an idea. The processualist objections to migration explanations are far deeper than that.

Hence also we can understand the emphasis that Anthony (1990) gives to migration as a process, capable of being understood at a general rather than a particularistic level. This is essential if migrations are to be reintroduced into processual archaeology, though he has no clear solution to the problem of finding empirical evidence that could support such hypothetical migrations in preference to other explanations of culture change.

On the other hand, in an approach which stresses the interpretation of the past or giving meaning to the record, there are very different possibilities for the use of migrations. It is still necessary, of course, to consider the merits of conflicting explanations and to balance the evidence in favour of them, but the emphasis on interpretation allows much greater scope for invoking explanations for which there may be no immediate possibility of providing evidence.

In this way, different intellectual orientations to the project of understanding the past will produce very different attitudes to the value of the concept of migrations.

## THE WIDER CONTEXT OF MIGRATION THINKING

Archaeology is not, however, just a narrowly academic discipline, but operates in a broader context of social and political life. It provides ideas and images of the past for use in other contexts and is itself influenced to a greater or less extent by factors outside archaeology. If we are to understand the popularity at certain times of migration ideas, then we should also look to the wider social context of those ideas. There has been little interest in why they were once popular, but in trying to look at the wider context of archaeological thought, we encounter some problems.

The first problem is the prevailing method of writing the history of archaeology. This has adopted an extremely progressive tone, singling out for praise and notice the great men and the great discoveries which have paved the way to the current state of archaeology. It is an approach which is highly teleological, and has little time for those whose work does not lie on the straight and narrow path of progress, and whose ideas are not now adopted into the mainstream of current archaeological thinking. Such writers are marked out for criticism or abuse. It is also an approach which is internal to the subject and takes little account of the social, economic, and political context in which archaeology is done, except occasionally to criticise the political perversion of archaeological ideas. It should be our task not to single out those who have blazed the trail of archaeological progress, but to try to give a sympathetic understanding to all past writers, including (perhaps especially) those whose ideas have been rejected.

The second problem is closely related: it is the lack of aware ness of archaeology as a form of cultural production. Archaeology is a form of practice which is deeply embedded in a social, political, and cultural matrix; it is to some extent isolated by the institutional structures within which it operates (such as the growth of an academic sphere which writes largely for itself rather than for a wider public), but it is to a greater or lesser extent influenced by, and in turn itself influences, a whole range of other cultural practices. To understand the development of archaeology as a whole, or even the work of a single individual, it is necessary to explore the nature of these cultural relationships.

The third problem lies in the recognition that archaeology is a textual practice, that is, much of the communication of ideas, information, and argument is done through the medium of text. Not exclusively, of course, since we also use drawings, maps, charts, photographs, film, reconstructions, museum, displays, the artefacts, and monuments themselves, and even theme parks to transmit ideas about the past, but the predominant mode is still the written text. We have begun to pay some attention to the way in which museums and monuments are used as vehicles of communication, but unlike many other disciplines we have not yet given much thought to the nature of the archaeological text. Elsewhere, especially in geography, anthropology, history, and economics, various people have begun to explore the nature of their texts, paying particular attention to such concepts as style, genre, and rhetoric; in the natural sciences there has been a special emphasis on the use of language and its effects on the scientific writing and thinking. These are subtleties which have scarcely yet entered in to our perception of the nature of archaeology.

These comments have been very general, and would apply equally to the investigation of any theme in the history of archaeology. To illustrate their specific relevance to the theme of migrations, let me quote a few examples. In the traditional histories of archaeology, what we might perhaps call the ultimate case of migrationism, typified by von Däniken's extraterrestrial invaders, are relegated to the lunatic fringe and deemed scarcely worthy of serious notice by archaeologists; likewise, the marginally more acceptable theories of the hyperdiffusionists (or perhaps more specifically the hypermigrationists) such as Elliot Smith and Perry are abused and ridiculed as damaging diversions from the road of progress. I would contend that a more appropriate approach would be to ask why (at least to judge by quantity of book sales) invaders from outer space are more attractive than the theories of archaeologists, or why for most of the 1920s the hyperdiffusionist view was so popular and how it related to other concerns of the time. Secondly, on the question of the importance of language, I would mention two recent attempts to consider the general problem of migrations (Adams *et al.* 1978, Rouse 1986). Neither of these pays sufficient attention to the meaning or possible range of meanings of such terms as diffusion, migration, or invasion. Not only can the words apply to a variety of specific social processes and events as discussed above, but the precise word chosen can also be important, since each has its own connotations or overtones which can often only be fully appreciated with a full understanding of the broader social context of their use.

In our analysis of archaeological ideas we need to take great care of the precise language used not only to appreciate fully what is being said, but also to understand why it is being said and how words come to shape our concepts. It follows from this, and from what has been said above about the critical importance of the cultural context of archaeological practice, that we cannot give a general account of how the idea of migrations has been used in archaeology without detailed analysis of individual authors and their writings. Clearly that is not yet possible without a great deal more research, but I will make a start on such a project, in order to demonstrate the possibilities, by looking at a few examples from British archaeological writing, and in particular I will try to show that one of the common ideas about explanation by migration, linking its rise to European imperial expansion and militarism and its decline to the post-war emergence of a more peaceful form of political interaction, may not be an adequate account.

The first example is the work of the hyperdiffusionists, Elliot Smith and Perry. As I have said above, it is not a case of defending or rehabilitating them, but of understanding them, and I shall look in particular at the ideas expressed in William Perry's book *The growth of civilization* (1924). From a careful reading it is clear that the idea of the unique origin of civilization and its diffusion from a single source is one part of a network of ideas arising partly from opposition to existing themes in anthropology and partly from the social and political context of the time. The key to this is his opposition to the idea of social evolution which had dominated much of nineteenth-century anthropological thinking, and its notion of progress, in particular progress achieved through competition as a form of social natural selection, and its perceived implication of the human species as inherently aggressive. They therefore emphasized the importance of food production as offering an opportunity, the almost accidental nature of the rise of civilization, and the rarity of its occurrence, and the possibility of decline (degradation) as well as rise (incidentally, all ideas with which we would now be in sympathy, though we would put the number of times it happened at nearer ten than one). They also emphasized the essentially peaceable nature of the human species as represented in early food-producing societies; warfare was seen as the by-product of the expansion of civilization, in the warrior aristocracies on the fringes of the civilized world. In contrast to the evolutionary vision of the past as a path of human progress, we have the past recreated as a neolithic utopia, a golden age from which the modern world has sadly declined.

These ideas must be understood against the background of the growing disenchantment felt in the late nineteenth and early twentieth centuries as industrial recession, agricultural depression, the problems of imperial responsibility, and ultimately the traumatic effects of the First World War caused people to reconsider their notions of social progress. In Perry's own words, "It is commonly assumed that violent behaviour is "natural" to men.... I am convinced that this is one of the most profound mistakes that can be made, and that, until this error is eliminated from current thought, there is little hope for any solution of the greatest problem that confronts us as civilized men and women, namely, the elimination of violence from the relations between states, and indeed from all human relationships" (Perry 1924, 191–2). The idea of a neolithic golden age was also taken up by such writers as H.J. Massingham, who was not only an enthusiastic colleague of Perry and Elliot Smith, but also a writer about the English countryside and agriculture, heavily involved in an attempt to undo the damage of industrialization and restore the rural economy of England by returning to a form of environmentally friendly farming and a rural society of small scale owners. These ideas are an important part of the ancestry of modern ecological thought (Bramwell 1989) and the green movement, but were also given a form of legitimation by the apparent demonstration of the possibility of such a peaceable, non-industrial early agricultural utopia, a society which by the construction of such monuments as Avebury had even left the countryside more beautiful than it had found it.

Perry's ideas of migration, then, can only be understood as part of a complex reaction to the theories of social evolution and the political problems of the time. Migration was not part of an imperial vision of the world; far from it, it was part of a vision of the past constructed in direct opposition to the problems created by modern European society and its industrial and imperial growth.

My second example concerns the interpretation of British prehistory. Clark (1966) in his paper on the invasion hypothesis in British prehistory speaks of an "invasion neurosis" which had affected British archaeology throughout the earlier part of the twentieth century, and related it to the known historical invasions of Britain and to the imperial vision of the British as conquering "citizens of the world". While this may be partly true, I am not sure that it is the full story. My impression (which is based on something less than a full survey of all the literature) is that although there was for much of the late nineteenth and early twentieth century a prevailing tendency to explain British prehistory by reference to material known on the continent, for most of this period the connection was not normally perceived as an invasion; other, more general terms, such as migration or even influence were used, though the precise mechanism was seldom specified. The term "invasion", though certainly used earlier (e.g. Crawford 1922), only seems to have become common after about 1930 (Estyn Evans's (1930) LBA sword-bearers, Hawkes and Dunning's (1931, 1932) two Belgic invasions, Piggott's (1938) EBA aristocratic invaders into Wessex, the Marnian invasions in various papers of the late 1930s).

To classify all these interpretations, including the earlier ones, as "invasions" loses much of their meaning and subtlety. Instead, I would suggest that we should see the prime emphasis of these earlier accounts being not so much on the process which introduced continental material to Britain as on the heterogeneity of the British past which represented an amalgam of many different elements. Notions of British identity have constantly been renegotiated, but one prevailing theme in the later nineteenth century was the diversity of our past; much was owed to the Anglo-Saxons as the founders of many of our traditions of law and government, but Anglo-Saxon England had successfully incorporated later comers such as the Vikings, Normans, Huguenots, and others, and this concept could be extended as well to the pre-Saxon Celtic and Roman populations; the process was not, however, total, and the social rejection of the Jews in particular was matched by their exclusion from the mixture of the past. A vision of our past as one which blended many diverse elements into a unity would therefore favour interpretation of the prehistoric past in terms of external influences, and the concept of migration should therefore be connected as much with notions of national identity as with imperial ambitions.

Why the specific term "invasion" should have become so much more popular after 1930 needs a different sort of explanation. Perhaps in this case it was the increasing militancy of the European states at the time, and the increasing sense of British isolation from events in Europe, that predisposed archaeologists to think in those terms.

My final example goes back again to Clark's 1966 paper, and his explanation of the decline of the "invasion neurosis" as due to Britain's declining imperial status and a return to "open-minded re-examination". He says, however, "When all is said the object of British archaeology is surely to tell us about the lives of the people who, generation by generation, age by age, in unbroken succession occupied and shaped the culture of the British Isles". Though this may be related to fading imperial power, it is specifically related to a redefinition of British identity with emphasis on continuity and isolation rather than diversity and constant external influence. It is perhaps no coincidence that this was written in the 1960s when Britain was faced with the problems of post-war Commonwealth immigration culminating in race riots and apocalyptic warnings about the future if the tide of migration was not stemmed. Exclusion, not incorporation, was the key to national identity.

This brief discussion has done no more than sketch a possible interpretation of a few examples, but it demonstrates the importance of a detailed analysis of the cultural context of archaeological ideas, and of a sympathetic attention to the nuances of language.

Timothy Champion, Department of Archaeology, University of Southampton.

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# Research History of the Single Grave Culture – a Commentary

by C. J. BECKER

In the latest number of Journal of Danish Archaeology Kristian Kristiansen contributes to the debate whether prehistoric immigrations can be established from the archaeological sources alone, and as an example chooses to renew the old argument about the Jutland Single Grave Culture (SGC). The question of the first appearance of this culture in Denmark has played a central role in our whole conception of the cultural development in the country's Neolithic, and as well as being important for the interpretation of related groups both in other parts of Scandinavia and in much of central and eastern Europe. Its importance can be attributed to a well established internal relative chronology, the large number of finds, and not least to the fact that there is such a rich and well studied material from the other (mainly earlier) group, the Funnel Beaker Culture (TRB). The problems are now, as earlier, the exact dating of the two groups in relation to each other, and the question of their economy and material/mental culture. During the last decades discussion has revolved chiefly around the first question. Did a massive immigration of a new people take place, or were there for some reason only radical changes in the economy, burial customs, and entire material culture of the old population? The immigration theory remained the dominant one until the early 1960's, while subsequently the alternative view received much support especially from archaeologists of the younger generation. The question has still not been finally answered. KK's article is therefore an important contribution to the discussion. My comments on it will be confined to making supplementary points and criticisms of the author's conclusions.

KK divides his comments into three sections. First comes a review of the theoretical models that in the 1960's and 1970's inspired Scandinavian archaeologists to try new interpretations, and were one of the main reasons for the emergence of a different, and to many older colleagues surprising view of the cultural development in especially the Scandinavian Neolithic. Such a review is helpful as a guide through the history of research. One is given among other things an adequate explanation of why "migrations" as a concept do not necessarily involve radical changes in culture, and why they are left unmentioned in new scholarly and popular descriptions of the cultural history of the Neolithic. Even the National Museum exhibition (up to now) follows this line, except with the Pitted Ware Culture.

KK's next section deals with the Jutland SGC, and it is mainly here I have comments to make. The third section deals with related Corded Ware groups in the rest of Europe and beyond, and would be difficult to discuss in brief despite its qualities and interesting viewpoints.

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# *Research History of the Single Grave Culture – a Commentary*

by C. J. BECKER

In the latest number of Journal of Danish Archaeology Kristian Kristiansen contributes to the debate whether prehistoric immigrations can be established from the archaeological sources alone, and as an example chooses to renew the old argument about the Jutland Single Grave Culture (SGC). The question of the first appearance of this culture in Denmark has played a central role in our whole conception of the cultural development in the country's Neolithic, and as well as being important for the interpretation of related groups both in other parts of Scandinavia and in much of central and eastern Europe. Its importance can be attributed to a well established internal relative chronology, the large number of finds, and not least to the fact that there is such a rich and well studied material from the other (mainly earlier) group, the Funnel Beaker Culture (TRB). The problems are now, as earlier, the exact dating of the two groups in relation to each other, and the question of their economy and material/mental culture. During the last decades discussion has revolved chiefly around the first question. Did a massive immigration of a new people take place, or were there for some reason only radical changes in the economy, burial customs, and entire material culture of the old population? The immigration theory remained the dominant one until the early 1960's, while subsequently the alternative view received much support especially from archaeologists of the younger generation. The question has still not been finally answered. KK's article is therefore an important contribution to the discussion. My comments on it will be confined to making supplementary points and criticisms of the author's conclusions.

KK divides his comments into three sections. First comes a review of the theoretical models that in the 1960's and 1970's inspired Scandinavian archaeologists to try new interpretations, and were one of the main reasons for the emergence of a different, and to many older colleagues surprising view of the cultural development in especially the Scandinavian Neolithic. Such a review is helpful as a guide through the history of research. One is given among other things an adequate explanation of why "migrations" as a concept do not necessarily involve radical changes in culture, and why they are left unmentioned in new scholarly and popular descriptions of the cultural history of the Neolithic. Even the National Museum exhibition (up to now) follows this line, except with the Pitted Ware Culture.

KK's next section deals with the Jutland SGC, and it is mainly here I have comments to make. The third section deals with related Corded Ware groups in the rest of Europe and beyond, and would be difficult to discuss in brief despite its qualities and interesting viewpoints.

In his earlier writings about the Jutland SGC KK has inclined to the autochthonous interpretation, no doubt owing to his extensive knowledge of and the way he has been influenced by more recent Anglo-American scholarship, the so-called "New Archaeology" (an expression of diminishing applicability!). It may surprise some readers to find he no longer regards social-anthropological or economic factors as the explanation of the SGC's appearance, but speaks of the immigration of a new people. Like every other serious scholar KK has a right to a new opinion, and it should surprise no one if several of his colleagues were to follow suit. To me this is far less important than KK's account of his earlier attempts to explain the appearance of the SGC in Jutland. So long as a problem in archaeology has not been solved to everybody's satisfaction, every possibility should be looked into and evaluated critically; this is the only road forward for scholarship. We may however take note that once again evolutionist theories seem not to have been able to solve the problem.

JDA is an international periodical, and this may lend the question especial important, for it is not merely an internal controversy for Neolithic research in Scandinavia, but has been regarded as a schoolbook example of cultural historical interpretation applied to a purely archaeological material (Brøndsted 1957, 260). This means that a short account of the background in research history is entirely in its place, but the account should include the main points and refer to the papers where the new material or new interpretations were first presented. It is not enough merely to mention the most recent article reiterating an argument that may have been used several times before; and the main phases of the debate should in all events be stated correctly.

To mention some places where these lines have not been followed, Sophus Müller (1898) and P.V. Glob (1944) are quoted at the beginning of the section on the Jutland SGC for seeing this as representing the immigration of "Indo-European speaking peoples". In 1898 Sophus Müller did not mention Indo-Europeans at all, and in 1944 Glob cites other, mainly German scholars' theories, and concludes prudently that the immigrants may have been Indo-European peoples without mentioning their language at all (1944, 235 ff.).

Dealing with the history of more recent research KK describes the change to evolutionistic interpretations that resulted from the increasing numbers of $^{14}$C dates, and then says that these can support arguments against the immigration hypothesis from a different direction. As it is the situation in Jutland that is being considered, a better starting point might have been Malmer's work (1962) on the Swedish-Norwegian Battle Axe Culture, which takes a major part of its at that time shocking arguments from new studies of the Jutland group. His book is earlier than the whole $^{14}$C debate. Afterwards the role this came to play for the whole discussion could properly be described. A number of younger archaeologists concluded, as KK says, that the chronological objections to the evolutionary theory were now removed. However not all were convinced (Davidsen 1975, 1978; E. Jørgensen 1977). It would also have been possible to refer to Becker (1973, 180), where it was emphasized that scientific and archaeological methods should lead to the same conclusions independently before the evidence can be regarded as convincing. Most people have failed to see that though there are many $^{14}$C datings of the three phases of the SGC, there are still too few of the late TRB. Furthermore the familiar safety margins of the method mean that the two Neolithic groups could have lived side by side for a couple of generations – which is enough to support an invasion hypothesis. Has it been forgotten that "reliable" pollenanalytical and geological studies in the 1930's and 1940's let the Ertebølle Culture survive far into the Middle Neolithic?

For KK the debate on immigration versus indigenous development of the Jutland SGC is by and large confined to the last decades. When facing the problem for the first time – for instance as a student – the "old" immigration hypothesis really stands opposed to three propositions, all of which conclude instead that there was an indigenous development. In correct order they are 1) Malmer's re-interpretation (1962), 2) various contributions connected with $^{14}$C dating, and 3) theoretical studies rooted in arguments from "New Archaeology". KK's return to the invasion hypothesis may not seem so epoch-making to colleagues with "old-fashioned" views. The discussion does not really seem so new, despite the fact that the date of the invasion in relation to the TRB has been changed twice since 1944.

If the debate as a whole is to be described correctly – for instance because of its place in research history – it should also be said that the discussion took place in the 1930's and 40's. This is a serious omission on KK's part. As a full account is available in print (Becker 1954, 132-37) there is no need to repeat here the arguments that were used to support an autochthonous solution (Åberg 1937 and 1949), nor the repeated opinion of Danish scholars that the SGC's appearance in Jutland could only be explained as the immigration of a new folk from the south. Also Brøndsted's considered and cautious views could have been mentioned.

Work from the 1950's and 60's on the TRB in central and western Jutland could have been placed in a different light than by KK (p. 212ff.). He writes that no systematic efforts to prove or disprove the immigration theory was made either then or later, and apparently does not lay much weight on the works mentioned (Davidsen 1975, 1978, E. Jørgensen 1977). In my opinion there lay systematic research behind these two important works, and it completely changed the picture of the late TRB in these areas. Firstly a previously unknown final phase of the TRB was identified in 1954 (the Valby or MN V phase – Becker 1954), and it was also present in central and western Jutland. Secondly a new type of burial structure, the stone packing grave, was found in the same regions, and it showed that the TRB culture was present throughout the Middle Neolithic in many of the areas where the SGC made its first appearance. It is hard to understand why KK continues to describe these areas as sparsely populated or deserted. Also he mentions the stone packing graves in a curiously obscure manner. It is true that they are individual graves, but their entire construction (meaning the fixed rituals behind them) are as different as possible from the earliest SGC graves.

This brings us back to KK's assertion that really no systematic attempt has been made to confirm or disprove the immigration theory. What arguments would KK accept? Presumably if evidence could be obtained from e.g. the examination of skeletal material from the final TRB and the earliest SGC in Jutland, this would be sure enough, but as everyone knows the lime-poor soil is the reason why not a single properly preserved skeleton has been found from either the stone packing graves of the TRB or the earliest Single Graves. For the same reason it is not possible to study the economy of either group properly. Animal bones are absent from the few known settlements. Impressions of cultivated plants (or carbonised material) are still too scarce for any definite conclusions. It may be noted in parentheses that the common view that the cereal crops of the TRB were wheat and barley, but the SGC only had barley, is not correct, as also wheat impressions are found in the pottery of this group (Rostholm 1986a, 231). Finally, it is still unclear whether $^{14}C$ dating can answer this particular question. As well as the familiar margin of uncertainty, continued research on calibration curves seems to reduce the possibilities especially at this point of time. What about new systematic excavations? Perhaps, but archaeologists with field experience know how little chance even the best prepared project would have with our present knowledge.

The problems surrounding the immigration theory must not be laid aside, they must be capable of a final solution. We must be optimistic and allow ourselves to await one of the surprises that are one of archaeology's most charming aspects.

C. J. Becker, Institute of Archaeology, University of Copenhagen.

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# Reviews

O.M.C. HAEX, H.H. CURVERS & P.M.M.G. AKKERMANS (eds.): *To the Euphrates and Beyond. Archaeological Studies in Honour of Maurits N. van Loon.* A.A. Balkema Publishers, Rotterdam/Brookfield 1989. 304 pp, 10 diagrams, 41 figures, 5 plates.

This *Festschrift* to Maurits N. van Loon, professor of Near Eastern archaeology in Amsterdam, contains 20 articles and a bibliography of van Loon's publications written by colleagues from his excavations in Eastern Anatolia and Syrea and by his former students at the Oriental Institute in Chicago and at the University of Amsterdam. The composition of the book reflects his broad knowledge and interests in prehistory and historic archaeology, in linguistics, palaeography, and iconography, in the collaboration between archaeology and the natural sciences, and in archaeological theory, methods, and techniques. On this background it is understandable that the topics of the articles vary from typological studies of a single group of artifacts to wide-ranging considerations or reviews of archaeological problems, often with a starting-point in van Loon's own excavations at Korucutepe, Tell Selenkahiye, Mureybit, Bouqras, or Tell Hammam et Turkman.

We are led from detailed studies of Neolithic figurines (Erik Lohof), crescent-shaped axes (Friedrich Lüth) animal headed cups at Mari (Sally Dunham), and the seal used by the god Tispak to kill Mušhuššu, the dragon (F.A.M. Wiggermann) – through surveys on the origin and early development of ceramics (Marie le Mière), mortuary practices in the Halaf period (Peter Akkermans), and the beginning of the third millennium in Syria (Hans H. Curves) – to an intriguing reconstruction of the famous battle at Qadesh, outlining step by step the positions and movements of the various units of the Hittite army and the Egyptians under the command of the Pharaoh Ramesses II (M.J. de Bruyn).

Of particular interest for Danish archaeologists are perhaps a microwear analysis of borers from an Early Neolithic site in the Jordan Valley published by Johannes Bueller and three studies with a wider methodological perspective.

In the first of these studies, entitled "Ground plans and archaeologists: On similarities and comparisons", D.J. Meijer explores the criteria used by archeologists, and the conclusions they draw, when they compare the lay-out of an architectural complex or the plans of houses from sites that are sometimes far from each other in time and space. The main question regarding similarity is obviously the extent of the identity of buildings, i.e. in this case of plans. Do we require congruence or a simple superficial likeness? Do we compare measurements? In his introduction Meijer states that in his opinion there are four aspects involved in an analytical classification: form, location, utilitarian function, and symbolic function. Any priority of one of these aspects or variables depends on the particular theory with which one approaches the ancient buildings. In his study he shows how archaeological comparisons often – and for obvious reasons – depend on the form of houses, as represented by ably if evidence could be obtained from e.g. the examination of skeletal material from the final TRB and the earliest SGC in Jutland, this would be sure enough, but as everyone knows the lime-poor soil is the reason why not a single properly preserved skeleton has been found from either the stone packing graves of the TRB or the earliest Single Graves. For the same reason it is not possible to study the economy of either group properly. Animal bones are absent from the few known settlements. Impressions of cultivated plants (or carbonised material) are still too scarce for any definite conclusions. It may be noted in parentheses that the common view that the cereal crops of the TRB were wheat and barley, but the SGC only had barley, is not correct, as also wheat impressions are found in the pottery of this group (Rostholm 1986a, 231). Finally, it is still unclear whether $^{14}$C dating can answer this particular question. As well as the familiar margin of uncertainty, continued research on calibration curves seems to reduce the possibilities especially at this point of time. What about new systematic excavations? Perhaps, but archaeologists with field experience know how little chance even the best prepared project would have with our present knowledge.

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In two other articles the authors make an attempt to combine archaeological and literary sources towards the identification of historical peoples. In the Near East a number of scholars, including Sahlins, Spooner, Adams, Nissen, Mortensen, and Khazanov, have described the development of pastural nomadism as a result of a close symbiotic relationship between settled agricultural communities and people living in the marginal areas. More specifically, many have associated pastural nomadism with the advent of urbanism and the spread of irrigation agriculture in the late 5th and 4th millennia B.C. But in his study of "Jebel Bishri and the Amorite homeland: The PPNB phase" Juris Zarins argues for a much earlier origin related to the PPNB villages of the 7th millennium B.C. in Palestine and Syria with a slightly later spread across the Jazirah into Northern Iraq. He then continues with an attempt to bridge the gap between the 7th and the 3th millennia B.C., concluding in an identification of these early pastural nomads with the predecessors of the Amorites, a tribe of Semitic nomads attested for the first time in the literary sources of the mid-third millennium B.C. in the area around Akkad in Southern Mesopotamia.

It is very stimulating to read this bold and rather provocative study, written by an American, in conjunction with another article in the book, also written by an American archaeologist. Glenn M. Schwartz' study on "The origins of the Aramaeans in Syria and northern Mesopotamia: Research problems and potential strategies" is an attempt to establish the archaeological identity of a population usually distinguished by its ethnolinguistic components. But although the methodological problems are similar, the discussion in this case is more safely limited in time within a few hundred years around 1000 B.C.

In conclusion it may be said that the editors of the book have succeeded in creating a *Festschrift* with a number of well presented studies that will appeal to the interest of a wide range of archaeologists – as well as to Maurits N. van Loon himself.

*Peder Mortensen*

MAGDALENA TEMPELMANN-MACZYŃSKA: Die Perlen der römischen Kaiserzeit und der frühen Phase der Völkerwanderungszeit im mitteleuropäischen Barbaricum. Römisch-Germanische Forschungen, Band 43. Mainz 1985. 339 pages, 24 figures, 16 tables, 14 coloured plates, 66 other plates, 3 appendices.

Beads have hitherto been unevenly dealt with in archaeological writing. Although a number of systems of classification have been put forward, they have generally been described subjectively by the different authors. Apart from certain characteristic types, that are treated separately, beads seem not to have been regarded as very important. In recent years however there has been increasing interest for their study, not least owing to finds of important Later Germanic and Viking production sites where beads were made.

Tempelmann-Maczyńska's work is an important contribution to this subject, and will make it easier to treat beads of the Roman period in the same way as other archaeological finds. Subjective description may with practical advantage be replaced by reference to types, and in some cases types are datable within chronological limits. The aim of the work has been the wish for a separate treatment of beads of the Roman period, where glass beads are regarded as an independent group under Roman imports. The book is based on a thesis written in 1970–74 at the Jagiellon University in Kraków. It may be noted that only limited use is made of literature from after 1975.

The material studied covers beads from the Roman Iron Age and the earliest phase of the Migration Period (Eggers' phases B, C, and D), i.e. from the beginning of the 1st century until ca. A.D. 450. The geographical term "mitteleuropäische Barbaricum" covers in some degree the so-called Germania libera. The extensive catalogue includes finds from Western Germany and West Berlin, East Germany, Austria, Czechoslovakia, Poland, and the Soviet Union.

Altogether about 56,000 beads have been recorded. Glass beads are the largest group with 35,000. As the greatest part of these are assumed to be imported, they are after coins the most numerous group within Roman finds. In addition there are 14,000 amber beads, and a smaller number of other materials: clay, bone, stone, rock crystal, bronze, zinc, tin, lead, and iron. Gold and silver beads are not included, as they are placed in the category, jewelry and decorative art, and are dealt with separately in several other works.

One of the main aims of the authors was to devise a system of classification that takes account of material and method of production. Beads are divided into groups, types, and variants. It should be possible to insert new types or variants into the system.

Glass beads have individual traits reflecting method of manufacture – dealt with in a separate chapter. Despite production in large numbers, not only of monochrome but of richly decorated beads, only a few are completely alike, and many of the polychrome beads are represented by only a single example. The 29 groups and 387 types with their variants demonstrate the great differences existing between glass beads, and the special features of their production. Among the amber beads distinction is made between hand-made and turned types; decoration, if present, is subordinated to form.

The positions of the beads in undisturbed inhumation burials and their combination with other chain elements in cremations, shows that they were worn primarily around the neck. Chains with beads of the same type occur relatively seldom, and when do it is often in the form of very long strings with over 100 monochrome or goldfoil glass beads, or short strings of figure-eight shaped amber breloques. No strings are known with polychrome beads of the same type. The commonest combination is glass and amber beads with the former in the majority. Sometimes a deliberate colour combination can be seen. No two identically composed strings occurred in the material studied, but in some areas there were strings with certain similarities.

Glass beads were probably not bought as whole chains, except perhaps those with identical bead types, but were obtained on different occasions. As time passed new beads were added or replaced existing beads in the chain. There were no significant differences in the combinations of beads in strings to go around the neck in the material studied, and there is no basic typical form of central European string of beads.

C. 45,000 beads could be dated, most of them from graves. The chronology set up is based on occurrences in closed finds with datable objects, mainly fibulae. With the exception of certain characteristic types there were no leading forms. Most types were in use for a long period, but some were confined to a couple of phases. The earliest appearances of certain types that show differences between cultural areas are of interest. The greatest frequency of beads begins in late period B2 and culminates in the later Roman period and in period D. From B2 onward there is an increase in the number of new types, and after C2 there are fewer new types. The greatest type variation is found in C1b and C2. The largest number of new types is in B2 and C1a.

The occurrence of beads in the separate phases shows that in the early Roman period there were few beads and the only clear concentration was in Samland. In the later Roman period there are concentrations of beads in the Saale area and on the right bank of the lower Elbe. Other accumulations are seen at the mouth of the Vistula and in the area of the West Baltic Culture. Though beads are the commonest type of ornament in graves from period D, the number of finds is smaller (partly because there are fewer sites). In this phase a concentration can be seen especially in the area of the Niemberg group.

If the frequency of glass beads is compared with that of other Roman imports, it is seen that the influx of beads into mid-European Barbaricum largely agrees with that of glass vessels, whose import begins in B1. In B2/C1 there is a clear increase in the glass vessels, but the majority of the finds are from D. Both forms, beads and vessels, appear the most frequently in the later Roman period and the early part of the Migration period.

The distribution of the beads provides a basis for a reconstruction of trade routes between the Roman Empire and the barbarian areas. Amber was exported to the Roman Empire from the Baltic coast, and the route makes itself clearly seen. Mapping the different types of beads shows no significant local concentrations, although some types are clearly locally restricted. Beads are on the whole supra-regional, but an analysis of the finds from different cultural areas shows certain main tendencies.

Lack of information about production sites makes it difficult to trace the origin of the separate types. In the case of the glass beads we may assume that many Roman and provincial Roman workshops were in simultaneous use. We may suppose there were two categories of glass factories – those that made vessels and those that made beads. The reason for this distinction is the different colour combinations and different production techniques and tools. Polychrome beads with complex decoration were made in highly specialized workshops, while simple and monochrome beads could be made as by-products in workshops for glass vessels. One could imagine that melon beads were made in factories for ribbed bowls, and polyhedric beads were made in factories for ground glass vessels.

Little is known of sites producing beads within the Roman area. Written sources mention Alexandria as a centre for making mosaic beads. Glass was widely produced in Syria and Palestine. Around the year 0 glass factories began in Italy. In the Argonne in Gaul beads have been found together with glass mosaic rods. Cologne and Trier were centres for making glass, and in Trier there is evidence of bead manufacture in several periods. Some of the late types from this town are clearly made in Teutonic taste. A few glass workshops are known from the barbarian areas, for instance Komakov on the Dniestr, where beakers with ground ovals and applied threads were produced in the later Roman period. Probably opaque red glass beads were made in the settlement of Abidnia in White Russia, and some of the beads in the Černiachov culture appear to have been made locally. In the whole period it was possible to import raw materials from the Roman Empire, so simple beads could have been made locally. Despite the lack of evidence one may regard local production as probable at the end of the Roman and beginning of the Migration periods.

In the case of amber beads it is likely that turned beads were produced in the Wielbark culture starting in period B2. Only a few barbarian amber working sites are known, some in Kujavy, two near Warsaw, and one at Świlcga near Rzeszów.

Concentrations of particular types in particular areas have led to hypotheses about the way they were brought. Goldfoil glass beads near the south Baltic coast might have come by sea from the northwest, for which their occurrence also in Denmark and southern Sweden argues. However a simultaneous influx from the southeast cannot be excluded. Several polychrome types in early cemeteries of the Wielbark and West Baltic cultures are remarkably similar to beads from the north coast of the Black Sea. The largest number of finds is from Pomerania, and there are large concentrations by the lower Vistula and in Samland. The route from the Black Sea *via* the Dniestr to the mouth of the Vistula played an important role from period B2 onwards, and the same route was probably in use in the later Roman period, when face-beads and beads with special chequerboard patterns were imported. Melon beads of faience may have come from as far away as Egypt. Other types also reveal a common origin – for instance some small types of bead in the Niemberg group. They may have come from Trier or Cologne, or even been made within the barbarian area.

The 56,000 beads recorded make up only a fraction of the original number. They indicate an extensive trade. Beads were easy to transport and probably cheap to buy. Their distribution is wide, and barter between the barbarians often scattered them far away from the trade routes. [Translated by David Liversage].

*Birgit Lind.*

# Book Chronicle 1990

KIM AARIS-SØRENSEN, KAJ STRAND PETERSEN and HENRIK TAUBER: *Danish Finds of Mammoth* (Mammuthus primigenius (Blumenbach)). *Stratigraphical position, dating and evidence of Late Pleistocene environment.* Geological Survey of Denmark, DGU Series B, No. 14. København 1990. 44pp.

A description of 125 finds of mammoth from Denmark, of which 14 have been C-14 dated, the most recent being 13,200 years old. The environment of the Late Pleistocene is reconstructed on the basis of faunal and floral remains.

C. J. BECKER: *Nørre Sandegård. Arkæologiske undersøgelser på Bornholm 1948–1952* (with an English summary: *Archaeological investigations at Nørre Sandegård, Bornholm).* Det Kongelige Danske Videnskabernes Selskab, Historisk-filosofiske Skrifter 13. Commissioner: Munksgaard, Copenhagen 1990. 200pp.

A multi-period site on the north-east coast of Bornholm with several important find complexes: Two early and one late Maglemosian settlement; settlement assemblages from the Early Neolithic and from the Battle-Axe Culture; cairns from the Early Bronze Age and a cemetery with cremation pits from the Late Bronze Age; 500 cremation pits from the Early Iron Age and two inhumation graves of the Late Migration Period.

BIRGITTA HÅRDH: *Patterns of Deposition and Settlement. Studies on the Megalithic Tombs of West Scania.* Regia Societatis Humaniorum Litterarum Lundensia, Scripta Minora 1988–1989:2, Lund 1990. Distribution by Almqvist & Wiksell, Stockholm. 107pp.

A follow-up on "Ceramic Decoration and Social Organization" (1986) by the same author, paying special attention to the stylistic and chronological variation of pottery from the megalithic tombs.

ERWIN STRAHL: *Das Endneolithikum im Elb-Weser-Dreieck.* Veröffentlichungen der urgeschichtlichen Sammlungen des Landesmuseum zu Hannover 36. Teil 1–3. Verlag August Lax, Hildesheim 1990. 350pp text, 250pp catalogue, 119 plates, and 78 maps.

This voluminous dissertation deals with c. 4000 finds, including material from c. 900 graves, from the Single-Grave and Bell Beaker Cultures and from the Late Neolithic/Early Bronze Age in the triangle between the rivers Weser and Elb, North-West Germany.

EINAR ØSTMO: *Helleristninger av sørskandinaviske former på det indre Østlandet. Fylkene Buskerud, Akershus, Oslo, Oppland og Hedmark.* Universitetets Oldsaksamlings Skrifter, Ny rekke nr. 12. Oslo 1990. 174pp. With a summary in English.

A new registration and analysis of the Bronze Age rock-carvings in the Oslo region in South Norway. The author concludes that the carvings with figure-motifs are found in areas where Bronze Age metal finds are frequent, but cup-marks are more widely distributed.

PER ETHELBERG: *Hjemsted 2 – tre gravpladser fra 3. & 4. årh. e. Kr.* Skrifter fra Museumsrådet for Sønderjyllands Amt, 3. Haderslev 1990. 209pp. With a summary in German.

The first publication of the large excavations of graves and settlements at Hjemsted, South-Western Jutland, appeared in 1986 (see review in JDA 6, pp.237–8). This new volume presents the material from graves of the 3rd and 4th centuries AD and touches on the cultural geography of Denmark in the Late Roman Period.

LARS JØRGENSEN: *Bækkegård and Glasergård. Two Cemeteries from the Late Iron Age on Bornholm.* Arkæologiske Studier vol. VIII. Akademisk Forlag / Universitetsforlaget i København, 1990. 176pp.

The publication of two late Iron Age cemeteries on Bornholm forms the basis for a discussion of settlement organisation and social development on the island during the Migration Period and the Viking Age.

LOTTE HEDEAGER: *Danmarks jernalder. Mellem stamme og stat* (with an English summary: *The Iron Age of Denmark – Between Tribe and State).* Aarhus Universitetsforlag 1990. 430pp and 3 microfiche.

This dissertation focuses on the evidence for political centralization in the later part of the Iron Age and the emergence of the earliest state structure. The author emphazises the discontinuity from the Early to the Late Iron Age and places the division around c. 200 AD.

PENELOPE WALTON & JOHN-PETER WILD (eds.): *Textiles in Northern Archaeology. Nesat III: Textile Symposium in York, 6–9 May 1987* (North European Symposium for Archaeological Textiles Monograph 3). IAP, Archetype Publications, London, 1990. 231pp.

Twenty-five fresh reports from studies of textile manufacture, ranging from bast fibre fabrics of the Ertebølle Culture to the clothing of AD 17th and 18th century Dutch whalers found on Spitsbergen.

MOGENS BENCARD, LISE BENDER JØRGENSEN & HELGE BRINCH MADSEN (eds.): *Ribe Excavations 1970–76,* Vol. 4. Sydjysk Universitetsforlag, Esbjerg 1990. 189pp, 32 tables (text and tables in two separate vols.).

Dendrochronology dates the town of Ribe back to AD 704–710, when a regulated marketplace was established, making Ribe the oldest town in Denmark. In this volume M. Bencard and Lise Bender Jørgensen describe the excavation and stratigraphy of the earliest layers in the light of the most recent discoveries (see L. B. Frandsen & S. Jensen in JDA vol. 6, pp.175–189). The founding of Ribe is discussed in relation to the founding of other North European towns. In a separate chapter Kjeld Christensen presents the wood-anatomical and dendrochronological results.

STEFAN BRINK: *Sockenbildning och sockennamn. Studier i äldre territoriel indelning i Norden* (with an English summary: *Parishformation and parish-names. Studies in early territorial division in Scandinavia).* Acta Academiae Regiae Gustavi Adolphi 57. Studier till en svensk ortnamnsatlas 14. Uppsala 1990 (distribution by Almqvist & Wiksell International, Stockholm). 449pp.

The topic of this Uppsala dissertation is the sources relating to the conversion and parish formation in Scandinavia. The author presents a "name-semantic" analysis of parish names and produces a study of parish formation in Hälsingland, Middle Sweden.

HEIDEMARIE HÜSTER: *Untersuchungen an Skelettresten von Rindern, Schafen, Ziegen und Schweinen aus dem mittelalterlichen Schleswig*. Ausgrabungen in Schleswig, Berichte und Studien 8. Karl Wachholtz Verlag, Neumünster 1990. 136pp, 54 tables.

The book deals with more than 100,000 animal bones which were recovered during the 1971–75 excavations in the centre of Schleswig, and date from the 11th to the 14th centuries AD.

HENNING UNVERHAU: *Untersuchungen zur historischen Entwicklung des Landes zwischen Schlei und Eider im Mittelalter* (Siedlungsarchäologische Untersuchungen in Angeln und Schwansen, Band 2). Offa-Bücher, Band 69. Karl Wachholtz Verlag, Neumünster 1990. 113pp, 14 maps.

This series is dedicated to the settlement archaeology of the provinces of Angeln and Schwansen, part of the region left by the Angles and Saxons in the 5th century AD. The series reports on the progress of a research program supported by the German Research Council since 1982. The book by H. Unverhau deals with written sources from mainly the 9th to 14th centuries.

DIRK MEIER: *Scharstorf. Eine slawische Burg in Ostholstein und ihr Umland. Archäologische Funde* (Veröffentlichungen des Sonderforschungsbereichs 17, Band 15). Offa-Bücher, Band 70. Karl Wachholtz Verlag, Neumünster 1990. 181pp, 41 plates.

"Sonderforschungsbereich 17" at the University of Kiel deals with research concerning Scandinavia and the Baltic, which also includes the investigation of the Slavonic settlements and forts in the eastern part of Holstein. Scharstorf is dated (by dendrochronology) to 835 AD onwards, and it ceased to function c. 900 AD. The excavations have *i.a.* produced a large amount of early Slavonic pottery.

FREDERICK BAKER & JULIAN THOMAS (eds.): *Writing the Past in the Present*. Saint David's University College, Lampeter 1990. 215pp.

IAN BAPTY & TIM YATES (eds.): *Archaeology after Structuralism*. Routledge, London 1990. 314pp.

These two books present and represent the critical, post structuralist archaeology of the late 1980ies very differently. Both books are considering the practice and theory of archaeology from a contemporary and critical perspective, introducing new concepts such as discource, deconstruction, and dominance. While Archaeology after Structuralism remains within the same, distancing or dominating academic tradition which it critizises, Writing the Past in the Present is a successfull attempt to break away, offering a series of brief and readable essays, spanning from documentation and theory to museums.

MARGARET CONKEY & CHRISTINE HASDORF (eds.): *The uses of style in archaeology*. New Directions in Archaeology. Cambridge University Press 1990.

A series of papers from a conference held in 1985 covers the subject from a veriety of theoretical and analytical viewpoints. Most case studies are ethnographic or from outside Europe. This, however, allows a better identification of the meaning and function of style, thereby serving as illustrative examples for archaeological research.