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Aggemose - part II. Refitting and wall effect

By Ole Grøn

INTRODUCTION

In 1993 a shallow pit directly associated with a concentration of lithic material were interpreted as the remains of a small dwelling from the Kongemose Culture (Grøn & Sørensen 1996). This interpretation was based on a) the structural features preserved; b) the distribution patterns of the different artefact-types; and c) a comparison with other mesolithic sites with surviving structural remains. On this basis the position, approximate outline, and entrance zone of a mesolithic dwelling was suggested.

The Aggemose material is from a very small concentration. Compared to other Danish sites it is of rather limited size and from a typological point of view appears to be uncontaminated (Grøn & Sørensen 1996). In 1994 Sørensen refitted the material. The idea was to use the refittings as an independent test of our division of the site into a "dwelling area" and an "outside zone" around this.

The site was excavated and the artefacts recorded in one-metre squares. Where a hypothetical habitation border follows the boundry between two rows of squares, this poses no problem. Where such a border cuts through squares, however, it is impossible to determine whether an artefact from a square belongs on the one side of the postulated wall or the other.

In the illustrations, the refitted artefacts have been placed as close to the centres of the squares as graphically possible. This reduces the errors of their positions to less than 0.7 m (the distance to one of the corners). The outline of the hypothetical dwelling is shown as a rectangular shaded area measuring 3.5 by 3.5 metres in figures 1A and 1B.

Figure 1A shows all the lines of refitting observed except those from one core. Figure 1B shows the lines of refitting from the reduction of this core. Figure 2 shows the slightly revised dwelling, measuring 3.5 by 4.0 metres, suggested by this study. According to Sørensen, refitting reveals that quite a number of regular blades are missing from the material. These may either be located in the waste layer of which only a small test pit was excavated or have been transported from the site.

ANALYSIS OF THE REFITTINGS

To estimate how individual refittings relate to the hypothetical dwelling wall, four types of refitting may be distinguished:

A Refittings connecting a square outside the hypothetical dwelling with either another square outside it or with a square cut by its wall and thus containing material from either inside it or outside it. This category also comprises refittings connecting pieces found in one single square outside the proposed dwelling.

B Refittings connecting a square inside the hypothetical dwelling with a square outside it.

C Refittings connecting a square inside the hypothetical dwelling either with a square inside it or with a square which is cut by its wall and thus may contain material both from inside it and outside it. This category also comprises refittings connecting pieces found in a single square inside the proposed dwelling.

D The fourth type of refit connects a square cut by the hypothetical wall with another square cut by the same or another hypothethical wall. This category is of less interest since it does not yield any information on the exchange of material between the inside and the outside.

A total of 69 refittings were observed. With the postulated position of the dwelling they are distributed through the four categories as follows: A: 25 (36%), B: 2 (3%), C: 36 (52%), and D: 6 (9%) (fig. 2A; fig. 2B.a). It is interesting to note that only two lines of refitting connect squares inside the proposed dwelling with squares outside it. It is also noteworthy that these both connect squares immediately to the west of the proposed dwelling with squares inside it. If the proposed dwelling outline is adjusted by adding half-a-metre to its western side (fig. 2A), these refittings change from category B to category C and the distribution by category becomes: A: 25 (36%), B: 0 (0%), C: 37 (54%), and D: 7 (10%) (fig. 2B, b).

In both cases it is clear that the refittings indicate the existence of two independent zones within the approximately 7 by 8 metres large concentration of Kongemose material: one inside the proposed dwelling area and one outside it. This is shown in figure 2A, where some of the refitting lines of category A are shown as curved lines avoiding the proposed dwelling area to demonstrate that they do not necessarily cut through it in spite of the fact that they are shown as straight lines in the figure1.

To this point we have only been concerned with the single lines of refitting. In two cases, however, *series of refitting lines* indicate a connection between the inside and the outside of the hypotethical dwelling area. These two series are shown as straight dot-and-dash lines in figure 2A. They both connect the proposed habitation area with the zone to the east of it and thus support the assumption that an entrance should be located on this side (Grøn & Sørensen 1996).

The fact that it is possible to distinguish two complementary refitting zones in such a small concentration, one of which is conjunct with the postulated dwelling area, indicates that we are dealing with a highly structured accumulation of artefacts. Inside the hypothetical dwelling outline there are 37 refittings. Outside but immediately adjacent to it are other 25 refittings. Seven refittings give no information as they belong to category D, connecting artefacts that may belong to either the inside or the outside with other artefacts that may also belong to both zones.

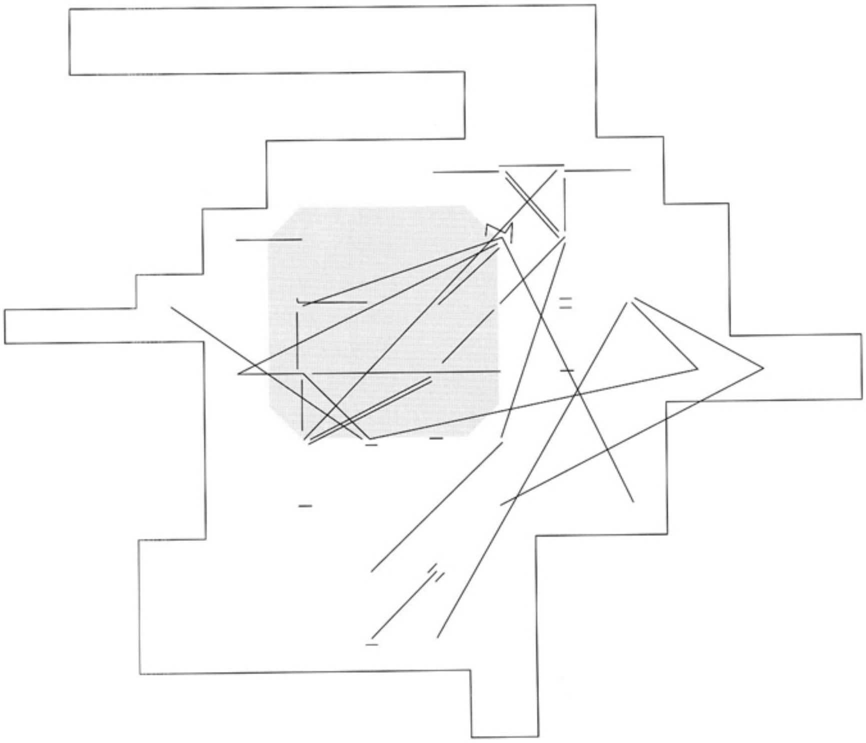
Out of a total of 62 refittings yielding relevant information, none connect the two zones. Considering the fact that they belong to a relatively small artefact accumulation, this seems quite a bold statement. To check the significance of this observation, the percentages of B-refits were calculated for the adjusted version of the hypothetical dwelling (4.0 by 3.5 metres) being moved all over the central part of the excavated area in half-metre steps. Figure 3A shows the value for each centre position of the dwelling. Figure 3B shows the corresponding percentage of C-refits, again with the values located in each centre of a series of conceivable locations of the hypothetical dwelling. A zero value occurs for the B-refits in two positions where at the same time the dwelling outline contains a reasonable amount (20-40) of C-refits.

The southern position, which is identical with the centre of the dwelling area in the position postulated in 1993, is marked with a full circle in figures 3A and 3B. It is interesting to note that this value is closely surrounded on all sides by values from 6.3% to 12.1%. Thus only a small dislocation of the outline will increase the percentage of B-connections considerably. This particular location for the dwelling outline can therefore be seen to produce a strong separation of the material not found in neighbouring positions.

The northern position is marked with a dotted circle. It is surrounded by somewhat lower values down to 3.1%. Its position is quite close to the north-western area where the low values show that refitting lines are nearly absent in this zone. The northern zero position thus seems more likely to be accidental than the southern one.

The southern position of the postulated dwelling outline has already been shown to behave reasonably in relation to the shallow pit containing remains of the culture layer and in relation to the distributions of a) lithic waste in general, b) blades and blade fragments, c) irregular pieces and d) burnt flint (Grøn & Sørensen 1996: figs. 5-6). Its

A



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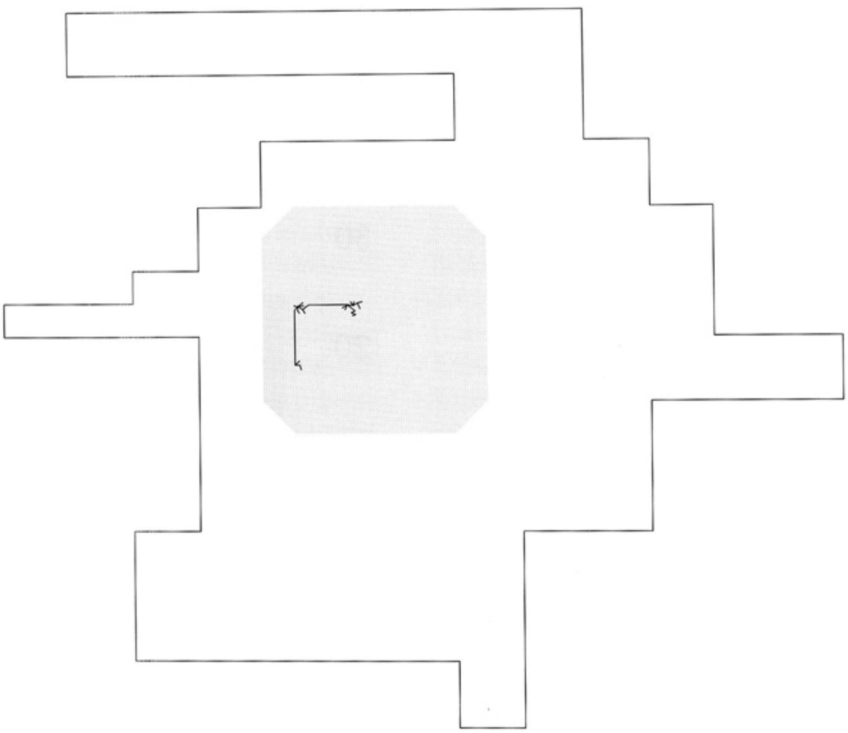

Fig. 1 A: Refitting lines of blades, flakes, cores etc. at Aggemose. B: Refitting lines from reduction of one core at Aggemose. The hypothetical dwelling area is shaded.

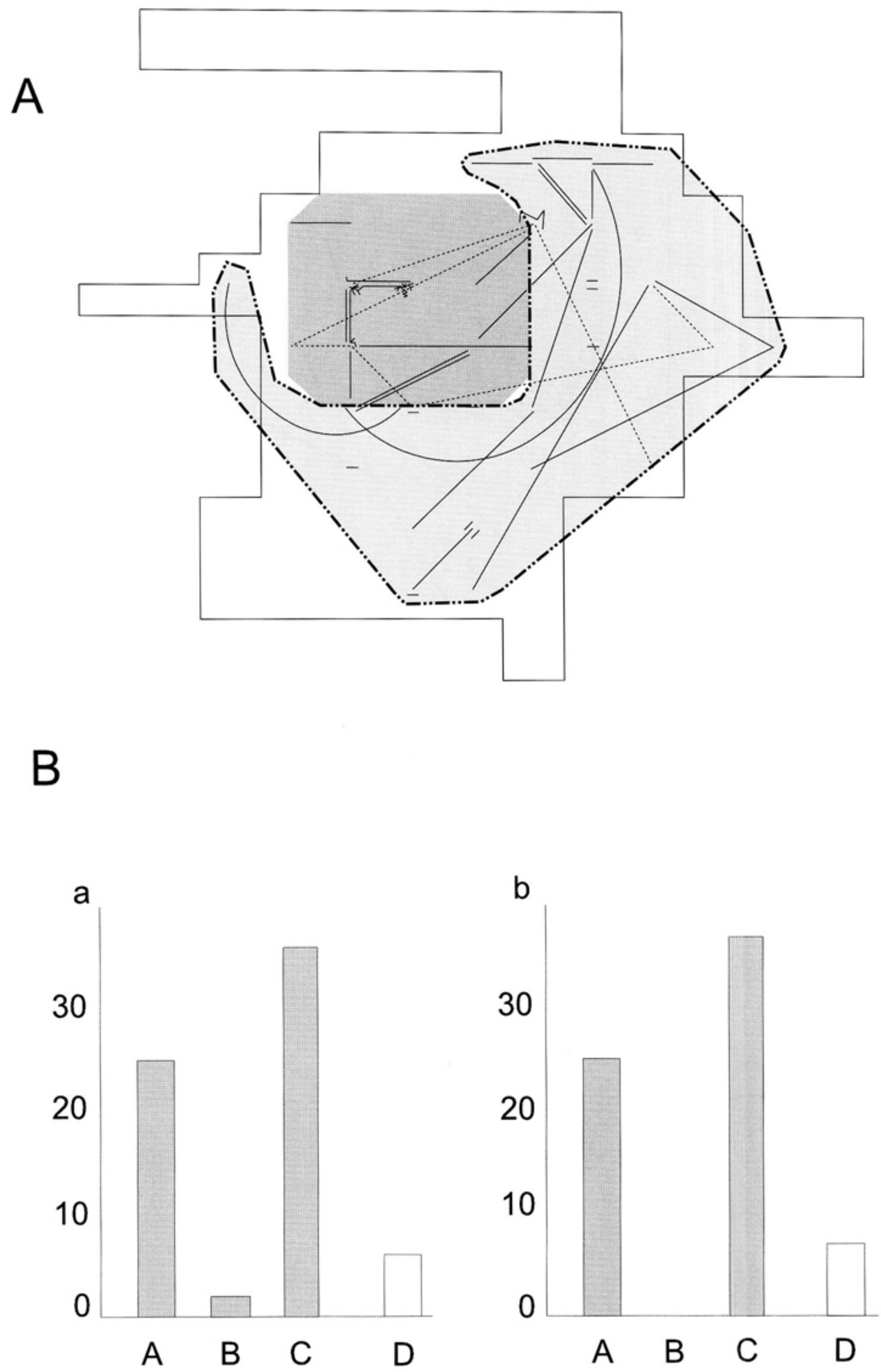

Fig. 2 A: The two complementary refitting zones at Aggemose. The lighter zone is proposed to be the area outside a habitation, the darker one inside it. The proposed dwelling area has here been enlarged with half a metre to the west compared to figure 1. Dash-and-dot lines show the two series of refits which connect the hypothetical dwelling area with the area to the east of it. B: The numbers of refittings of the categories mentioned in the text (Σ=69); B, a - the values for the dwelling floor suggested in 1993; B, b - the values for the modified dwelling.

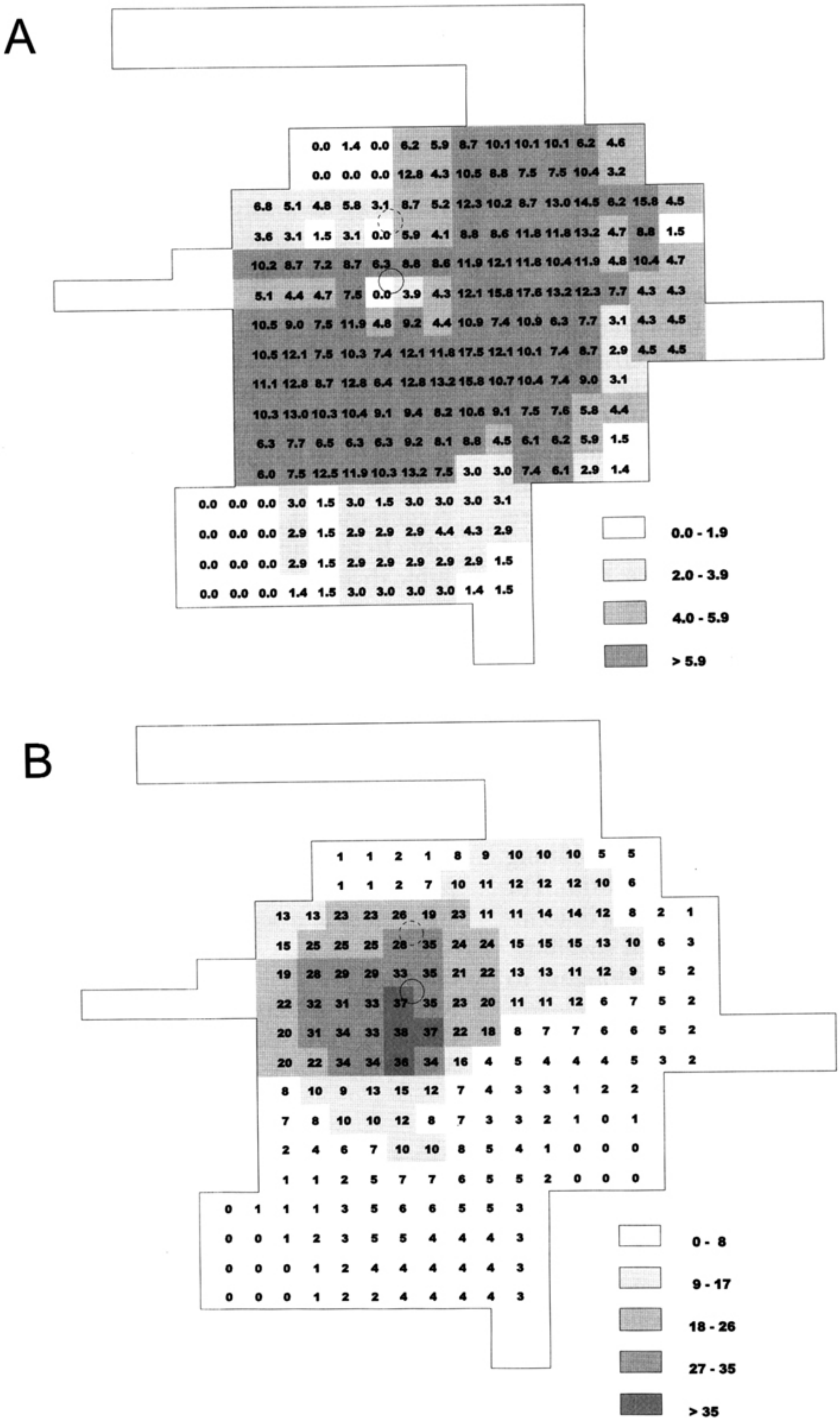

Fig. 3 A: The hypothetical dwelling outline is moved through the excavated area in half-metre steps. For each step the percentage of B-refits out of the total number of refits has been placed in the center cell. B: The same as A, but with C-refits replacing B-refits.

outline in the northern position, by contrast, cuts through the central part of these features. Such a border should at least have been observable where it cuts through the preserved part of the culture layer in the shallow pit.

CONCLUSION

The information obtained by refitting of the Aggemose material supports the interpretation we have already presented (Grøn & Sørensen 1996). The significant dichotomy between the two complementary refitting zones indicates that it is possible to observe the effect of a Kongemosian dwelling wall on the cultural items deposited in and around it. This is known as "wall effect". In respect of this analysis is it important to keep in mind that, even though refitting lines are shown as straight lines, this does not necessarily have any bearing on their "geographical" movements on the settlement surface.

The basic approach has been to distinguish "refitting zones", zones which appear as closed units with regard to refittings. Where such zones outlines with concave parts, such as the zone adjacent to the Aggemose "dwelling zone" (fig. 2A), their refitting lines may *cut through* other refitting zones which they are actually separate from. For the Aggemose site, three straight refitting lines intersect the outline of the hypothetical dwelling. Had they not been distinguished as belonging to another category of refittings from those clearly inside the "dwelling area", they would have made the observation of wall effect on the site difficult.

Since one must expect that many Stone Age habitations contain an "inside" and an "outside" refitting zone, and the latter will often be of a concave shape surrounding the dwelling, it is not unlikely that the problems in distinguishing proper wall effect may rather reflect a general misunderstanding of the meaning of the lines which visualize the refittings than the absence of walls and wall effect.

Waste layers and dumps may appear as zones that are not connected to their immediate surroundings but to more distant zones such as, for instance, dwelling areas. Had the waste layer on the Aggemose site been excavated, the obvious thing to do would have been to operate with this as a third zone. Flintknapping was obviously carried out in the "dwelling zone". The "missing blades" observed by Sørensen may well create numerous connections between the latter and the waste zone.

A strategy must be designed for each site analyzed. Without any preserved dwelling remains it may be difficult to construct fruitfull hypotheses. Obviously sites with more than one habitation phase can be expected to be too blurred to allow for the distinction of delicate features such as wall effect. In the case of the Aggemose site, however, it seems that it has been possible to produce a coherent reconstruction of a mesolithic dwelling. Of course one can reject the interpretation in the absence of conclusive proof. But the majority of the generally accepted models for economy, social organization, trade systems and even typological development in archaeology would have to be rejected if such demands for objective proof were to be insisted upon. Even refitting cannot *prove* but only indicate contemporaneity of material, just as very distinct and meaningfull distribution patterns can only *indicate* that we are dealing with an isolated activity phase. In the uncertain world of archaeology, the Aggemose site seems to be a fortunate case.

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REFERENCES

Grøn, Ole & Sørensen, Søren A. 1996: Aggemose. An Inland Site from the Early Kongemose Culture on Langeland. *Journal of Danish Archaeology*, vol. 11, 1992-1993: 7-18.

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Ringkloster
Ertebølle trappers and wild boar hunters in eastern Jutland
A survey

by Søren H. Andersen

ABSTRACT

The Late Mesolithic Ertebølle culture of Southern Scandinavia is known for its coastal settlements, the *"køkkenmøddinger"*. However it did not occupy the coastal zone alone, but was also present in the interior areas along freshwater lakes and rivers. When one hopes to give as detailed a picture as possible of the range of the settlement structure and economy of this culture, the lack of excavations of inland settlements in Jutland is strongly felt. The Ringkloster settlement in eastern Jutland is an Danish inland Ertebølle site, the first to be excavated and published in Denmark in the last ca. 50 years. The settlement is located on the prehistoric shore of Skanderborg lake, and thanks to excellent preservation conditions for organic materials has given us a fascinating insight into the material culture and economy of a west Danish inland Ertebølle settlement.

The excavation was extensive and comprised a settlement area on dry land with a large number of structural remains such as pits and hearths of different types, trenches, post holes etc., and an adjacent "dump zone" in the prehistoric lake in front of the settlement site with thousands of animal bones and artefacts of organic materials.

The settlement covered the whole Ertebølle culture of the later part of the Atlantic and the beginning of the Early Neolithic Funnel Beaker culture of the Subboreal, i. e. 5400 - 3550 BC. The sequence therefore also covers the Mesolithic-Neolithic transition, which at Ringkloster is dated to 3940 - 3820 BC.

Ringkloster is by far the largest inland settlement in this region due to a combination of several factors: The site was optimally located in the centre of the lake region, and it most probably functioned as a sort of inland "central site" surrounded by a series of smaller sites and contemporary with an extensive occupation along the coastline only ca 20 km away. In contrast to the "established" Danish opinion this site demonstrates that extensive inland Ertebølle occupation *also* took place in the older Ertebølle period, i. e. 5400-4700 BC; however the occupation at Ringkloster was of special intensity as regards debris and site area in the middle and younger Ertebølle 4700-3990 BC - as can also be observed at the coastal settlements. The pollen analytical study shows a primeval Atlantic forest of lime, elm, oak, alder and hazel. During the Ertebølle occupation a distinct elm and lime decline is observed - which was probably caused by the activities of the Ertebølle population. At the beginning of the Subboreal, ca 3900 BC, the first activities of (Neolithic) farmers are indicated by pollen of ribwort and a contemporary decrease of the forest, combined with a higher frequency of open ground herbs, all together demonstrating the opening up of the forest for farming activities.

The faunal remains tell that Ringkloster is a seasonal (winter) site occupied from autumn to early spring. The settlement is interpreted as a location for the procurement of meat, furs/hides and antler. The economic activities were centred on the hunting of wild boar, red deer and aurochs, combined with the trapping of animals with fur - especially pine marten and otter. The skeletons of the fur-bearing animals were discarded intact in the dump zone,

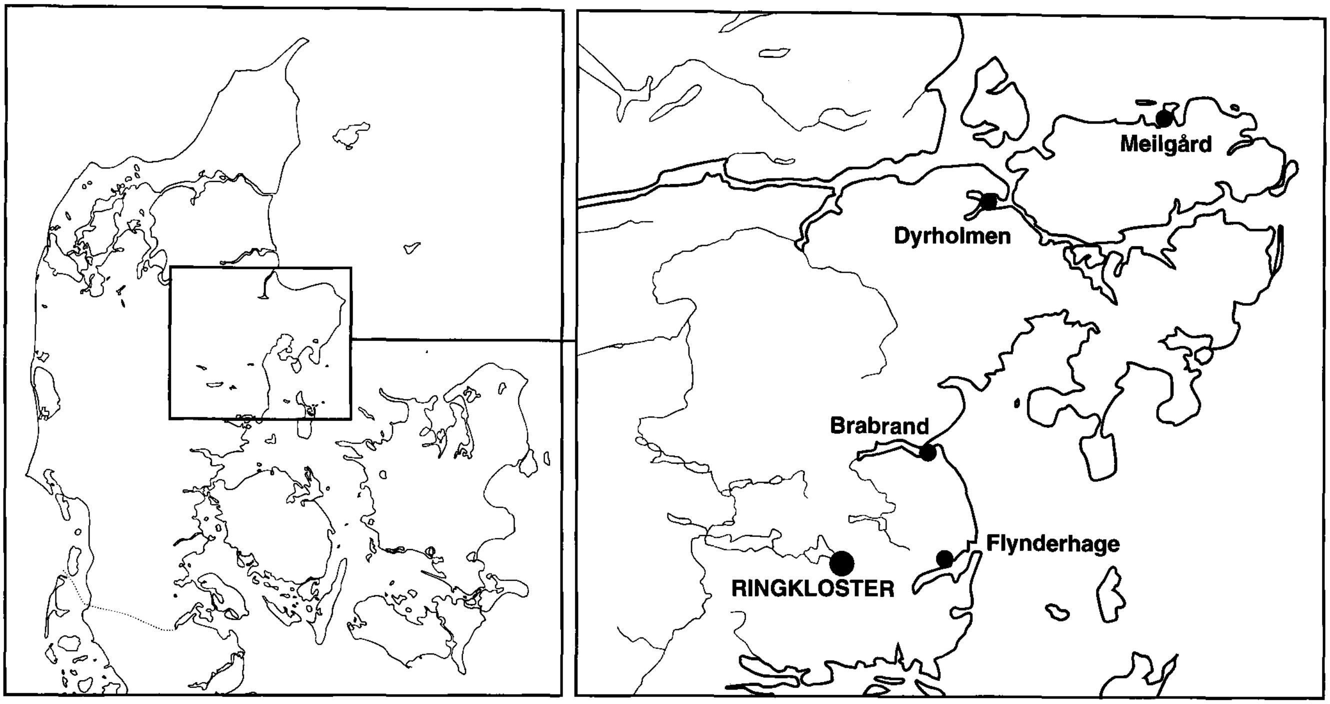

Fig. 1 Denmark and the area of study in East Jutland with the position of Ringkloster and some contemporary, coastal Ertebølle settlements. The High-atlantic coastline (ca. 4000 BC) is marked on the detailed map; S. Kaae del.

and the bones have distinctive fractures from the traps in which the animals were caught, and also cutting marks from the skinning process. Both its strong seasonality and the many bones of wild boar and pine marten make Ringkloster unique within the Ertebølle record of Scandinavia. The analysis of the bones of the larger mammals seems to demonstrate that the meat of these species was removed from Ringkloster to another location - probably on the coast. Quite extraordinary is the presence of bones of dolphins and marine fishes such as cod, saithe and flounder, species which prove contacts between Ringkloster and the coastal region.

The seasonal and economic interpretation of Ringkloster is supported also by the artefact inventory, which is distinctly different from what is known from the many excavations at coastal sites. At Ringkloster the dominant types are scrapers (used for hide), burins, denticulate and micro-denticulate blades, and transverse arrowheads, but in strong contrast to the coastal sites axes were uncommon. Artefacts of antler were abundant, as was antler waste, while bone tools are few - especially bone points, which normally are one of the common types in the *køkkenmøddinger.* New Ertebølle types from Ringkloster are curved bone "skinning knives" of rib bones, and oyster shells used as knives and/or scrapers.

Sherds of the usual Ertebølle pointed-base pottery and oval vessels ("lamps") were found in great numbers, and a small part of it is quite extraordinarily decorated with bands of stabs, lines of double stabs and rhombic patterns. Decorated Ertebølle pottery is extremely rare in Denmark and is only known from a small group of settlements in central eastern Jutland - within 20-25 km of Ringkloster.

As already mentioned the Ringkloster material includes a series of marine indicators - bones of dolphins, marine fish, oyster shells and amber. Such materials clearly show contacts between Ringkloster in the interior of Jutland and the coast, but of what character and at what social level is difficult to tell - i. e. do these materials reflect seasonal movements of people or groups of people from the coast into the interior of Jutland, or are they the vestiges of exchange networks connecting two independent settlement/social systems, an inland and a coastal? In other words are we dealing with one large coastal settlement system which used the interior (Ringkloster) for seasonal (winter) procurement of meat and skins, or do we have had two independent systems, "forest hunters" and "coastal fishermen"?

At present most arguments point towards interpreting Ringkloster as a seasonal part of one large East Jutland Ertebølle settlement and procurement system, which included both the coast and the interior. Such a situation must inevitably also have brought into existence social relations independent of whether these were originally intended or not. Ringkloster, therefore, must also have played an essential social role in the east Jutland Ertebølle system - a role as essential as the economic one.

INTRODUCTION

The Ertebølle culture of Southern Scandinavia is famous for its coastal sites, especially the "køkkenmøddinger" (kitchen middens), like the *locus classicus*, Ertebølle itself (Madsen *et al.* 1900; Andersen & Johansen 1987). The sites which have received most attention in the study of the Ertebølle culture are coastal settlements in Jutland, i.e. Meilgaard, Ertebølle and Dyrholmen (fig. 1). This has given a false impression of the Ertebølle culture as a purely coastal culture characterised by large kitchen middens, an opinion which is widespread in the international literature. However, this opinion needs strong modification.

As early as 1892 the first Danish inland Ertebølle site, Vester Ulslev on Lolland, was mentioned in the literature (Bahnson 1892, p. 163) and later similar sites were recorded from Zealand - especially in the large Åmosen basin (Mathiassen *et. al.* 1943; Andersen 1983) and in the Neverkær bog on Funen (Albrectsen 1973; Andersen 1977). Inland settlements are described also from other areas of the Ertebølle culture, e. g. Southern Sweden (Ageröd V, Bökeberg III) (Althin 1954; Larsson 1983; Regnell *et al.* 1995) and Northern Germany (Ellerbek and Satrup Moor) (Mestorf 1904; Schwabedissen 1960; 1994). The main part of this comes from the eastern and southern part of the Ertebølle area, while excavations of inland Ertebølle settlements in Jutland were not carried out or published. In contrast to the excellent preservation of organic materials at the coastal settlements, the inland sites in this part of Denmark showed no trace of Mesolithic bone, antler or wood This was due to the sandy subsoil and acid bogs, which provided geological conditions similar to those found in most other Northwest European countries.

Nevertheless, numerous stray finds and surface collections from a large number of settlements along the rivers and lakes of Jutland have clearly demonstrated that the Ertebølle culture also exploited the inland biotopes of this region (Mathiassen 1937). Unfortunately very few of the inland sites have been systematically excavated and properly published.

To obtain as complete a picture as possible of the total range of the subsistence activities of this culture, it has for many years been desirable to find and excavate an inland site in Jutland, preferably one where organic materials were preserved, and to use it for the comparative analysis of coastal and inland settlement systems. Such a site was played into our hands with the discovery of the Ringkloster settlement.

THE RINGKLOSTER SITE

History of investigation

Ringkloster was the first inland Ertebølle site in this part of Denmark where bone, antler and wood were preserved; even today, almost 30 years after its discovery, it is still the only Late Mesolithic inland settlement in this area with good conditions for the preservation of organic materials.

As the only publications are preliminary descriptions of the first 3 years of excavation (Andersen 1975; 1979b), and because different aspects of the material have been used and referred to on several occasions in the international literature, the following survey is given as an attempt to provide an up-to-date, general picture of the status of research of this unique north European Mesolithic settlement (Rowley-Conwy 1981; 1993; Andersen 1975; 1994; Enghoff 1994).

Mesolithic flint artefacts have been known for many decades from surface collections on inland sites in Jutland (they were earlier labelled "Gude-

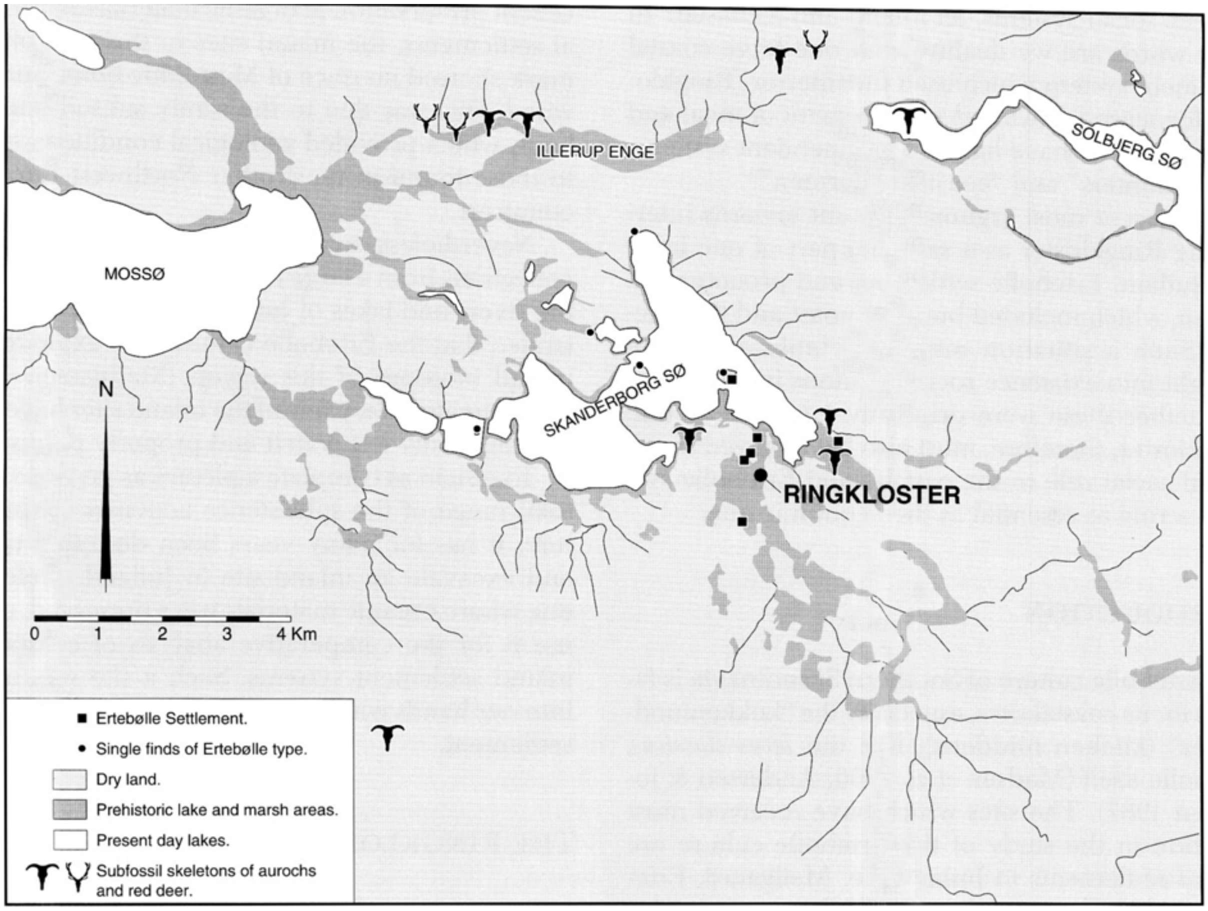

Fig. 2 The extension of the lakes in the Skanderborg Sø region in the Late Atlantic (dark shaded). Subfossil finds of aurochs and red deer are indicated; single finds and settlements of Ertebølle type are marked; S. Kaae del.

naa Culture" (Mathiassen 1937), a term which today has been totally abandoned because it is based on mixed sites containing artefacts from all Danish Mesolithic cultures (Andersen & Sterum 1971).

In actual fact the Ringkloster settlement was *not* a new Mesolithic site. It had been known for years, and amateur archaeologists had collected artefacts from the surface of the ploughed field. It was labelled as site no. 86 by Mathiassen, when he published his paper on the "Gudenaa Culture" (Mathiassen 1937, p. 53). Apart from a single test-pit in the settlement area proper, no excavation took place on this site in connection with his work in the late 1930s.

In 1969 drainage work in the bog adjacent to the settlement exposed large quantities of Ertebølle artefacts, and as a great surprise also well preserved animal bones, antler and wood. The artefacts and the presence of the organic materials showed that for the first time a west Danish inland Ertebølle settlement had been found with good preservation conditions for organic materials. A test excavation followed, and revealed a 20-80 cm thick "waste layer" or "dump zone" of discarded material in the prehistoric lake sediments (today a bog) in front of the dry land settlement. The situation at Ringkloster is therefore similar to that at many other Late Palaeolithic and Mesolithic sites of Northern Europe, i. e. it incorporates a habitation area proper on dry land and an adjacent "dump" in the lake sediments in front of the settlement, e.g. Stellmoor, Star Carr etc. (Rust 1943; Clark 1952).

Geology

Ringkloster is located in eastern Jutland very close to Skanderborg Sø, one of the most beautiful areas of Denmark, consisting of a mixture of steep forest-covered hills interspersed with wider valleys, small boggy areas and larger lakes (fig. 2). The area is called "the central Jutland lake upland" (Jacobsen 1976, p. 2), and ca. 10 km to the Southwest is the highest part of Denmark with elevations of up to 173 m. 3 - 5 km to the East-Northeast we find the lake, Solbjerg Sø, and 8 km to the west is the large lake, Mossø. In the past there used to be another large lake to the North, now the bog Illerup Enge (fig. 2).

Skanderborg Sø is one of the largest lakes in Denmark (ca. 9 km^2), today measuring 4-5 km North-South and 6 km East-West; by Danish standards it is deep (18.8 m), and in the Mesolithic (with less sediment) it must have been even deeper. The bottom-relief is like the surrounding landscape very undulating. The shores (especially towards North and East) are steep and depth increases rapidly, and therefore the reed belt along the lake is narrow. Many small rivers and springs have their outflow in the lake - especially towards the east and south (fig. 2).

The distance from Ringkloster to the east coast of Jutland (Norsminde Fjord) is as the crow flies ca. 14-18 km; to the Northeast (Brabrand Fjord) it is ca. 18-20 km; and to Horsens Fjord in the South it is ca. 14-15 km. In the Late Mesolithic the fjords cut much further into eastern Jutland and the distances were some kilometres shorter (fig. 3)[1].

Skanderborg Sø is located just 6 km west of the main watershed in eastern Jutland, and as a part of the Gudenå catchment area it is drained to the west via Mossø into the Gudenå, which then runs in a North to Northeast direction to the sea ca. 55 km away at Randers Fjord. Topographically the Skanderborg Sø catchment area is separated from Horsens Fjord (to the South) and Norsminde Fjord (to the East) by ridges of hills, running parallel to the coast. There is therefore no direct connection by water from Ringkloster to the east coast (fig. 3).

The subsoil of this region is a mixture of morainic clay and meltwater sand and gravel. The areas to the North, East and Southeast of the lake are dominated by morainic clay, while sand and gravel dominates towards the west and Southwest. At the settlement proper the subsoil is clay, while the opposite side of the lake is characterised by sand and gravel. The bottom of the prehistoric lake in front of the settlement is blue-grey calcareous clay.

Along the southern edge of Skanderborg Sø is a large system of morainic hills running E-W; this ridge was formed during a late stage of the Weichselian glaciation, when the ice front was just south of the lake (Harder 1908). To the south this hill ridge is connected with a 3-4 km long (NW-SE) and 1-2 km wide "valley" which was either eroded by a small local glacier or by melt water running towards the north from the ice front to the south.

A large local meltwater lake formed in this valley, and thin layers of calcareous clay and fine sand were deposited on the lake bottom ("varves") - a geological situation quite different from that in the rest of the Skanderborg Sø system, which follows the "normal" geology of this region, i. e. with sediments of melt water sand and gravel (Harder 1908).

The presence of this type of clay combined with a high water level in the modern bog is the background for the extraordinary preservation conditions at this location. In the rest of the Skanderborg Sø area several other Mesolithic settlements are known, but they are all without organic material, and follow the normal west Danish pattern with only flint, stone and charcoal preserved.

The Late Glacial and Early Postglacial history of Skanderborg Sø is well illustrated by systems of lake terraces along the shores, which show a gradual lowering of the water level from ca. 29.50 m above present sea level in the Late Glacial to ca. 24-25 m in the Mesolithic; the modern lake level is 23-24 m above sea level.

As the connection between the valley and Skanderborg Sø was very narrow and the above mentioned morainic ridge formed a sort of threshold on the lake bottom, it was impossible for the sediments to be washed out into the much larger and deeper parts of Skanderborg Sø, resulting in a very fast sedimentation in this part of the lake.

As early as the Atlantic period a swamp with a dense vegetation of alder (*Alnus sp.*) was established

1 We have tried experimentally to measure how long it takes in a modern environment and without any close knowledge of the terrain to walk from the coast to Ringkloster. The result was 5-6 hours.

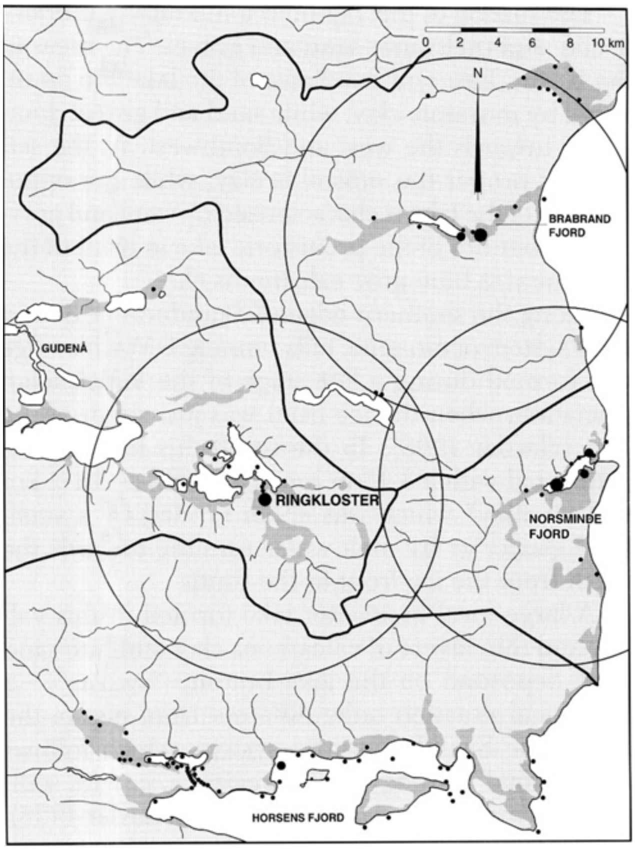

Fig. 3 Central eastern Jutland with the maximum extension of High-atlantic fiords and lakes (dark shaded): Ertebølle settlements are also indicated. The biggest settlement, "central" site in each resource area is marked by a large dot. Each "central" site is surrounded by a 10 km circle; Thick black lines indicate main water sheds S. Kaae del.

along the lake shore, and the accumulation of sediments continued during the following millennia.

Another geological aspect of this area is the occurrence of large deposits of red ochre only 1.6 km to the east of Ringkloster. The concentration and extension of ochre is so large, that even today the fields and hillsides are coloured bright red; the ochre was exploited and used as the basis for paint production as recently as in the 16th century[2].

The environment

In the Mesolithic Skanderborg Sø was much larger than today especially towards the West, Southeast and South, where it had several large extensions which today are bogs (fig. 2). These areas, especially those to the South, must at this time have been lakes, extensive swamps and boggy areas and a very characteristic topographic element in the biotope of the Mesolithic. The southern part of the lake had also a lot of small inlets, and the steep-sided hills were cut by gullies going down to the lake shore. Altogether this gave a very varied biotope.

The lake in front of the Ringkloster settlement was 3-4 km long and 6-700 m wide, and was connected with the main lake through a very narrow opening where "Ringkloster" (today a farm) is located[3].

The sediments and levels of the cultural layers responded to variations in the level of the prehistoric lake. During the Late Mesolithic occupation (pollen zone VII) we observe a gradual rise in the water level, followed by a lowering indicating a change to a drier climate at the transition from pollen zone VII-VIII (Atlantic-Subboreal) at ca. 3900 B.C.

Humified peat could be followed to an altitude of ca. 25 m, and this combined with the archaeological finds shows the maximum extent of the lake and the position of its shore during the Ertebølle occupation.

The pollen analysis gives a detailed picture of the vegetation around the settlement before and during the habitation period from the Atlantic to the early Subboreal (pollen zone VII-VIII) (Rasmussen this volume).

Prior to the occupation (in the Atlantic period, pollen zone VII) the landscape was characterised by a dense and stable primeval forest dominated by lime (*Tilia sp.*), elm (*Ulmus sp.*), oak (*Quercus sp.),* hazel (*Corylus avellana*) and alder (*Alnus sp.*) with a restricted field layer vegetation. In the forest there was also a dense vegetation of ivy (*Hedera helix*), which may have been a climber on tree trunks and branches. The most dominant vegetation type near the settlement however was an extensive alder carr covering

2 One cannot exclude the possibility that this resource also was exploited in the Mesolithic, cf. the use of red ochre for tanning skins etc.

3 "Ring" is a Danish place name and "kloster" is Danish for "monastery". In the medieval period "Ringkloster" was a convent.

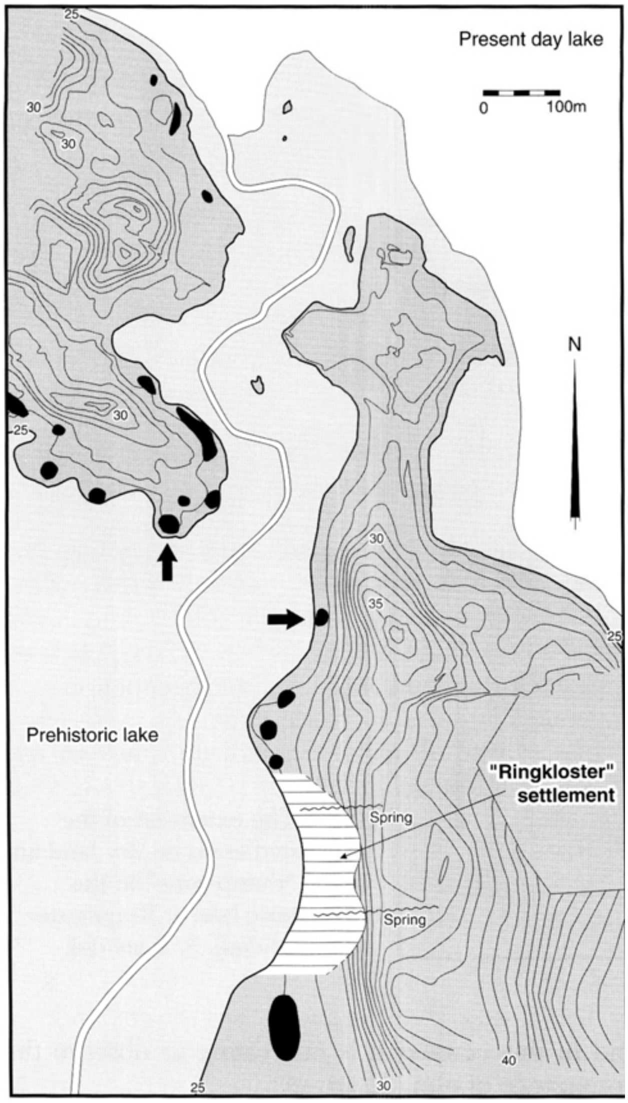

Fig. 4 The Skanderborg Sø and the Ringkloster area in the High Atlantic period, 4000 B. C. "Smaller", Late Mesolithic Ertebølle sites in the vicinity of the Ringkloster settlement are marked by black. Arrows indicate where test excavations have taken place. S. Kaae del.

a belt along the lake margin, with open water only found further from the shore. Also today dense alder carr vegetation is a characteristic feature along the shores of Skanderborg Sø - especially where the lake is shallow.

From the beginning of the Ertebølle occupation the settlement refuse was deposited in organic mud (gyttja) - indicating there was open water in front of the settlement, but gradually (mainly from the transition Atlantic/Subboreal) the lake filled in and the lake shore changed into a dense alder carr. The preservation conditions were very good, but some of the organic remains have been gnawed by mice and beetles, probably because they lay on the surface for some time before they ended up in the wet, calcareous sediments[4].

An important question is whether it has been possible to find traces of man's impact on the surrounding vegetation. According to the palynological investigations (Rasmussen 1998 - this volume) two main phenomena are observable during the Ertebølle occupation in the Atlantic: A contemporary and distinct elm and lime decline several hundred years before the end of the Ertebølle phase. Thus the elm decline at Ringkloster is older than the "classical" Danish elm decline at the transition from Ertebølle to Funnel beaker culture, ca. 3900 B.C. According to Rasmussen the early elm and lime decline at Ringkloster is likely to reflect the local activities of the Ertebølle population, either as a clearing of the surrounding forest, or as a systematic selection of lime and elm trees to make canoes, dwellings and wooden tools. This opinion is supported by the dominance of elm in the charcoal samples. Also the relatively high frequency of hazel (*Corylus avellana*) could be a result of human impact, in this case of systematic coppicing of hazel to produce long and slender stakes for fish fences, etc., such as have been found at Ringkloster and are a very characteristic aspect of many Ertebølle (coastal) settlements, e. g. Tybrind Vig (Andersen 1985, pp. 60-61). Also hazelnuts were an important food resource and an essential component of the diet.

Later (at the beginning of the Subboreal period, ca. 3900 B.C.) the pollen diagram indicates a fall in the lake level and a simultaneous decrease of the forest followed by a higher frequency of open ground herbs; the first pollen finds of ribwort (*Plantago lanceolata)* are recorded at this stage. These vegetation changes demonstrate an opening of the primeval forest, and the activity of Neolithic farmers in the vicinity (also indicated by archaeological finds at the

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4 Unpublished report from cand. scient. Bodil Noe-Nygaard of 18/3 - 1985.

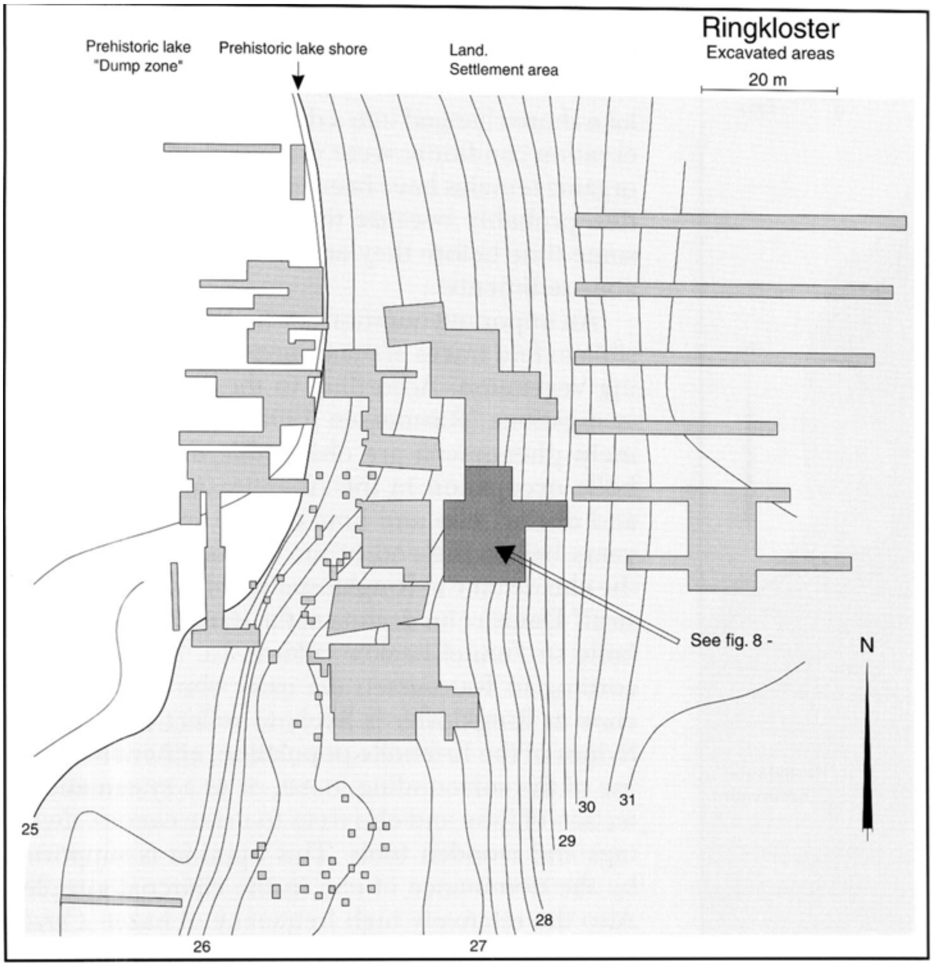


Fig. 5 The extension of the excavated areas on dry land and in the "dump zone" in the prehistoric lake at Ringkloster (dark shaded). S. Kaae del.

site - see later). The decrease in the forest is a sign of anthropogenic influences aimed at making clearances for cattle grazing; traces of arable farming are not directly recorded in the two Ringkloster diagrams.

A sample of 205 pieces of wood from the Ertebølle occupation layer (of which 115 were charred) has been determined as to species (Malmros 1986)[5]. The commonest charcoals identified were elm (*Ulmus sp.*) (24%), hazel (*Corylus avellana*) (17%), oak (*Quercus sp.*) (17%) and alder (*Alnus sp.*) (16%), which reflects the types of wood used at the site as firewood and left over from the production of wooden tools. This sample gives an impression of which specie(s) of wood were chosen by the inhabitants, and in this context it is interesting to observe the dominance of elm (*Ulmus sp.*).

The determinations of the unworked and uncarbonized wood show that alder was completely dominant (70%), followed by elm (10%) and hazel (9%). This shows the type of vegetation growing close to the settlement. Analysis of seeds and fruits from the cultural horizons in the lake sediments has also been carried out (see later)[6].

The fauna of the late Atlantic/Early Subboreal in the region around Skanderborg lake is shown by the thousands of animal bones from the "dump zone" in front of the settlement, and by subfossil

[5] Unpublished report by C. Malmros in the National Museum, NM VIII A 5502 of 11/11-1986.

[6] Unpublished reports by G. Jørgensen in the National Museum, NM VIII A 5502 of 18/9-1974 and 28/1-1976.

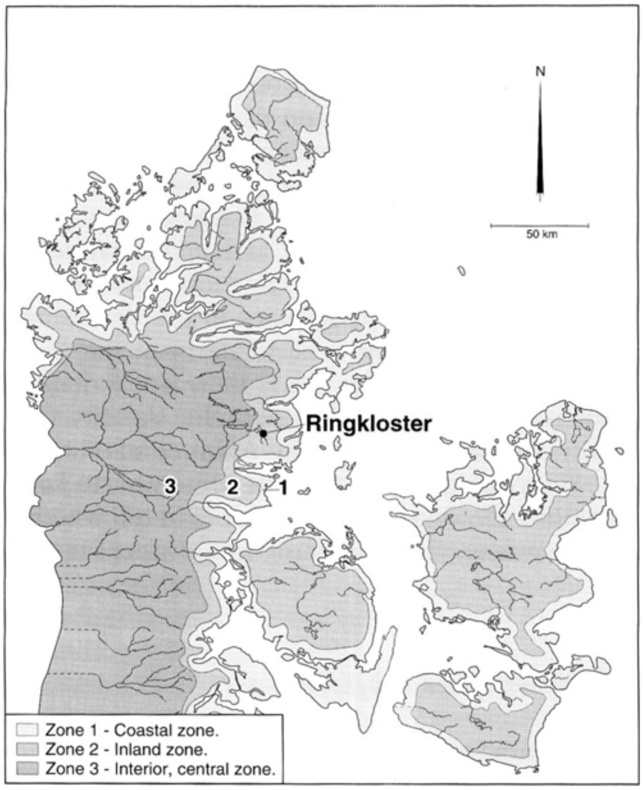


Fig. 6 The position of Ringkloster in relation to the 3 Ertebølle occupational zones in Jutland. S. Kaae del.

skeletons of aurochs (*Bos primigenius*) and red deer (*Cervus elaphus*) found during peat-digging in bogs of the region (fig. 2)[7]. For a description of the faunal remains: see the papers by Rowley-Conwy (1998) and Enghoff (1998) in this volume.

The many small rivers and the lake offered excellent opportunities for fishing, and the extensive swamps and marshy areas, especially south of the settlement, must have offered very good conditions for wild boar, waterfowl etc.

Altogether the area around the site constituted a very mixed biotope which included primeval forest, extensive alder swamps, lake shores, open lake, many small streams and rivers, and the possibility of good fishing at the narrow passage between the two parts of Skanderborg Sø.

The settlement

The settlement lay at the northern end of the prehistoric lake, ca. 800 m south of the narrow passage between the two parts of Skanderborg Sø. The concentration of other Mesolithic sites where the two lakes join is a reflection of the fact that such a position is favourable for fishing, but as Ringkloster is further to the South it is doubtful if access to good fishing played any role for its location (fig. 4).

The Ringkloster settlement is located at the sloping foot of a 3-4 m high, rather steep hillside facing West to Southwest. This hill belongs to a large glacial terrace which follows the eastern side of the bog/ lake area. In the Late Glacial or early Post Glacial the lake eroded the terrace at a level of ca. 26.5 - 27 m above sea level, thereby forming a 20-30 m wide flat area running east-west along the lake, which was the settlement area (fig. 4). Subsequent to the Stone Age the hillside has been flattened out by erosion and ploughing. To the North and South the settlement area is delimited by two small headlands, and at the site two streams had their outflow from the hill - probably one of the location factors of the settlement (fig. 4).

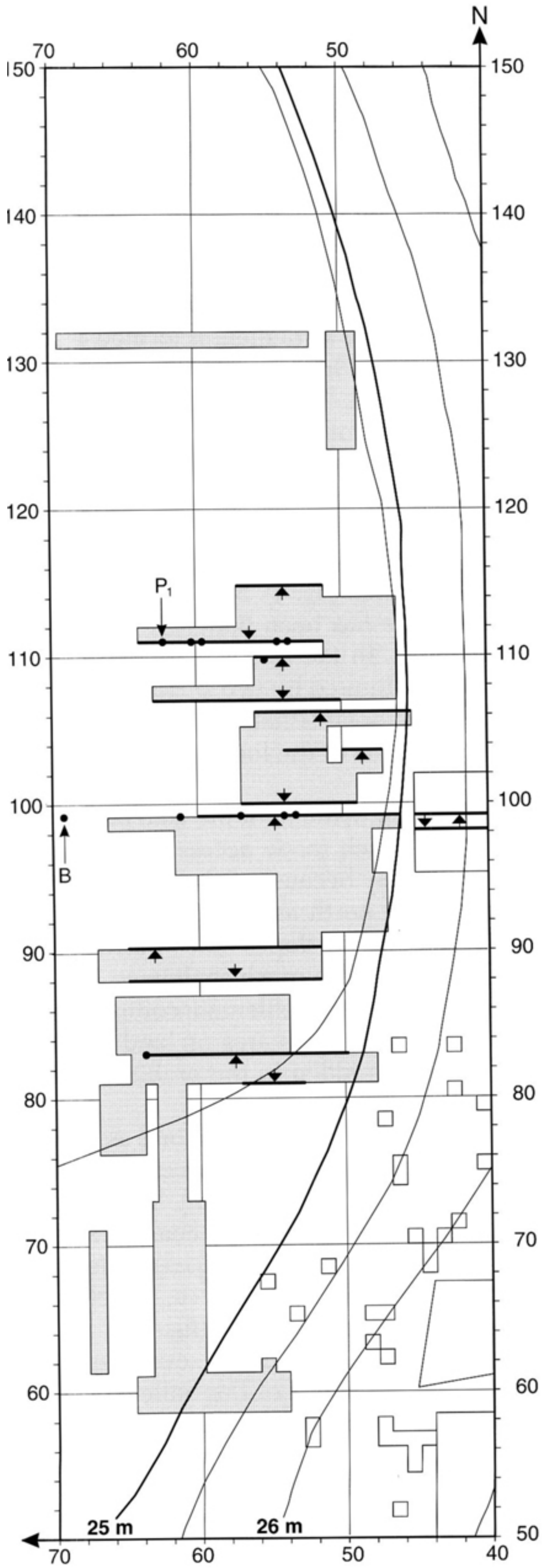
In front of the settlement the lake bottom slopes very steeply, which made access to the settlement from the lake easy because of the great depth of water. Towards the north and south (where the headlands are) the bottom slopes much more gently and the lake was therefore much shallower.

The full Ringkloster settlement comprises two different units - a settlement area on land and an associated dump or midden in the prehistoric lake deposits in front of this.

The settlement area on the shore, as defined by the distribution of flints, measures ca. 100x30 m orientated north-south (ca. 3000 m^2). This is the same size as the largest contemporary coastal *"køkkenmøddinger"* (Andersen 1995). The adjacent "dump zone" in the lake sediments measures ca. 90x20 m orientated north-south (ca. 1800 m^2)(fig. 5).

To both the North and South several smaller and well defined flint scatters of Ertebølle type are to be found well separated from the main site. To the North at least 3 such flint concentrations have been recorded, measuring 20x20 m, 10x10 m and 10-15x15 m respectively. To the South 2 concentrations measuring ca. 20x20 m and 10x10 m are also known, and

7 The data for the map, fig. 2, have been kindly submitted by Knud Rosenlund, Zoological Museum, Copenhagen.



Mesolithic flint debris has in addition been found on the terrace to the rear of the settlement (fig. 4). The horizontal distribution of cultural remains in the main settlement area on dry land furthermore reflects smaller discrete concentrations. All these observations prove that Ringkloster was not one large settlement unit from the very beginning, but is the result of an accumulation of archaeological debris from many visits to the site. The most extensive and intensive occupation took place in the Late Mesolithic Ertebølle period - particularly in the Late/ Younger Ertebølle. The site is therefore a demonstration of a high level of topographic stability/continuity and thereby indirectly resource stability for ca. 1800 years covering the Late Mesolithic to Early Neolithic. However, it is impossible to tell whether the site was used continuously in the strict sense or not.

The setting of the Ringkloster site

It is essential to see settlements not only as individual sites, but also as a part of the territory in which they were located, and of the larger settlement system in which they functioned.

In view of this the Skanderborg Sø region has been the object of intense reconnaissance for many years, but despite this no more than 5 other Ertebølle sites have been recorded (apart from scattered stray finds of blade cores, axes, etc.)

A cluster of small flint concentrations is found on a SE facing headland ca. 375 m NNW of Ringkloster - closer to the narrow passage between the two prehistoric lakes (fig. 4).

All the other Ertebølle sites in the lake area are distinctly smaller than Ringkloster and measure only ca. 10-20x10-20 m; flint debris and flint artefacts have been surface-collected from ploughed fields, and in two cases small test excavations have been carried out (fig. 4).

If we look at the area in terms of site catchment (Vita-Finzi & Higgs 1970), ca. 30% of the total area

Fig. 7 Excavated areas in the "dump zone" at Ringkloster. Measured sections are indicated by thick, black lines and arrows. The position of the pollen series "P1" and the boring "B" is also marked. Other pollen series are indicated by black dots. S. Kaae del.

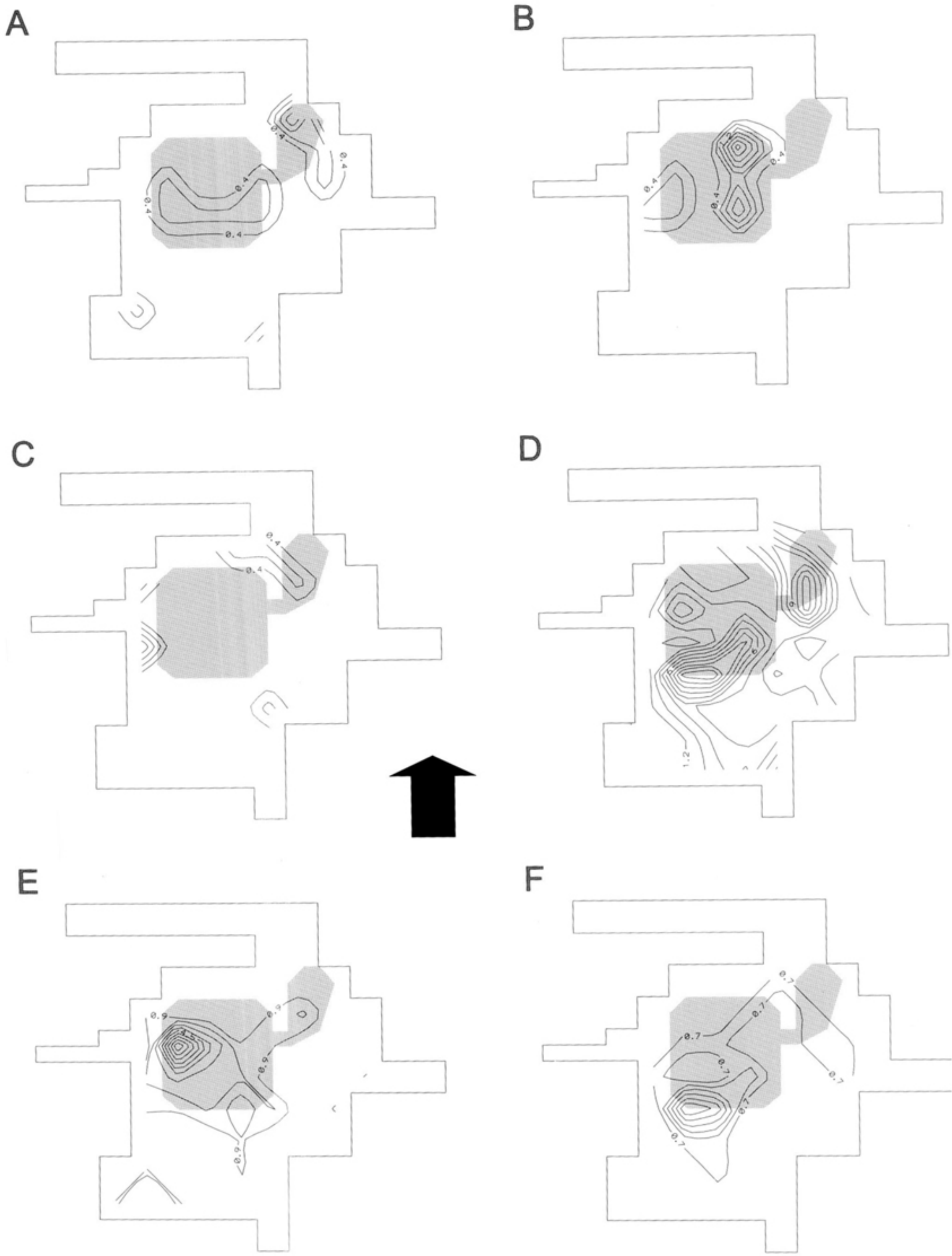


Fig. 7. Distribution of: A, broad trapezes, equidistance 0.4, max=2; B, burins and burin spalls together, equidistance 0.4, max=3; C, knives with retouched backs, equidistance 0.4, max=2; D, blades and blade fragments with micro-polishes on their edges, equidistance 1.2, max=120; E, intact blades with no observable micro-polishes on their edges, equidistance 0.9, max 9; F, intact blades with micro-polishes on their edges, equidistance 0.7, max=7.

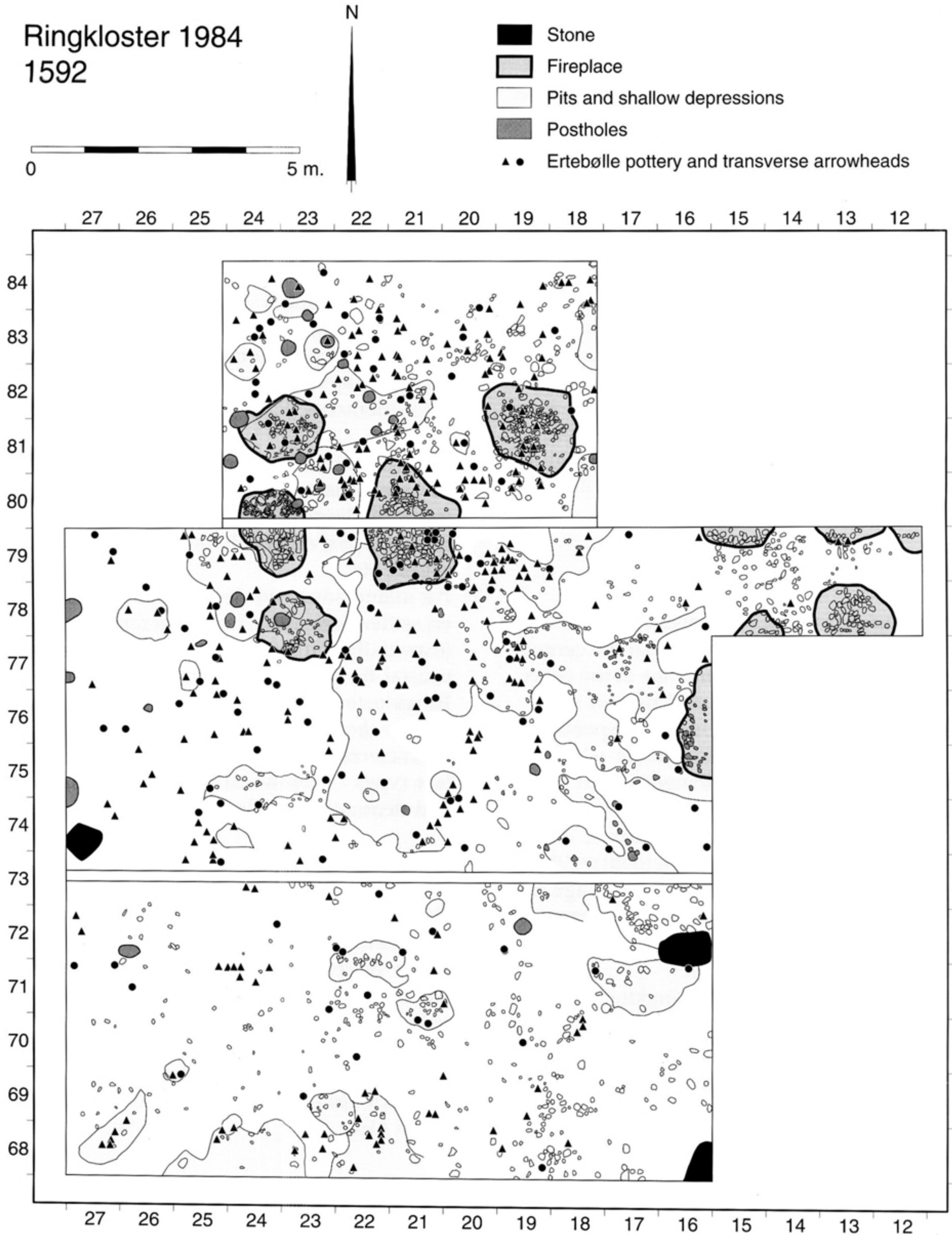


Fig. 8 Excavation plan of a part of the Ringkloster settlement on dry land. Black dots indicate transverse arrowheads of late Ertebølle-type. Black triangles indicate thick-walled Ertebølle pottery. S. Kaae del.

within a 5 km radius (78.57 km^2), in the Late Mesolithic was lake, ca. 22% swamp and ca. 48% high-lying, dry ground. Within a 10 km radius from the settlement (ca. 314 km^2) lake made up ca. 11%, swamp ca. 7%, and dry land ca. 82% (fig. 3).

Altogether the inland Ertebølle settlements of the Skanderborg Sø territory cover ca. 7000 m^2 (fig. 3).

Reconnaissance along the shores of the other lakes in the region has not revealed any other large Ertebølle sites, but only stray finds and small flint scatters, and it is therefore an open question whether any other large settlements existed.

The conclusion is that Ringkloster gradually became the largest settlement in the Skanderborg Sø territory, primarily because it remained located at the optimal position in the resource area (the centre of Skanderborg Sø) for 1800 years. It can therefore be regarded as a sort of "central site" in the Late Mesolithic in this East Jutland territory (fig. 3).

Ringkloster in a regional context

The distribution map of the Ertebølle settlements in Eastern Jutland clearly demonstrates that the centre of gravity of the Ertebølle habitation lay at the coast (fig. 3). Here we find the largest and biggest settlements. Even if we take all source critical aspects into consideration, this fact is indisputable whether expressed in the number of settlements, their size, the thickness of the deposits or the number of tool types. A crude expression of this is a simple comparison of the total area of all the settlements within a 10 km radius of the central site, Flynderhage in Norsminde Fjord (ca. 11700 m^2) with the contemporary inland sites on Skanderborg Sø (ca. 7000 m^2) (Andersen 1995, pp. 48 and fig. 7).

Seen in a regional perspective Ringkloster is located where the distance to the nearest coastal area is ca. 14-18 km., whether one goes towards the North-east, east or south. In these fjords we find many contemporary Ertebølle settlements, and they are structured with one or two large, centrally situated sites surrounded by smaller "satellite" sites (fig. 3).

The topographical facts raise the obvious questions whether Ringkloster represents an inland forest system ("forest-hunters") independent of the coastal system ("coastal fishermen") - and if so how the system functioned in relation to the coast - or whether it was part of one "large system" with its centre of gravity on the coast incorporating both coastal and inland resource areas. These questions are dealt with later in this article.

Ringkloster in the settlement pattern of western Denmark

Traces of Ertebølle inland activities are known from most central and south Jutland rivers and lakes. Based on the number and range of tool types it is possible to divide the Ertebølle habitation in this region into 3 occupation zones, each characterized by its topographical location and the artefact types of the settlements (fig. 6).

1) A coastal zone (extending 0-10 km inland) with the great majority of the settlements, which are generally large in extent and have a wide range of tool types, especially of axes (Ertebølle, Norsminde etc.).
2) An inland zone with fewer (and generally smaller) settlements with a restricted range of tool types (especially with few axes) stretching from the coastal hinterland up to ca. 30 km inland, e.g. Ringkloster, Satrup Moor.
3) Finally there is An interior, central Jutland zone characterized by very small sites with few artefact types - mainly arrowheads, blade scrapers and denticulate blades.

A large number of the so-called "Gudenaa Culture" sites belong to the last mentioned group (Mathiassen 1937). As none of these sites have preserved organic material, we have no possibility of any determination of seasonality and subsistence activities. However, the preferred topographical location on river banks and along lake shores combined with the small area of the sites and the many arrowheads strongly argues in favour of interpreting these localities as Ertebølle "hunting camps" (Binford 1983, pp. 118 - 119).

EXCAVATION

The excavations began in 1969 and continued until 1985[8]. From the very beginning the work was estab-

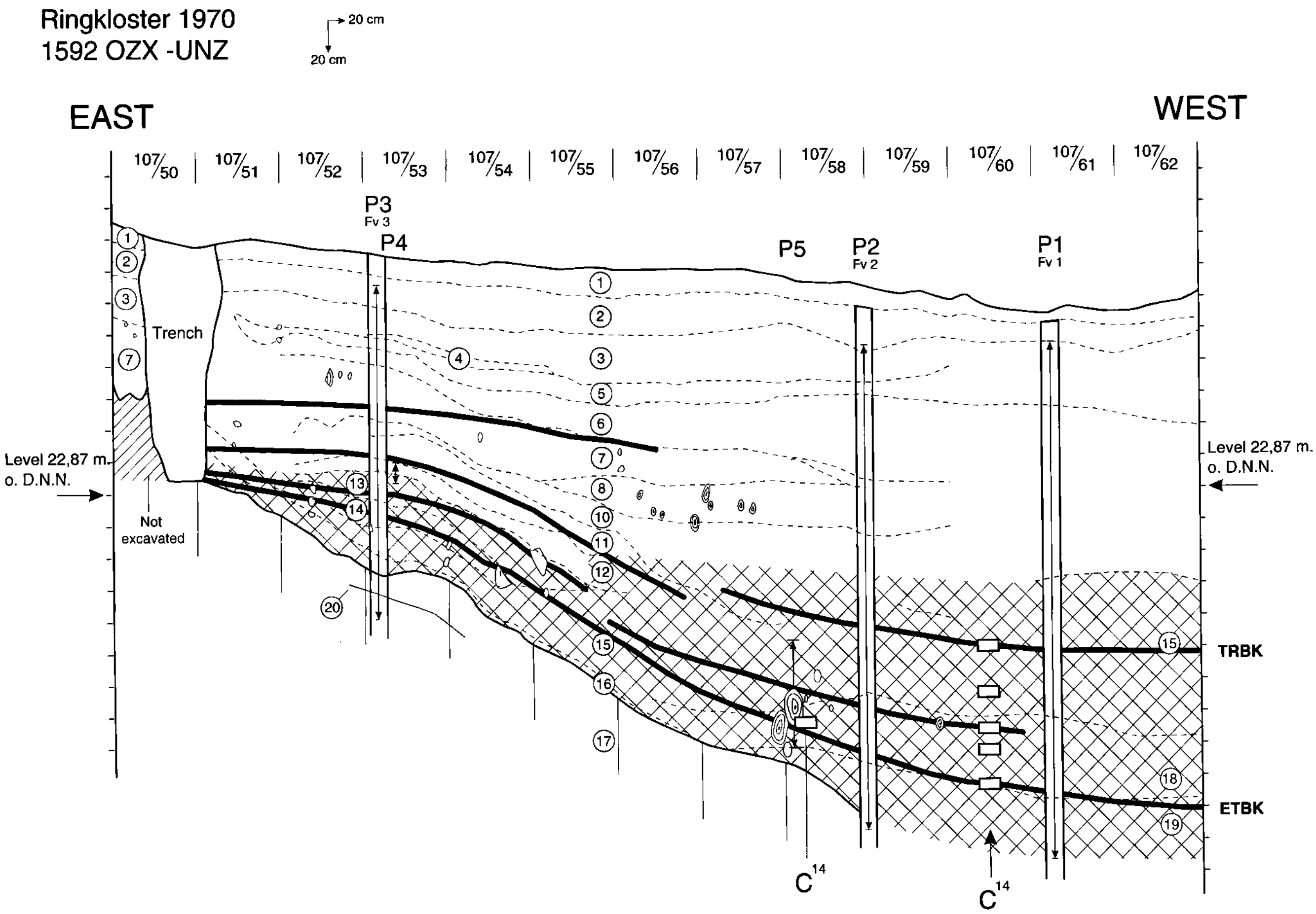


Fig. 9 East - West section running from the lake shore (left) through the "dump zone" into the lake deposits adjacent to the settlement. The gyttja horizons are cross hatched. The thick black lines indicate the main concentrations of artefact depositions. S. Kaae del.

lished as an interdisciplinary project with co-operation between archaeology and the natural sciences, and during the campaigns specialists from several disciplines participated in the fieldwork.

During the first years (1969-1980) the investigations were concentrated on the cultural deposits in the prehistoric lake (today a bog) with its exceptional organic finds, while the excavations from 1980-1985 were conducted on the settlement area proper on dry land and along the shore of the prehistoric lake. In an attempt to find a Mesolithic cemetery a natural terrace to the rear of the site was investigated by a series of test trenches and a large square (fig. 5). Altogether ca. 500 m^2 were excavated in the bog, and ca. 1600 m^2 on land. The Ringkloster investigation therefore belongs among the largest excavations of a Mesolithic settlement in northern Europe and includes in contrast to most other Mesolithic excavations not *only* the "midden" or "dump zone" (or a part of it), but *also* the main part of the habitation on dry land (fig. 5).

The habitation area proper was investigated in horizontal layers of 5 or 10 cm's thickness; features and discoloration were planned and described, and also documented with black-and-white and colour photographs. All artefacts were plotted with 3 co-

[8] The Ringkloster excavation has been sponsored by the Danish Research Council for the Humanities, Aarhus Universitets Forskningsfond and Arbejdsmarkedsnævnet for Århus Amt.

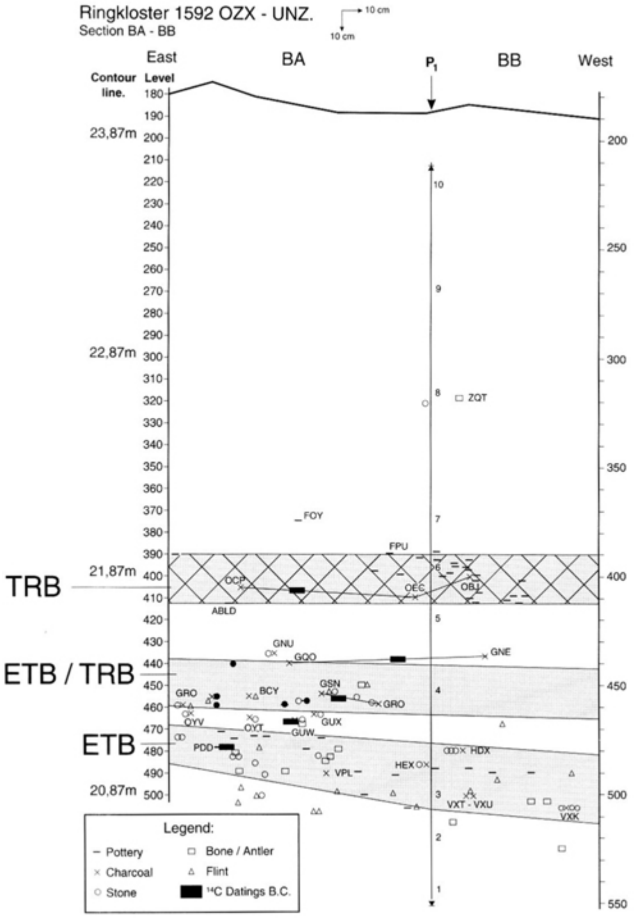


Fig. 10 The position of the pollen series "P 1" and the "cultural horizons" as they are defined by characteristic pottery. The Ertebølle horizons are shaded and the Funnel Beaker horizon is cross hatched. Black dots indicate Early Neolithic(?) sherds or sherds of a Mesolithic-Neolithic (transitional) type, cf. fig. 26. S. Kaae del.

ordinates, while flint debris was recorded by square meter.

The excavation in the prehistoric lake was carried out very carefully with 3-dimensional measurement of all objects, and pollen samples and material for ^{14}C dating were taken. Samples of the depositswere water screened. Owing to the very steep bottom of the prehistoric lake and the high (natural) water level, the excavation was technically very difficult, and depended on constant pumping and shoring up of the sections in the bog.

During the excavation a large number of sections at 1 or 2-3 m intervals were measured and described (fig. 7). Also 9 borings were made in the bog with the object of investigating the sediment stratigraphy and of obtaining samples for plant macrofossil and pollen analysis. One of these borings, "B", has been analysed, and from one of the open sections the pollen series "P1" has been investigated (fig. 7) (Rasmussen 1998 - this volume).

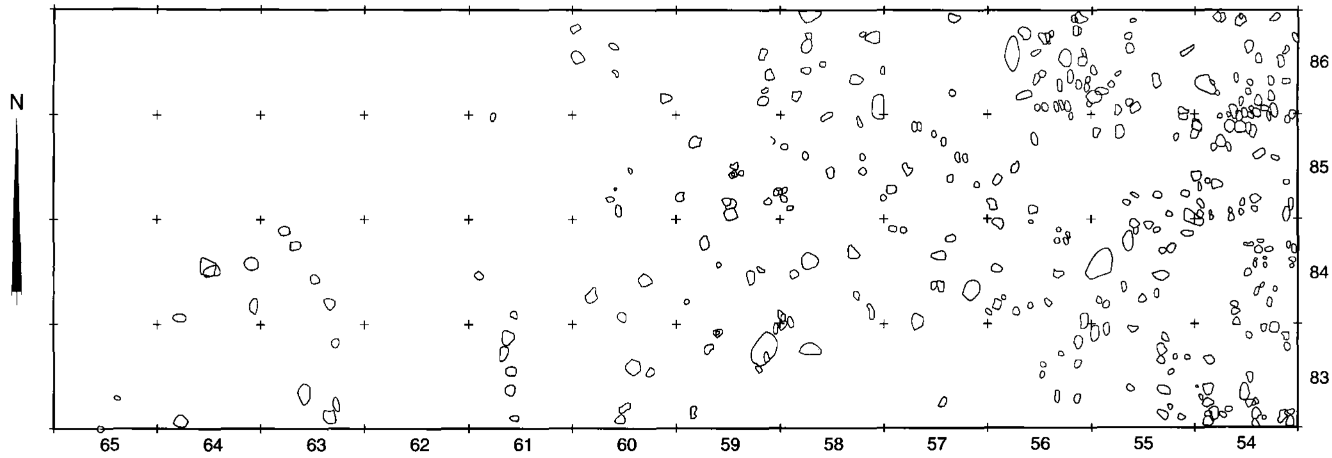
Of special importance is the pollen series P 1, because it comes from a clear stratigraphic and ^{14}C dated sequence with well defined archaeological types of Ertebølle and Early Neolithic Funnel Beaker culture material. Therefore this pollen series gives one of the very few direct correlations in Denmark between faunal/environmental analysis and well defined archaeological stages (cf. fig 10).

Stratigraphy of the dry land habitation area

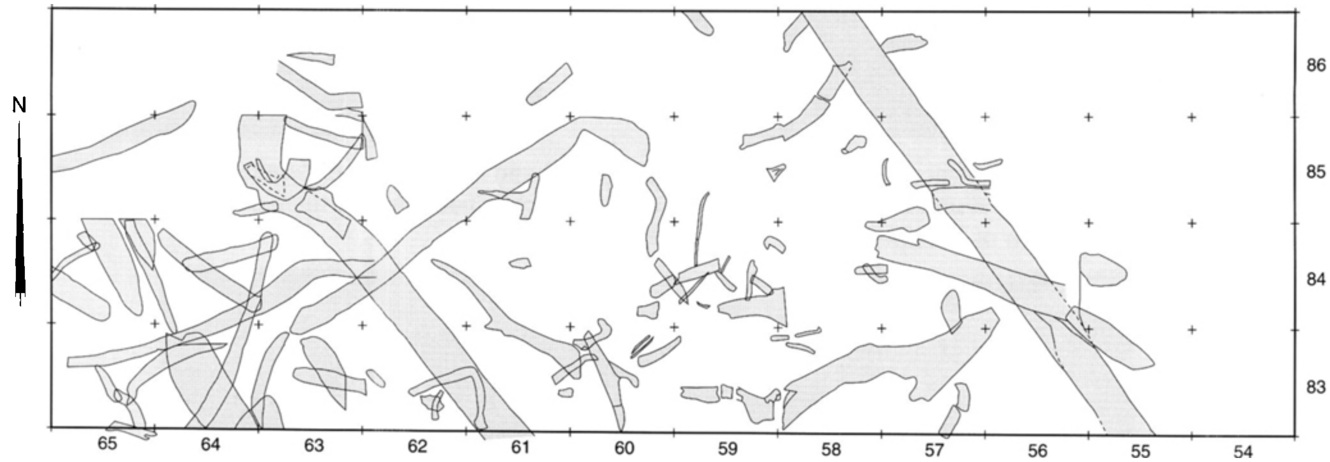
Due to soil erosion the habitation area on dry land was covered with sand and sandy humus from the terrace behind. Therefore only a small part of the area had been disturbed by ploughing - mainly the part closest to the modern bog, where the covering sediments were thinnest. Below the eroded sediments was a ca. 20 cm thick *in situ* occupation horizon with cultural debris.

The top layer was a black (charcoal-rich) sandy horizon characterized by many cooking stones, flint debris and artefacts of Ertebølle type. The layer dates to the youngest Ertebølle occupation phase at Ringkloster. The high content of cooking stones is very interesting because layers with similar contents are found also as the youngest horizons at several of the large coastal settlements, e. g. Flynderhage and Norslund (Andersen & Malmros 1966, pp. 37), Bloksbjerg (Westerby 1927, pp. 22-24) and Vålse Vig (Bahnson 1892, pp. 166-168). Below this was a ca. 10-15 cm thick, sandy, cultural layer with Ertebølle material and fire-cracked stones. In this horizon and below (in the top layer of the subsoil), were many settlement features such as stone hearths lying either directly on the surface of the subsoil or in shallow pits, fireplaces without stones, series of stake, and post holes, and also charcoal patches, pits of varying shape, size and depth, and systems of parallel stone filled ditches (fig. 8). Although no well defined building structures were recorded during the excavation, the features and distributions of finds

Ringkloster 1977. Stones



Ringkloster 1977. Tree trunks, branches, bark etc.



Ringkloster 1977. Antler and bone.

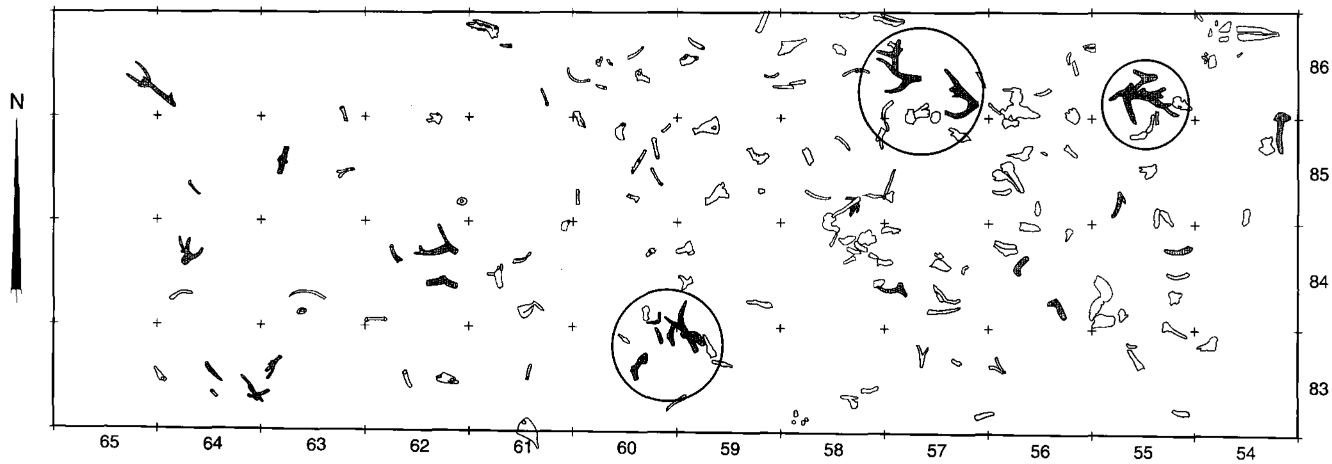


Fig. 11 Plans of the horisontal distribution of stones (top), tree trunks and large branches (middle) and bones and antler (bottom) in the "dump zone" of the excavated square 1977. The prehistoric lake shore is to the right. Antler is dark shaded. Heaps of "antler waste" are marked by a circle. S. Kaae del.

Fig. 12 Heaps of seven pelvis bones of red deer (*Cervus elaphus*) (left) and three pieces of "antler waste" of red deer (*Cervus elaphus*)(right) in the "dump zone". The last-mentioned show clear cut marks at the base and are the remnants of the production of T-shaped antler axes. P. Dehlholm photo.

Fig. 13 Section of the "dump zone" in front of the Ringkloster settlement. Animal bones, antlers, tree trunks and some stones are visible on the surface of the prehistoric lake bottom. P. Dehlholm photo.

Fig. 14 T-shaped antler axe with a part of the preserved handle lying *in situ*. P. Dehlholm photo.

are highly suggestive of dwellings belonging to the Ertebølle phase.

The number and variety of the features at Ringkloster is remarkable, and distinguishes this settlement from the contemporary coastal settlements, where such features are surprisingly few considering the long occupation, e. g. Norsminde and Ertebølle (Andersen 1991; Andersen & Johansen 1987). This is another respect in which Ringkloster clearly represents a different type of Ertebølle settlement.

Due to the thinness of its cultural horizon and the long period of occupation, however, the area on land lacks stratigraphy, and it is therefore only possible to assign rather crude dates or habitation episodes to the individual features. Only the oldest and youngest levels are well preserved. Much work has to be done in the coming years with regards to analysis of the features and associated debris and artefacts from this part of the settlement.

Lake/bog stratigraphy

The sections show a rather uniform stratigraphy (fig. 9). The bedrock is boulder clay. In the prehistoric lake and along the shore this is covered by a series of thin, laminated layers 1-2 cm thick of white-grey calcareous clay and fine grey sand (fig. 9; layers 17+20). Along the shore the upper 5-10 cm of this

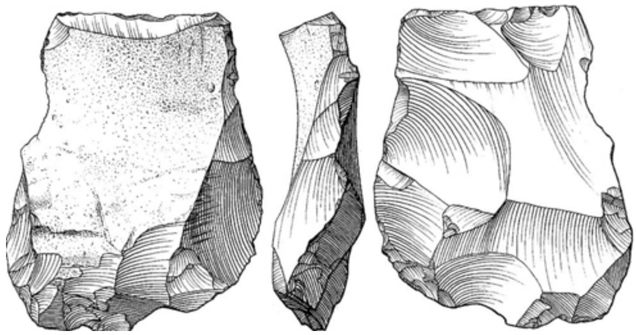


Fig. 15 "Scale worked flake" from the habitation area on dry land. These flakes are a (regional) West Danish type, and are waste from the production of transverse arrowheads in the Older Ertebølle culture of Jutland. (2:3) F. Bau del.

layer contains scattered cultural debris, which was probably trampled down by the inhabitants.

Out in the prehistoric lake the next layer is a 5-20 cm thick horizon of grey sand with small stones (< 5 cm)(fig. 9; layer 16); at shore the sand is mixed with drift gyttja indicating the erosion and sedimentation of organic materials. Further out this horizon contains freshwater gastropods and bivalves.

This deposit is followed by a horizon of homogeneous, unhumified, fine grained, brownish-green gyttja (*Limus detrituosus*) with many gastropods and cultural remains (fig. 9; layer 19). This is followed by a coarser brown detritus gyttja (or drift gyttja) with gastropods (*Lymnaea sp., Planorbarius corneus* and *Planorbis sp.*), bivalves (*Anodonta sp.* and *Unio sp.*), tree trunks, branches, bark, stones and cultural debris in the form of charcoal, flint waste, animal bones and antlers, worked wood, pottery, and artefacts of Ertebølle types (fig. 9; layer 18). This horizon is followed by a ca. 30 cm thick layer of coarse drift gyttja without molluscs (fig. 9; layer 15). Towards the lake shore the drift gyttja content increases, and gradually the gyttja horizons change into layers of humified alder carr peat (fig. 9; layers 11-14).

Along the prehistoric lake shore the number of tree trunks and branches was very high, being a combination of driftwood from the lake and windfalls from the shore - a phenomenon found at all Danish inland and coastal settlements and a nice illustration of how much natural wood was concentrated at such a Stone Age lake shore. There is no argument for interpreting this as an artificial construction or "platform" as has been done at Star Carr (Clark 1954, p. 2 and fig. 2; Pitts 1979, p. 33, 36).

The top horizon is 1-2 m thick brown-black, very humified alder carr peat (fig. 9; layers 2-10).

Along the lakeshore the gyttja horizons gradually becomes thinner and more humified, and the content of sand increases. The transitional layer from the sequence in the prehistoric lake to the occupation area on land (the ploughed field) is a black, humified and sandy deposit (fig. 9; layer 7).

Stratigraphy at the pollen series P1 (fig. 10). From bottom to top: the deepest layer is dark grey sand with fragments of freshwater molluscs (layer 1). Above this follows a layer of fine yellow brown gyttja with detritus, shells and shell fragments; in the upper ca. 30 cm of this horizon the first cultural remains appear (flints, animal bones, stones and charcoal) (fig. 10; layer 2). Layer 2 is followed by a ca. 5 cm transitional layer very similar to layer 2, but with more detritus (fig. 10; layer 3). Above this comes a thick layer of coarse, yellow-brown greyish detritus gyttja with tree trunks, branches, twigs, shells, shell fragments, fish bones and fish scales; this is the main cultural horizon and contains many finds of flint, pottery, stones, animal bones, antler and charcoal (fig. 10; layer 4). This layer is covered by a similar type of coarse detritus with branches, bark, twigs, a few shells, and cultural remains such as stones, pottery, flints and charcoal (fig. 10; layer 5). The next layer is a rather coarse, red-brown drift gyttja with scattered cultural debris such as pottery, flints, charcoal and stones (fig. 10; layer 6). Again follows a layer of red-brown gyttja with many secondary alder roots (fig. 10; layer 7). The upper two meters of the sequence consist of yellow-brown (fig. 10; layer 8) or black alder carr peat (fig. 10; layer 9) with alder roots and different degrees of humification (fig. 10; layers 8-9); a few bones and stones have been recorded at different levels in this horizon, reflecting short visits to the lake shore in later prehistoric periods. The top horizon is a black-brown strongly humified alder carr peat covered by grass turf (fig. 10; layer 10).

Our geological investigations and the typological development of artefacts through the sequence of layers demonstrate that in general the stratigraphy in the lake is undisturbed; however, along the lake shore erosion and water level change(-s) could have caused some mixing of sediments and materials.

Cultural horizons in the prehistoric lake

The excavation revealed several cultural horizons in the prehistoric lake sediments. Close to the shore the cultural horizons are embedded in strongly humified alder carr peat (fig. 9; layer 7), while further out they are found in fine gyttja with gastropods (at the bottom)(fig. 9; layers 18-19). Further up it is in coarse detritus gyttja and alder carr peat (fig. 9; layer 15).

The deepest cultural horizon is the Ertebølle layer, which is ca. 50 cm thick. The preservation conditions for organic material are excellent in the deep horizons of organic mud, but preservation of bone, antler and wood was less favourable in the higher levels dominated by the alder carr peat (although good compared with conditions in Jutland as a whole).

Close to the shore the frequency of objects of cultural debris is very high, while further out the content gradually decreases and finally disappears ca. 30 m from the shore. Vertically the "Ertebølle layer" is well defined, being delimited clearly both above and below by peat (close to the shore) and gyttja horizons (further out in the lake). To the north and south the cultural horizon could be followed along a ca. 100 m stretch of prehistoric lake shore, with the highest intensity of archaeological material being between the two small headlands.

Rapid sedimentation has made it possible to subdivide the occupation layer in the lake sediments stratigraphically. Plots of the depths of typical Ertebølle artefacts show two to four separate Ertebølle horizons, each 10-15 cm thick. These became increasingly separated from one another with increasing distance from the shore by layers of gyttja containing very few or no cultural remains (fig. 9-10).

Ca. 20 cm above the youngest Ertebølle horizon and separated from it by ca. 20 cm of coarse drift gyttja with few cultural remains is another horizon (Early Neolithic) ca. 20-30 cm thick, containing charcoal, some flint artefacts and debris, fire cracked stones and pottery (fig. 10). The youngest horizon in the bog contains scattered finds from the younger roman iron age (fig. 9).

The main part of the Ertebølle horizons are found in geological/sedimentary conditions similar to "taphozone" I and II (Noe-Nygaard 1995, pp. 70-73, fig. 33).

The cultural debris occurred along the edge of the prehistoric lake, generally with the highest intensity close to the lake shore, but it is characteristic that the distribution of debris is not uniform, and we can observe differences in the frequency of flints, ceramics and bone/antler between the land area and the lake deposits. While the amount of flint debris is 5-200 pieces/m^2 on the settlement proper, the frequency in the lake is only between 1 and 13 pieces/m^2. In contrast the number of sherds is low on land, while the frequency in the lake is high, very often rising to 50-70 sherds/m^2. The number of bones in the individual squares goes up to 29 pieces/m^2. Often the highest frequency of animal bones was found several metres from the prehistoric lake shore (fig. 11).

In particular some of the larger bones and antler waste occurred in discrete concentrations, presumably representing rubbish from individual households or butchering debris from individual hunting trips (fig. 12). Many of these small "dumps" are within a range of 5 m of the lake shore; further out such bone clusters are absent, and here all bones and antlers are lying individually (fig. 11 bottom).

The composition of these "bone heaps" varied considerably, but generally they consisted of pine marten skeletons, bones of wild boar, or of red deer antlers - often 3-4 pieces lying in a way showing that they must have been deposited contemporaneous - either tied together before being thrown out into the lake or deposited on the surface during periods when it was possible to walk on the ground surface (in dryer or colder seasons). During post-excavation analysis it has been possible to refit several bone and antler fragments, thereby linking together some of these bone-clusters. As regards fish bones the number is generally low, but they occur in delimited concentrations along the prehistoric lake shore; further out in the lake the number of fish bones is very low and here only larger bones such as vertebrae are found.

The Ertebølle horizon is also characterised by the presence of many branches, tree trunks and stones, generally the size of a fist, but sometimes larger - up to the size of a head. They are especially numerous in the top layer, where their frequency is high (up to 25 - 30 stones/m^2). Frequently these stones have been heated before being deposited in the lake ("cooking stones"), but many show no distinct trace of utilisation or heating. At present we can give no reasonable explanation for the presence of these stones, but it is evident that they were disposed of in the lake from the settlement proper during the occupation period.

THE FINDS

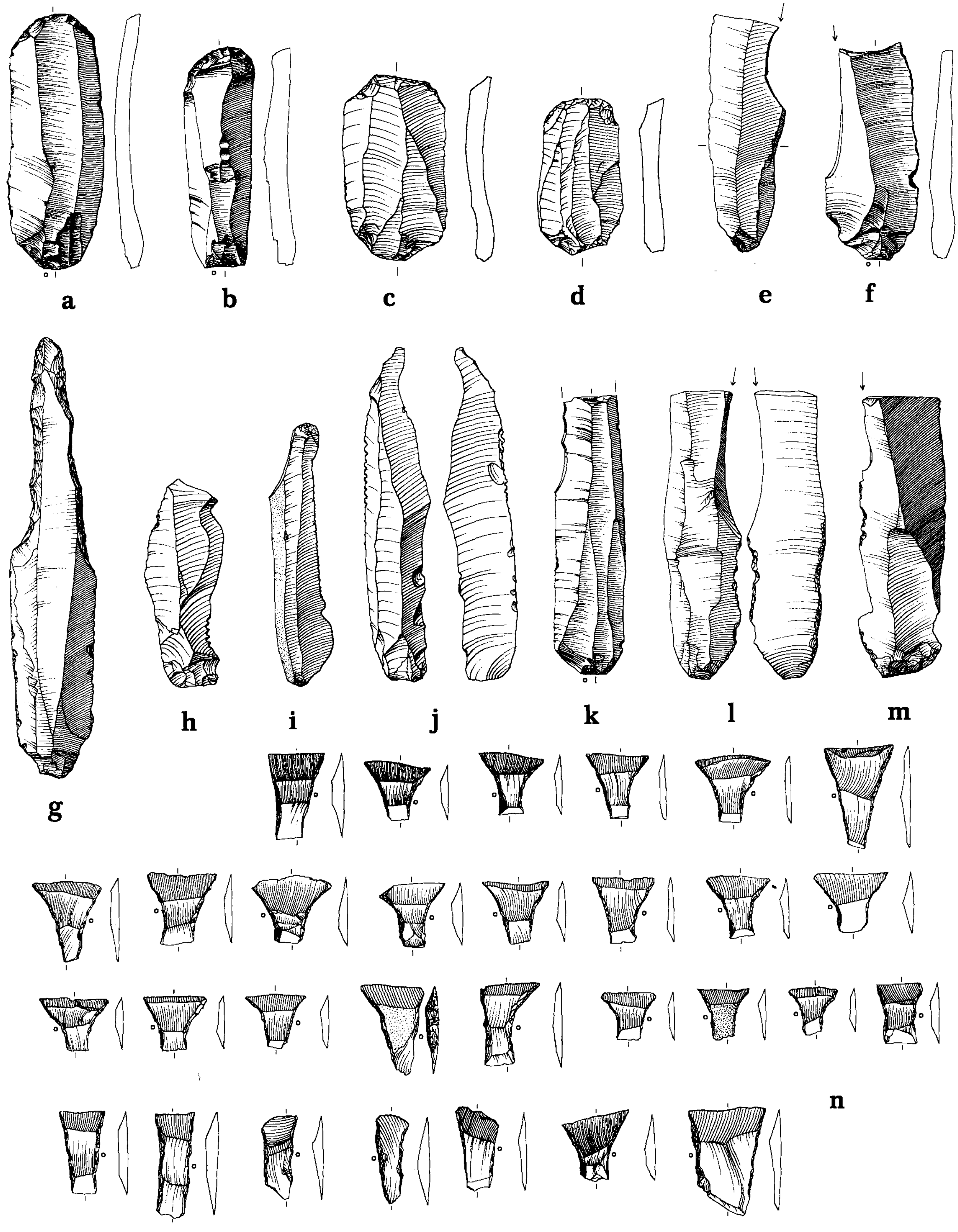
With few exceptions all the excavated material is artefacts and waste from the Late Mesolithic Ertebølle- and Early Neolithic Funnel Beaker Cultures. Some microliths from the Maglemose- and Kongemose cultures are the only finds which do not belong to the main (Ertebølle) occupation phase.

The thickness of the waste deposits and the typological changes in the artefact inventory also support the impression of a long duration of occupation.

If we look at the thickness and extent of the waste deposits associated with the different occupation phases it is evident that two thirds of the Ertebølle horizon belongs to the younger Ertebølle. This indicates a clear expansion of settlement area and intensity during the Late Mesolithic period. This has not been observed before at an inland Ertebølle settlement, and interestingly enough it fits excellently with observations from contemporary settlements on the coast (Andersen 1995, pp. 48).

The horizontal distribution of artefacts demonstrates that the occupation expanded in a horizontal direction and that the southern part of the "dump zone" is the youngest.

It is important to note that no significant difference between the land area and the lake area can be demonstrated with respect to the occurrence of individual implement types, but the frequency of debris is higher on the actual settlement area. In addition there is a clear tendency towards the occurrence of larger (and heavier) objects in the lake than on dry land.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Finds from the Ertebølle habitation area proper

In the settlement proper on dry land the archaeological remains consist of flint artefacts and flint debris, fire cracked stones ("cooking stones"), charcoal, potsherds and a few fragments of animal teeth. The frequency of flint debris and worked flints is low compared to what is found at contemporary Ertebølle coastal sites. Apart from some microliths and rhombic points from visits at the site in earlier Mesolithic periods (Maglemose and Kongemose cultures), all the artefacts of flint belong to the Ertebølle period - especially the late Ertebølle, but a number of scale-worked flakes also demonstrate settlement in the older Ertebølle period (fig. 15)(Andersen 1979a).

Finds from the Ertebølle horizons in the lake

A number of implements of flint, bone, antler, pottery and wood of the types common in the Ertebølle Culture were found in the "dump" in front of the settlement. However, some "new" types are also present.

The artefact types are the same as those known from other sites covering the same time span, but it is interesting that the relative proportions of the types differ markedly from what is found at the well known coastal sites.

Due to the long duration of settlement and the well documented stratigraphy and ^{14}C sequence we can observe several changes in the total artefact inventory. Some of these are only gradual and minor proportional changes, while others, i. e. the introduction of ceramics, are more abrupt and interesting from a cultural historical viewpoint.

The flint inventory is characterised and dominated by tools on blades made by a "soft" technique; especially by many blade scrapers, angle burins on a break, denticulate and micro-denticulate blades - types which are typical for the west Danish Ertebølle culture (Jensen 1994, pp. 51 and fig. 13, 3-5) and transverse arrowheads, while borers, truncated blades and axes (especially flake axes) are very few (fig. 16-17).

Fig. 16 A selection of the characteristic flint types from Ringkloster. scrapers (a-d), burins (e-f, l-m) borer (g) microdenticulated and denticulated blades (h-k) and transverse arrowheads (n). (2:3). Louise Hilmar and F. Bau del.

Together with these flint artefacts were found a large number of transverse arrowheads of the late Ertebølle type with expanding edge; also the type made on biconvex flakes dating to the older Ertebølle is present.

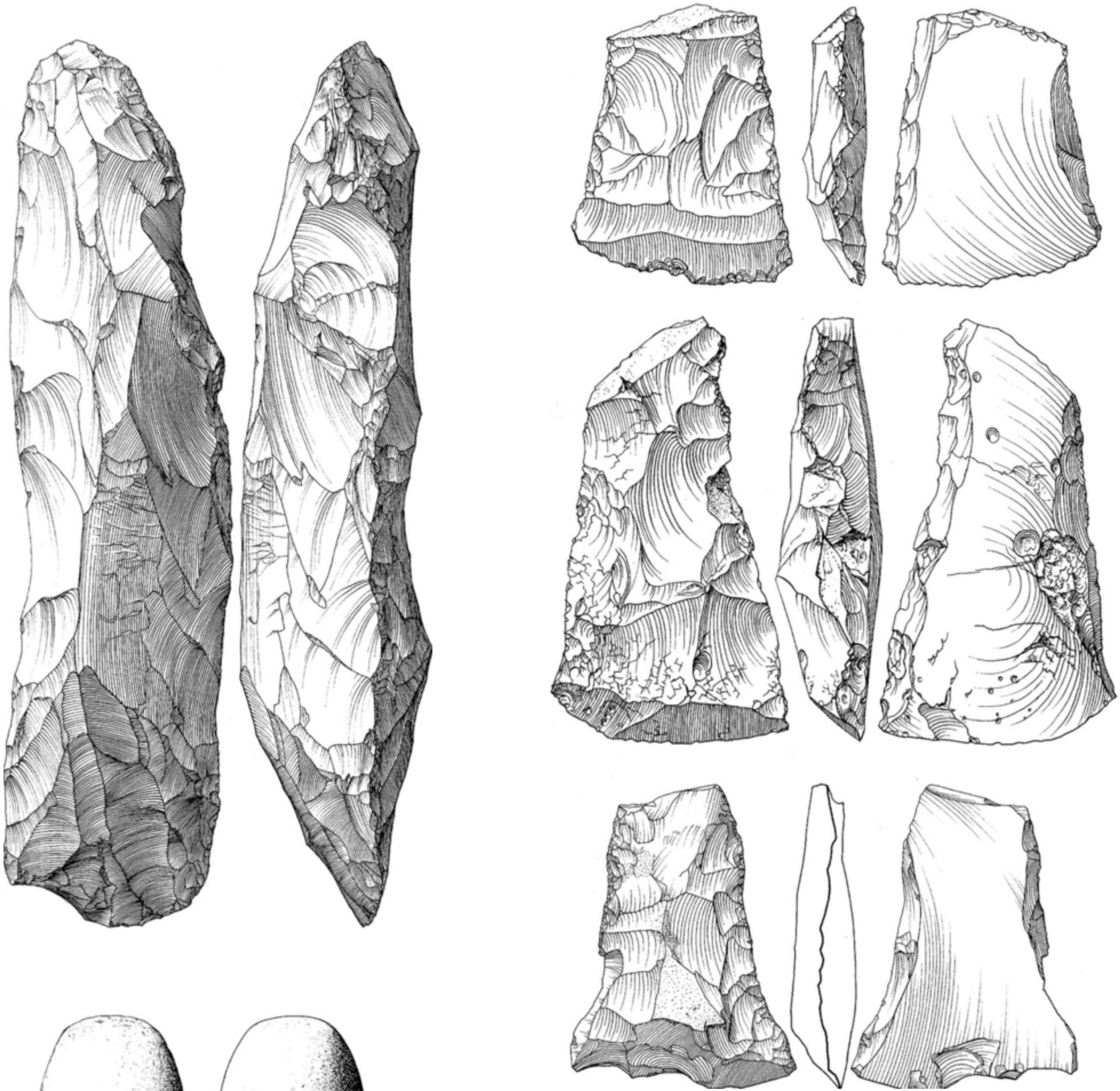
The number of axes is exceptionally low, flake axes in particular being rare in relation to the area excavated compared with other (coastal) Ertebølle settlements; besides the flake axes are small and irregular in size (fig. 17). We have a few axes of greenstone (diabase), one of which was extraordinary in having a shaft-hole (fig. 17 bottom).

A group of 21 complete blade scrapers, 18 broken scrapers as well as two burins and a blade borer have been investigated for traces of wear (fig. 16). Of the 21 complete scrapers, 17 were used for working hide. With the exception of two, the polish was interpreted as coming from dry hide. Only 4 showed wood-working polish. With these results in mind one would expect to find the same frequencies of worked materials within the group of broken scrapers, but surprisingly the hide/wood ratio turned out to be the opposite as 13 had been used for working wood, while only 5 showed polish from working hide. The wood-working pieces were very short (between 22 and 29 mm long), while the hide-working tools were all between 32-44 mm long.

The analysis of the Ringkloster scrapers suggests that short broken scrapers may not only be the result of heavy use, but could represent a separate functional and morphological group produced for working wood, while the complete scrapers in contrast seem to be hide working tools (Jensen 1982, pp. 224-225).

Approximately 60% of the lateral edges of the complete scrapers showed work polish, in most cases produced by wood, more occasionally by plant materials. This means that the blades were primarily produced and used as unretouched tools, and only served secondarily as blanks for retouched pieces.

A sample of 47 blades from the "dump" area in the lake has been analysed for traces of wear on the edges; of these 30% had been used for working wood, 17% for plant materials, 13% for fresh hide, 9% for dry hide, 9% for meat, 6% for meat and bone and finally 17% for bone and/or antler. In comparison with other Ertebølle sites the Ringkloster blades



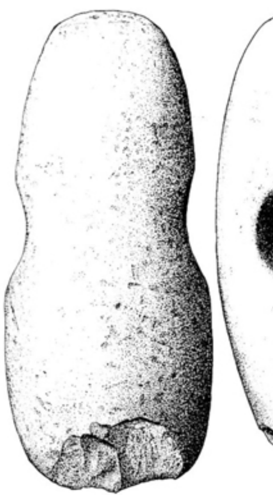


Fig 17 Core axe with specially treated edge (top left) and three flat flaked, symmetrical flake axe (right); the Ringkloster axes are generally smaller and more irregular than the flint axes on the contemporary coastal settlements. Green stone (diabase) axe with shaft hole (bottom left); diabase axes are extremely rare on Jutland inland Ertebølle sites. The type with a shaft hole is probably a local Ertebølle replica of (imported) Central European "Breitkeil"s, which are not known from Ringkloster, but from several other Late Mesolithic Ertebølle settlements in Eastern Jutland (2:3). F. Bau, Louise Hilmar and J. Mürmann-Lund del.

Fig. 18 Antler axes with the shaft hole near the burr (from the lower part of the "dump zone") (Older Ertebølle culture) (bottom) and with the shaft hole through the base of a sawn off tine (so called „T-shaped" antler axe) (Younger Ertebølle culture) (top). Photo P. Dehlholm.

show a higher frequency of use for fresh hide, wood and bone/antler, while plant and dry hide is less dominant (Jensen 1986, p. 24, Table 2).

The micro-denticulate blades, which seem to be a (regional) west Danish phenomenon, have also been analysed for traces of wear by Helle Juel Jensen, who came to the conclusion that contrary to the generally held opinion these tools were *not* used for cutting or sawing, but with a transverse motion perpendicular to the edge; her results seem to support the opinion that these artefacts were used in contact with siliceous plant stems - probably some kind of ripping and/or hacking of fibres. These implements reflect probably a "Neolithic" non-subsistence-related type comparable to the early ceramic production, and were an integrated part of Danish Mesolithic technology several centuries before the actual introduction of animal and plant husbandry ca. 3900 BC (Jensen 1989, p. 135; 1994, p. 5-68 and fig. 13, 4-5).

Summarised, the Ringkloster flint industry is characterised by many scrapers used for hide-working, burins, denticulate and micro denticulate blades and transverse arrowheads.

Tools of the usual Ertebølle types of bone and particularly red deer antler are also common, yet typologically uniform. In comparison with Ertebølle coastal sites, Ringkloster is characterised by a large quantity of red deer antler axes and antler waste, whereas bone implements are rare. A total of 677 pieces of antler have been recovered, of which ca. 55-60 % were worked. In this respect Ringkloster is similar to Stellmoor and Star Carr, which also both are characterised by large numbers of worked antler disposed of or cached in the lake in front of the site, It has been argued that both sites were specialized hunting stations (Grønnow 1987; Legge & Rowley-Conwy 1988).

Among the antler and bone artefacts we also find marked differences in the relative frequency of the different types. Red deer antler axes are numerous, and occur in two distinct types: deeper in the Ertebølle layer were those with the shaft-hole near the burr (19 pieces) (fig. 18), while higher up, were the T-shaped variety with the shaft-hole through the base of the tine (79 pieces). The T-shaped antler axe has a clear regional distribution in western Denmark, and is one among several west Danish Ertebølle

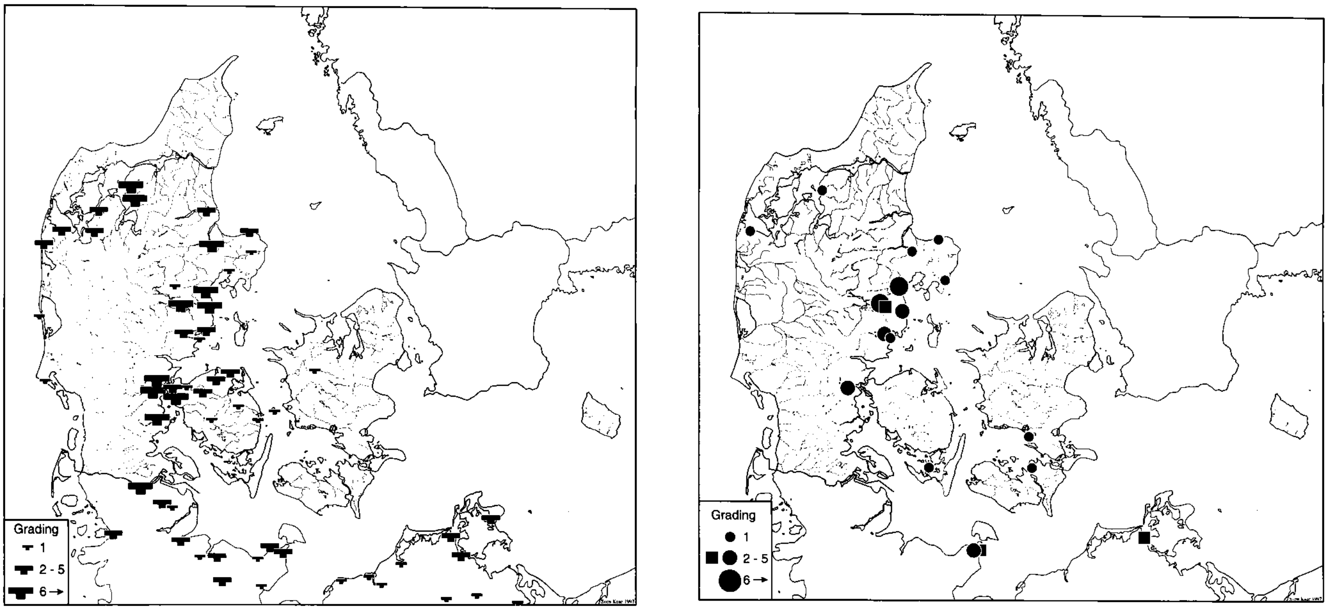


Fig 19. The distribution of T-shaped red deer antler axes (left) and "bone rings" made of scapulae (right). Some of the North German finds have square cuttings in the scapulae - a variant also known from Ringkloster. If we look at the number of the various types at the individual settlements, it is evident that the sites of central Eastern Jutland must have formed a dynamic centre for the production of these types. S. Kaae del.

types which reflect contacts between this region and north continental Europe, where the T-axe has a wide distribution (fig. 19 left).

The Ringkloster material also includes several semi-products, fragments of antler axes, and much characteristic waste from the production of antler axes of both types. Wooden shafts of hazel (*Corylus avellana*), rowan (*Sorbus sp.*) and dogwood (*Cornus sanguinea*) have also been found (fig. 14). A plot of the vertical distribution of the antler axes demonstrates three well defined horizons separated by layers without any axes; the early type of antler axe belongs to the non-ceramic occupation phase, while the T-axes form two distinct horizons within the ceramic Ertebølle period; it is also interesting to observe that there are no antler axes in the youngest horizon.

A new type in Danish Ertebølle finds are chisels or burnishers made of sawn-off tines with a bevel at the tip, of which a long, narrow, tongue-shaped edge has been fashioned on the concave inner surface; two chisels have a perforation at the base. Strikers are very common; among these is a group of 5 whose surface has been scraped smooth - a type unknown from other Jutland Ertebølle settlements (fig. 20 g).

Only one antler with traces of groove-and-splinter technique is present. This is remarkable, as such pieces are common at coastal Ertebølle sites. The explanation for this is that antler with groove-and-splinter technique is waste from the production of harpoons (Andersen 1972). Apparently such production did not take place at Ringkloster.

Fragments of finely polished shafts ("bâtons") of red deer antler are also a part of the Ringkloster inventory (Andersen 1981, pp. 24-38), as well as nicely polished sawn-off tines of red deer antler.

Thirteen shoulder blades of aurochs, wild boar and red deer, from which at least 17-19 discs of varying size have been cut, were also found (fig. 20a). It was possible only to cut one disc from the smaller shoulder blades, while series of up to 3 discs have been cut from the much larger shoulder blades of aurochs. The bone discs served as raw material for the production of bone rings, of which 3 fragments were found (fig. 20b). Here again we have one of the regional west Danish Ertebølle types, which oc-

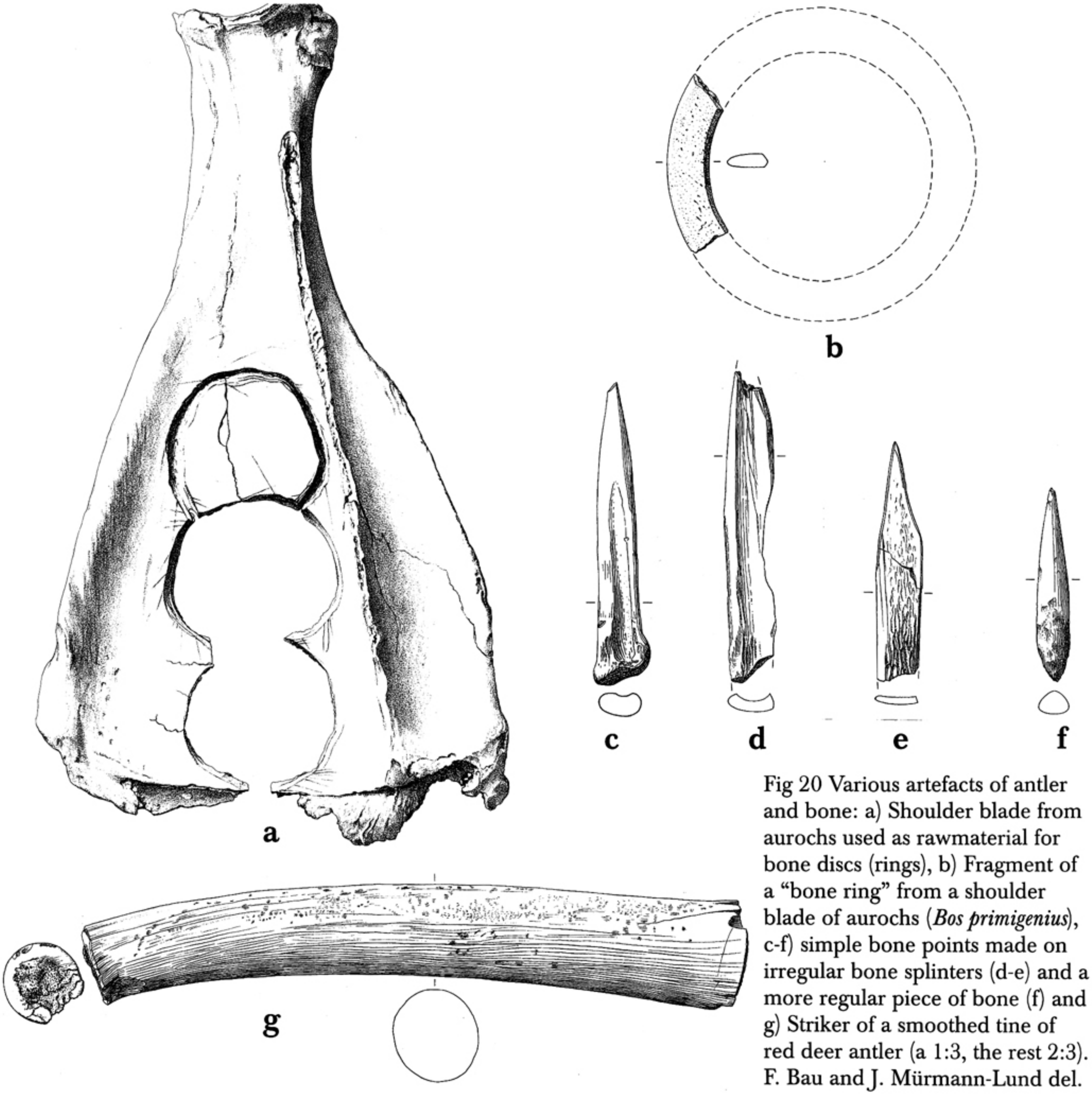


Fig 20 Various artefacts of antler and bone: a) Shoulder blade from aurochs used as rawmaterial for bone discs (rings), b) Fragment of a "bone ring" from a shoulder blade of aurochs (*Bos primigenius*), c-f) simple bone points made on irregular bone splinters (d-e) and a more regular piece of bone (f) and g) Striker of a smoothed tine of red deer antler (a 1:3, the rest 2:3). F. Bau and J. Mürmann-Lund del.

cur at several of the larger settlements especially in central eastern Jutland (fig. 19 right). They are also known from sites further south, e.g. from Hüde I in the Dümmer in Niedersachsen, Spoolde in central Netherlands (Clason 1986 fig. 12, p. 86), Grube-Rosenhof in Holstein (Schwabedissen 1994) and an unpublished site near Prohn in Mecklenburg, and they underline the close contacts between the West Danish Ertebølle culture and contemporary groups further south (Deichmüller 1969, p. 33, Abb. 2, 1). However the number of cut shoulder blades (and the number of bone discs) at Ringkloster is far greater than at any other settlement in this part of Denmark. It is evident that production of bone rings was an essential activity at the site. The use of these bone rings is still unknown; maybe they served as orna-

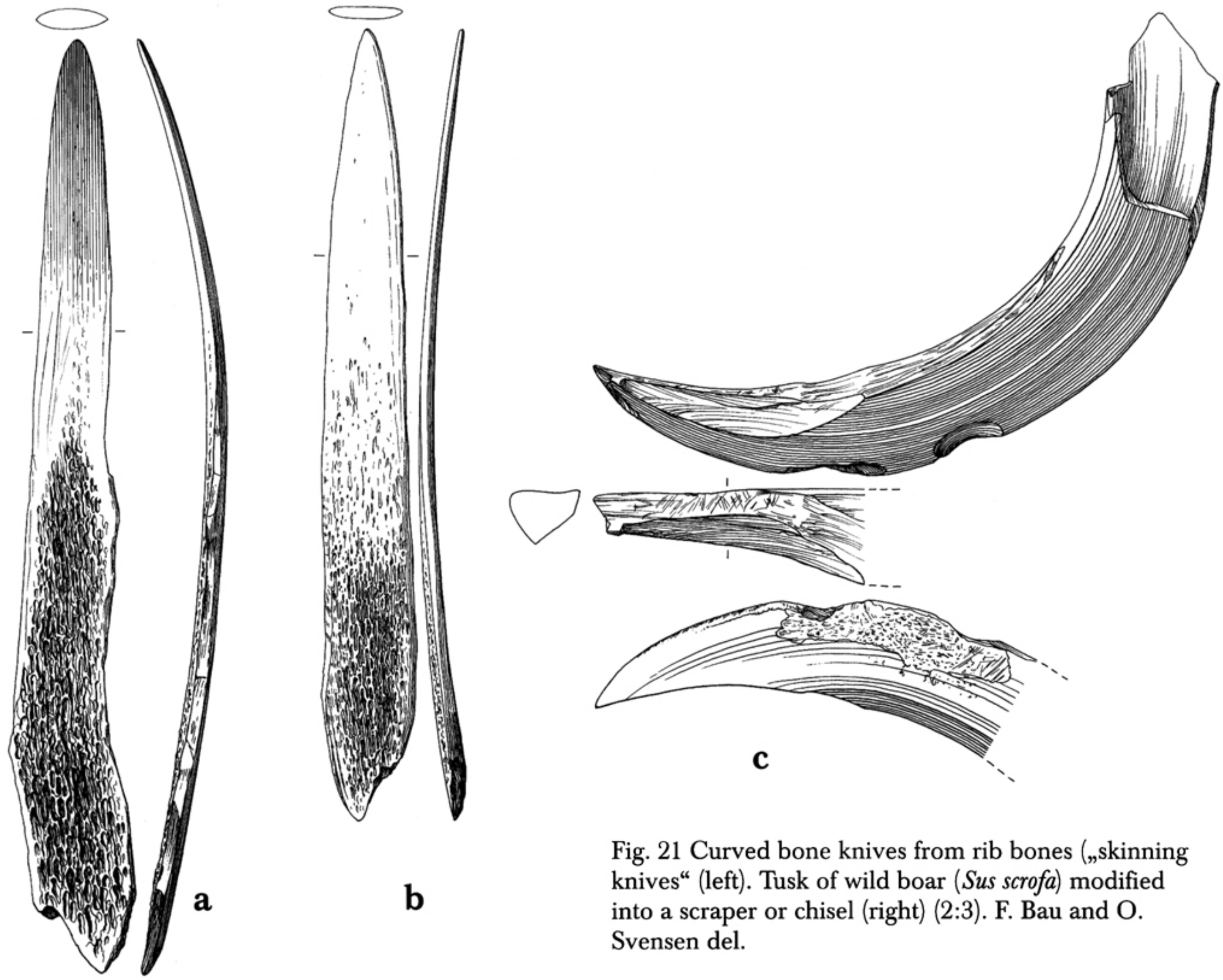


Fig. 21 Curved bone knives from rib bones („skinning knives“ (left). Tusk of wild boar (*Sus scrofa*) modified into a scraper or chisel (right) (2:3). F. Bau and O. Svensen del.

ments or as part of the clothing. Their similarity to the well known Rössen marble rings is striking, and maybe the west Danish bone rings are imitations of these and therefore are another element stressing the contacts/influences between the Danish Ertebølle Culture and central European (Neolithic) groups.

The number of bone points is very low (13 pieces). The majority (10) are made on irregular bone splinters with a short point. Only 3 are regular round-sectioned points (fig. 20 c and f). Waste products from the manufacture of such points are correspondingly rare. Not only the number, but also the form of these points, which otherwise are one of the most characteristic and numerous Ertebølle bone artefacts, is in sharp contrast to what is found at coastal Ertebølle sites (Andersen 1985; 1991; 1993).

A special Ringkloster type is a curved bone knife made of elk or aurochs rib, of which 15 (and one semi-product) are recorded (fig. 21 a-b). They are oblong with a pointed, slightly rounded tip and edges which are not really sharp, but are smooth and rounded near the point and rounded or not worked at all further up the handle. Seen in profile they are curved. Semi-products show that they were produced at the site. Knifes of this type are only known from Ringkloster, and an interpretation is therefore difficult, but they could easily have served as skinning knives, a function which fits well with the rounded tip and edges. However, they resemble similar artefacts known from Swiss (Neolithic) lake dwellings, at which they are often found in bundles of 2 to 5 tied together, and are interpreted as tools for whittling plant fibres (e.g. Bleur et al. 1993, Taf. 81,

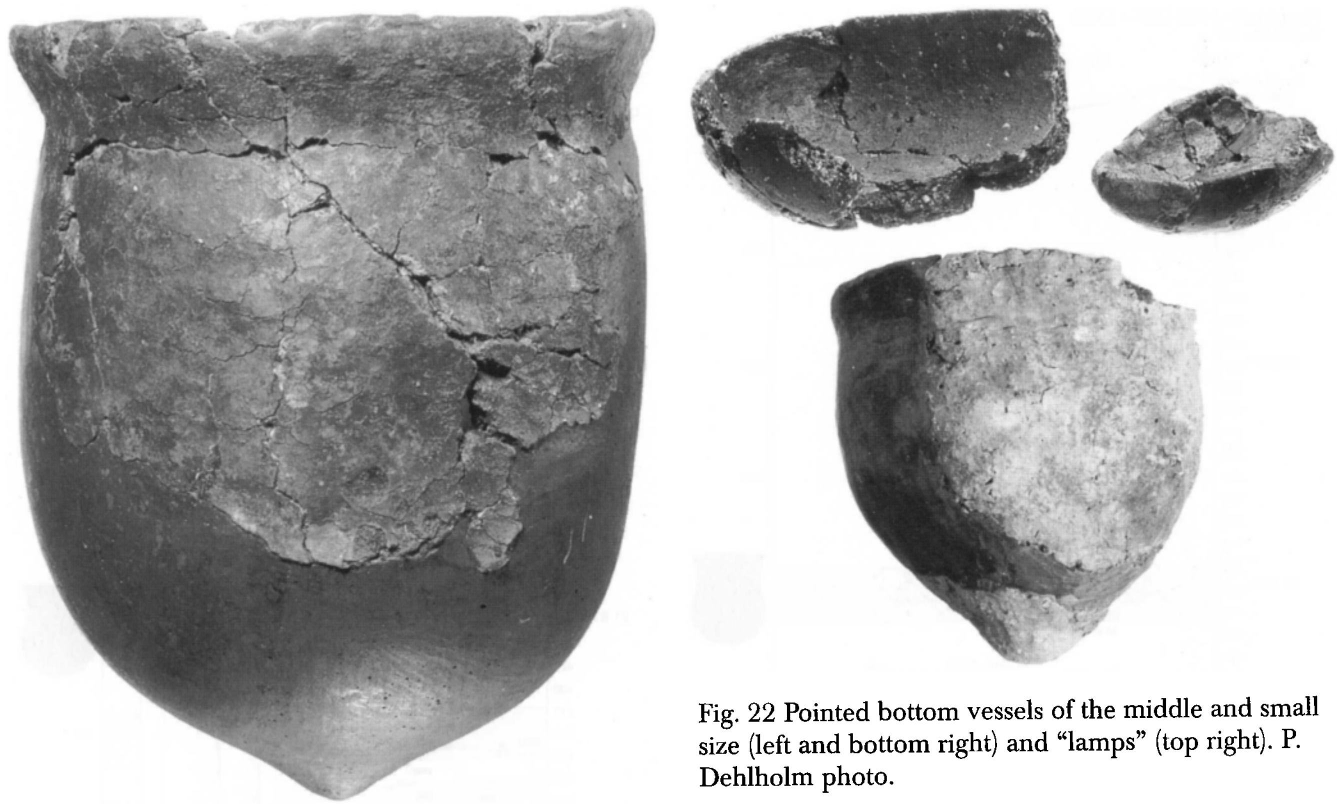


Fig. 22 Pointed bottom vessels of the middle and small size (left and bottom right) and "lamps" (top right). P. Dehlholm photo.

8-14 and Taf. 84, 13-15). A similar interpretation may also be valid for the Ringkloster pieces. No bone fish hook of the Ertebølle type is recorded.

Worked lower canines of wild boar were common; most frequently they were used as boars' tusk knives; one had been worked into a chisel (fig. 21 c); several tusks show traces of lengthways splitting and one piece has a perforation - made clearly with the intention of making ornaments from the outer side of the tusk (the enamel side); such ornaments are well known from Limfjord Ertebølle sites e. g. Bjørnsholm (Andersen 1993, 84, fig. 26) and Ertebølle (Madsen et. al. 1900, Plate VII lower row). One outer side of a tusk has been cut into a rectangular enamel plate, and another shows traces of perforation by drilling. From the Brabrand settlement a piece of wild boar tusk is also known, which had been sawn off at one end (Thomsen 1906, p. 35).

In two cases the whole front part of the lower jaw has been broken off and used as a tool with the tusks still in place. Similar objects are known from other Ertebølle sites such as Tybrind Vig (Andersen 1985) and Ølby Lyng (Møhl 1971), and this is a type, which must also be included in the Ertebølle bone inventory.

A single lower jaw of a beaver has been used as a knife without any modification (Sørensen 1969).

Three daggers of red deer ulna are present; one of them has a long tongue-shaped point very similar to the bone knives, and it is probable that this implement had a function similar to the bone knives.

Only one piece of bone/antler is decorated. The surface of a red deer vertebra is ornamented with a regular criss-cross motif on one side. This bone has been heavily used and the surface is shiny from wear.

Summarised the bone and antler industry of Ringkloster is characterised by a large number of worked and unworked antlers; especially antler axes and strikers, whereas bone artefacts are few; the most prominent of these are shoulder blades used for the production of bone rings, and bone skinning knives. New types are chisels with a bevel, and curved bone knives. The small number of bone points stands in sharp contrast to the situation at contemporary coastal settlements, the lack of perforated animal teeth, and the absence of ornamented antler.

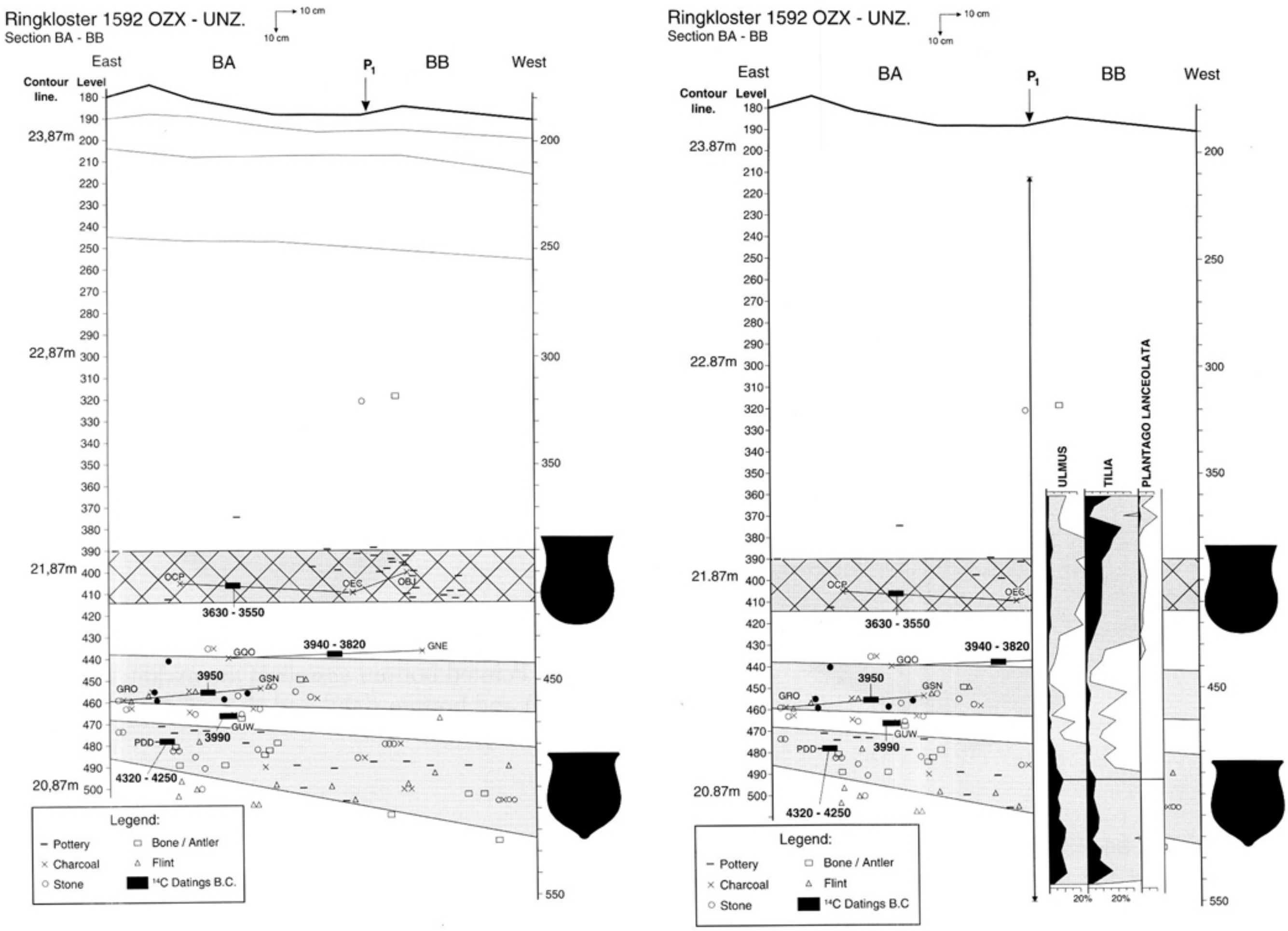


Fig. 23 The section at the pollen series "P1" and the vertical occurrence of typical Ertebølle and Funnel Beaker ceramics (left). The vertical occurrence of Ertebølle and Funnel Beaker pottery in relation to the pollencurves of elm (*Ulmus sp.*), lime (*Tilia sp.*) and rib worth (*Plantago lanceolata*). The thin horisontal line traversing the pollen curves indicates the "*Elm decline*" and the beginning of a contemporary decrease of lime. Above the Ertebølle ceramics the curve of ribworth appears for the first time, and continues without interruption during the Funnel Beaker Culture (right). S. Kaae del.

Ertebølle pottery is abundant and appear in two principal types - pointed bottomed vessels of at least 3 different sizes and oval "lamps" in a smaller and larger variant (fig. 22). Besides the ceramics, lumps of stone-tempered but unfired clay have been recorded from the "dump-zone" in the lake.

The Ertebølle ceramics have been analysed by Hulthén with respect to technique, tempering and raw materials (Hulthén 1977, pp. 42, 48 and 50). Eight samples of clay from within 1 km of the site have been analysed and compared with the ceramics. Two different types of clay has been used: a coarse non-calcareous clay and a more calcareous type. For tempering were used crushed rock (feldspar and quartzite) or chamotte. About 45% of the pottery also has plant material mixed into the clay (Hulthen 1977).

Pointed-base pots were found in large numbers - at least 31 vessels are represented. Thus the high frequency of ceramics is another very characteristic element at the site. The pottery appears some time after the beginning of the cultural sequence, and the

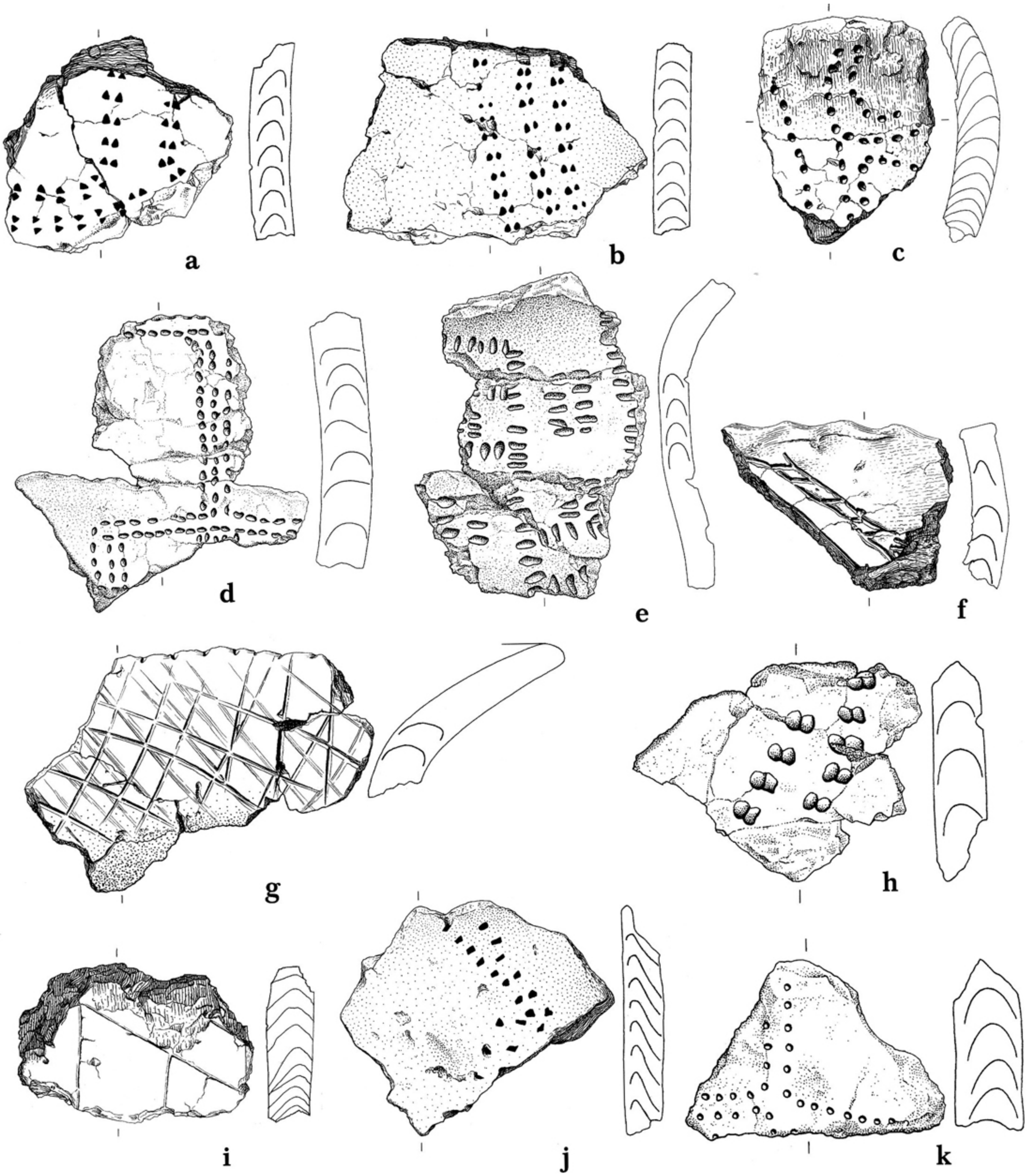


Fig. 24 Decorated Ertebølle pottery from Ringkloster (2:3). F. Bau del.

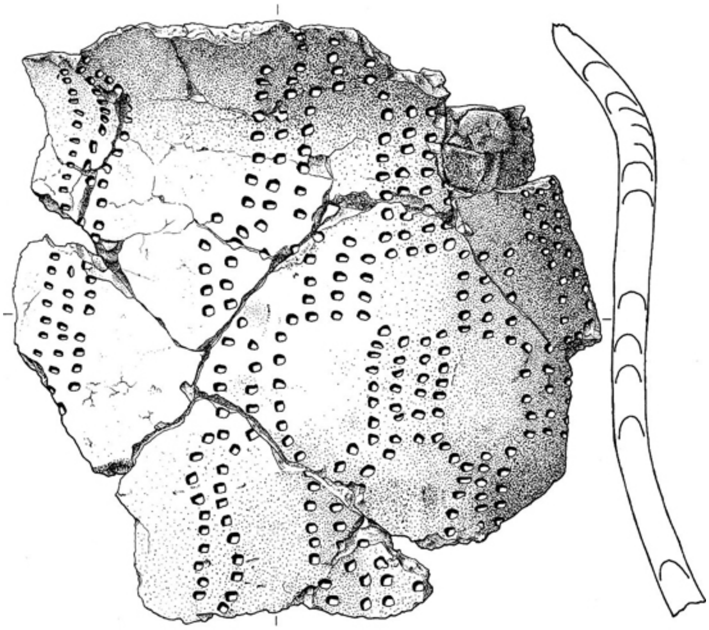
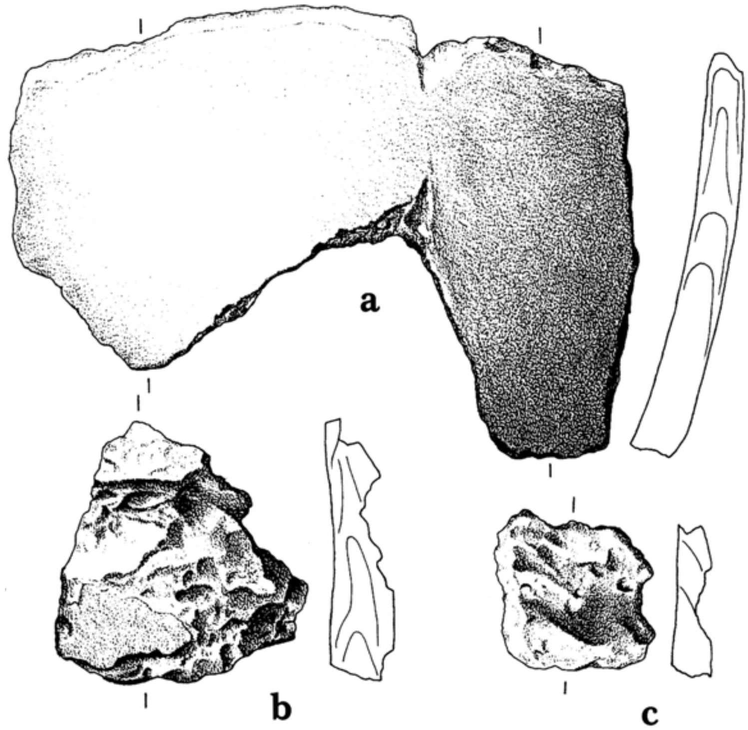


Fig. 25 Large fragment of a pointed bottomed pot decorated with a checkerboard pattern. From the Norsminde *køkkenmødding* in Norsminde Fjord, cf. fig. 3. (2:3) F. Bau del.



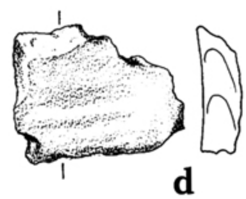


Fig. 26 Pottery found in the "transitional zone" between the Ertebølle and Funnel Beaker horizons in the "P 1" section, cf. fig. 10 and 23. (2:3) Louise Hilmar del.

Ertebølle cultural horizon at Ringkloster therefore covers both the "non-ceramic" and the "ceramic" Ertebølle phases, i. e. the whole duration of the Ertebølle culture. At Ringkloster the Ertebølle ceramics were present between 4700 and 3950 BC (fig. 23). The Ertebølle pottery reflects at least 3 distinct ceramic horizons, of which the topmost contains the most sherds. It is also in this horizon that we find the oval "lamps" and the small vessels or "cups". The frequency and type inventory of the vessels reflect some general tendencies during the Ertebølle period. In regard to the technique and thickness of the vessels there is a gradual change from the predominance of a thick-walled type in "H" and "U" technique in the deepest horizon (with a mean thickness of ca. 1.2 cm), towards the predominance of thinner sherds in "N" technique in the top horizon (with a thickness of ca. 1 cm), e.g. the smallest "cups" are only found in this layer. Also the rims undergo typological change during the occupation period. In the deepest ceramic horizon the rims are "decorated" with nail and finger impressions, while this feature is absent in the upper part of the "dump zone".

The Ringkloster Ertebølle pottery also reflect some local typological features. For example the body of the pots ranges from conical to cylindrical, while the bottom is rounded with an offset point; the rims are upright, inturned with a hollow colar, or everted.

The pottery often contains deposits of charred food remains on the inside, but this has not yet been analysed.

Most of the pots are undecorated, which is normal for Ertebølle vessels, but a few sherds (1-2%) exhibit decoration. This can be of three different types: rhombic patterns, irregular bands of stabs, and there is a distinctly finer type of pot with lines of double stabs (fig. 24).

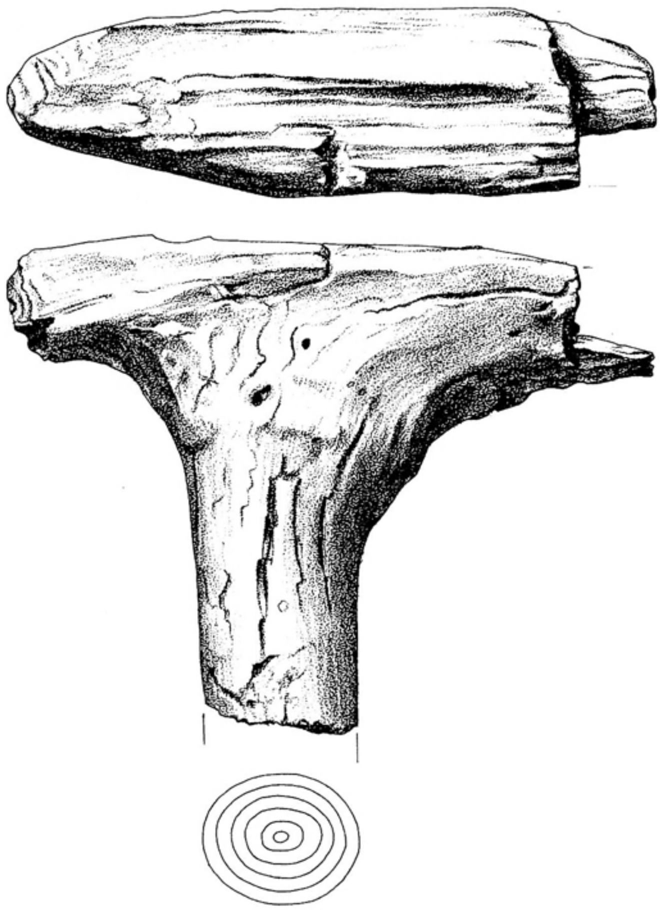


Fig. 27 Fragment of an axe-handle of hawthorn (*Crataegus sp.*). (2:3) J. Mürmann-Lund del.

In Denmark rhombic designs on Ertebølle pottery are only known from Brabrand (Klindt-Jensen 1947, pp. 21, fig. 11) and Flynderhage (Gabrielsen 1953, pp. 12). Decoration with lines of separate stabs is found only on pottery from three Ertebølle settlements in the Brabrand area and two in the Norsminde area; from the Norsminde ***køkkenmødding*** comes a large fragment of a pointed bottomed pot decorated with a checkerboard pattern (fig. 25).

Two sherds from settlements on Zealand are decorated in a similar way, but their cultural association is problematical (Becker 1939, pp. 263, fig. 21a; Mathiassen 1943, pp. 95, fig. 46, 15). In Sweden ornamented Ertebølle pottery is only known from the Löddesborg site (Jennbert 1984, pp. 58, fig. 48), and where the sherds are strikingly similar to those from Ringkloster, both in the technique employed and in the choice of motifs (cf. fig. 24 and fig. 25). A small number of related sherds are known also from the north German Early Neolithic settlements of Rosenhof, Boberg, Travenbrück (Hartz 1996 pp. 54, 1997 pp. 179, Abb. 5,5). and Dümmer I (Schwabedissen 1981 pp. 137, fig. 8, 1994 p. 398, Taf. 17, 1, p. 400 Taf. 19, 7-8; p. 401, Taf. 20, 1-2; Schindler 1961 pp. 28, fig. 7, 2; Deichmüller 1965 p. 17, Abb. 8 f, h, i & Taf. 1, 4).

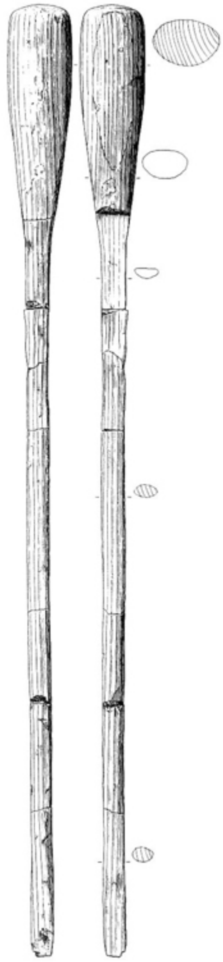
The use of motifs such as rhombic and net patterns and lines of points is familiar from decorated artefacts of bone, antler and amber in the west Danish Ertebølle culture (Andersen 1981), but the decorated sherds demonstrate for the first time the use of these motifs on another material (clay).

All the decorated sherds from Ringkloster are securely dated to the Ertebølle occupation and are found both on dry land and in the "dump-zone" in the bog; they reflect a type of decoration which is very unusual in Danish Ertebølle settlement finds. The double-stab motif however is completely unknown from other Danish Ertebølle sites. A related type of ornament is found on a vessel from the Early Neolithic settlement of Mosegården, ca. 20 km south of Ringkloster (Madsen & Petersen 1984 fig. 18a). A similar decoration is known from a round bottomed vessel from Dümmer I (Deichmüller 1965 Taf. 1, 4).

In comparison with the many other Ertebølle sites with pottery the geographical distribution of contemporary settlements with ornamented pottery is most striking, because they form a cluster in a small area of eastern Jutland (fig. 39). The presence of the same type of decorative motifs and technique within this geographically restricted group of East Jutland Ertebølle settlements obviously point towards some type of contact(s) between the sites (see later)

Of special importance is the presence of ceramics at the pollen profile P1 (fig. 23). In the deepest part of the sequence ceramics are absent. Above this follows a ca. 30 cm thick horizon with thick-walled Ertebølle pottery in "U"-technique. This is followed by a ca. 10 - 15 cm "sterile" horizon capped by a ca. 30 cm layer characterised by thin walled sherds in "U" and "N" technique (fig. 26). Unfortunately they are all uncharacteristic, so it is impossible to relate them to any specific cultural stage. However, the stratigraphic position tells that they represent an occupation at Ringkloster belonging to the youngest

Fig. 28 Bow of elm wood (*Ulmus sp.*), ca. 160 cm long. F. Bau del.



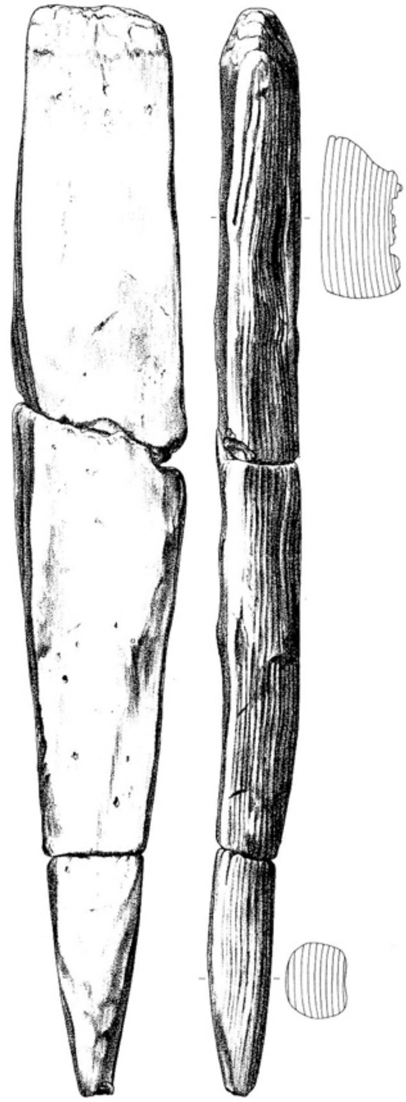


Fig. 29 (left) Fragment of a wooden arrow with a club-shaped head of hazel wood (*Corylus av.*). (1:3) F. Bau del.

Fig. 30 (right) Wooden wedge for splitting tree trunks. (1:3) J. Mürmann-Lund del.

Ertebølle or the transition between the Ertebølle and Funnel Beaker culture. Above this comes ca. 20 cm "sterile" gyttja capped by a ca. 25 cm thick, horizon with thin walled pottery of Funnel Beaker type in "N" technique".

The "dump zone" contained a number of sharpened and pointed hazel stakes (between 15 and 200

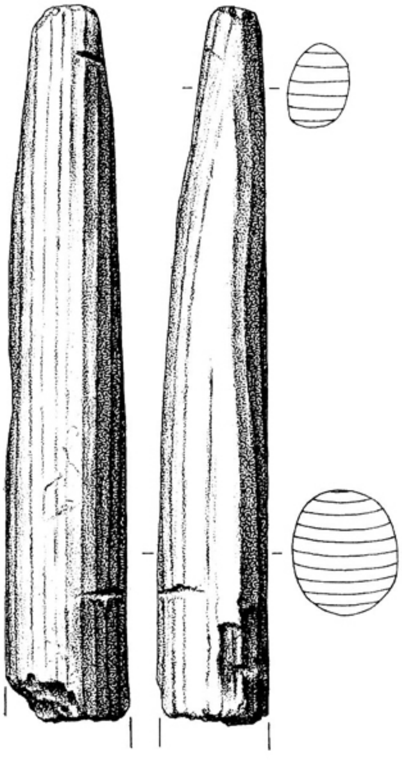


Fig. 31 Fragment of a spear or lance of ash wood (*Fraxinus exc.*). (2:3) J. Mürmann-Lund del.

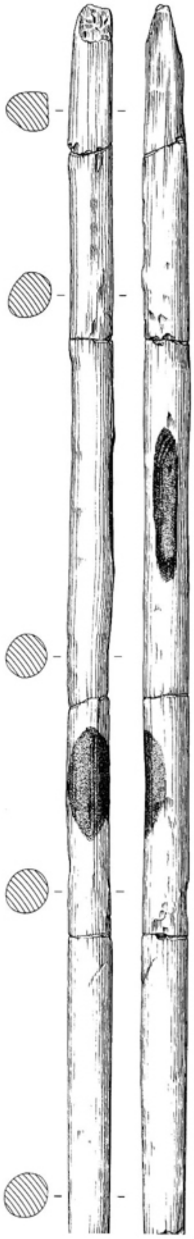


Fig. 32 Straight and cylindrical stick of oak (*Quercus sp.*) - probably a “digging stick”. (1:4) F. Bau del.

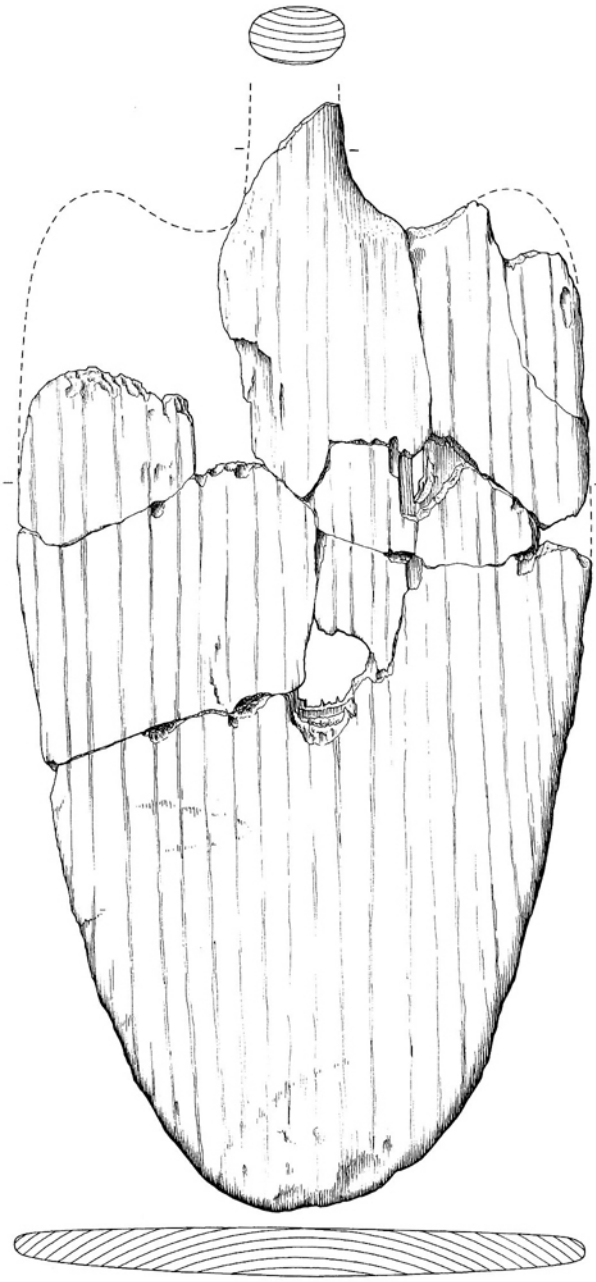


Fig. 33 Lower part of a paddle made of ash (*Fraxinus exc.*). (2:3) F. Bau del.

cm long) which probably derived from destroyed fish weirs in the prehistoric lake. However the number of such stakes is much lower at Ringkloster than at coastal Ertebølle sites. This is probably due to a combination of the season when the site was occupied (see later) and the steep lake bottom, which must have made it difficult to set up fish traps in the lake in front of the site. Chips from preparing and splitting of wood are numerous.

Wooden artefacts were also found, but due to the large amount of natural wood embedded in the layers and the technical difficulties of the excavation (the depth of the cultural horizons and the high water level), they were difficult to recognise and therefore relatively few were recovered. Among them are

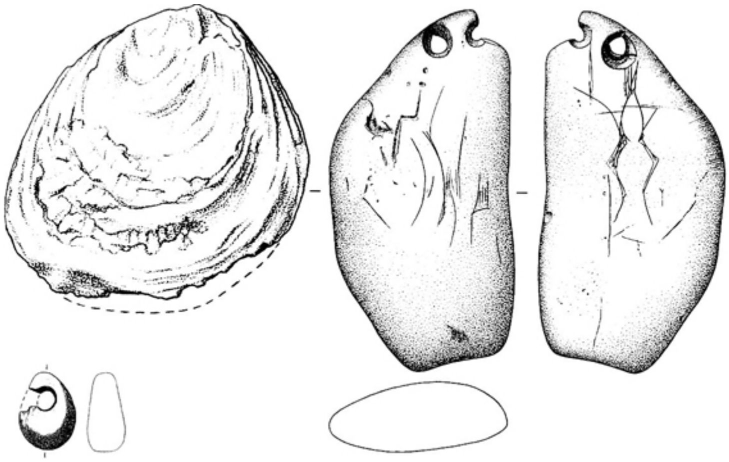


Fig. 34 Oyster shell (top left) and amber pendants. The large amber ornament has a nicely polished surface with an incised net pattern and a figure (person?) on one side. At the top this pendant has two perforations for the string. (2:3) F. Bau and J. Mürmann-Lund del.

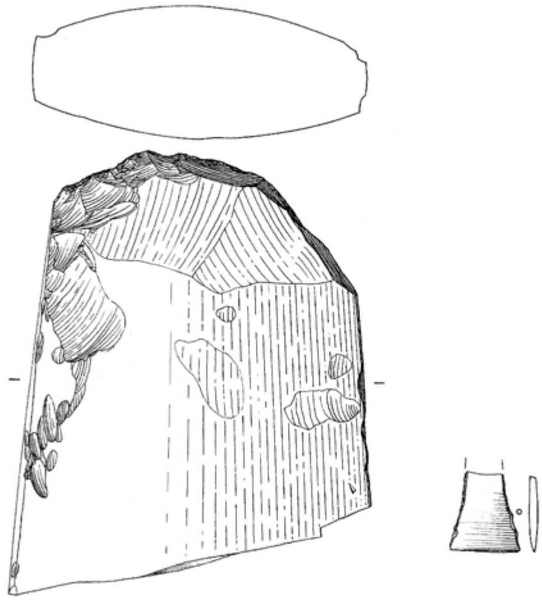


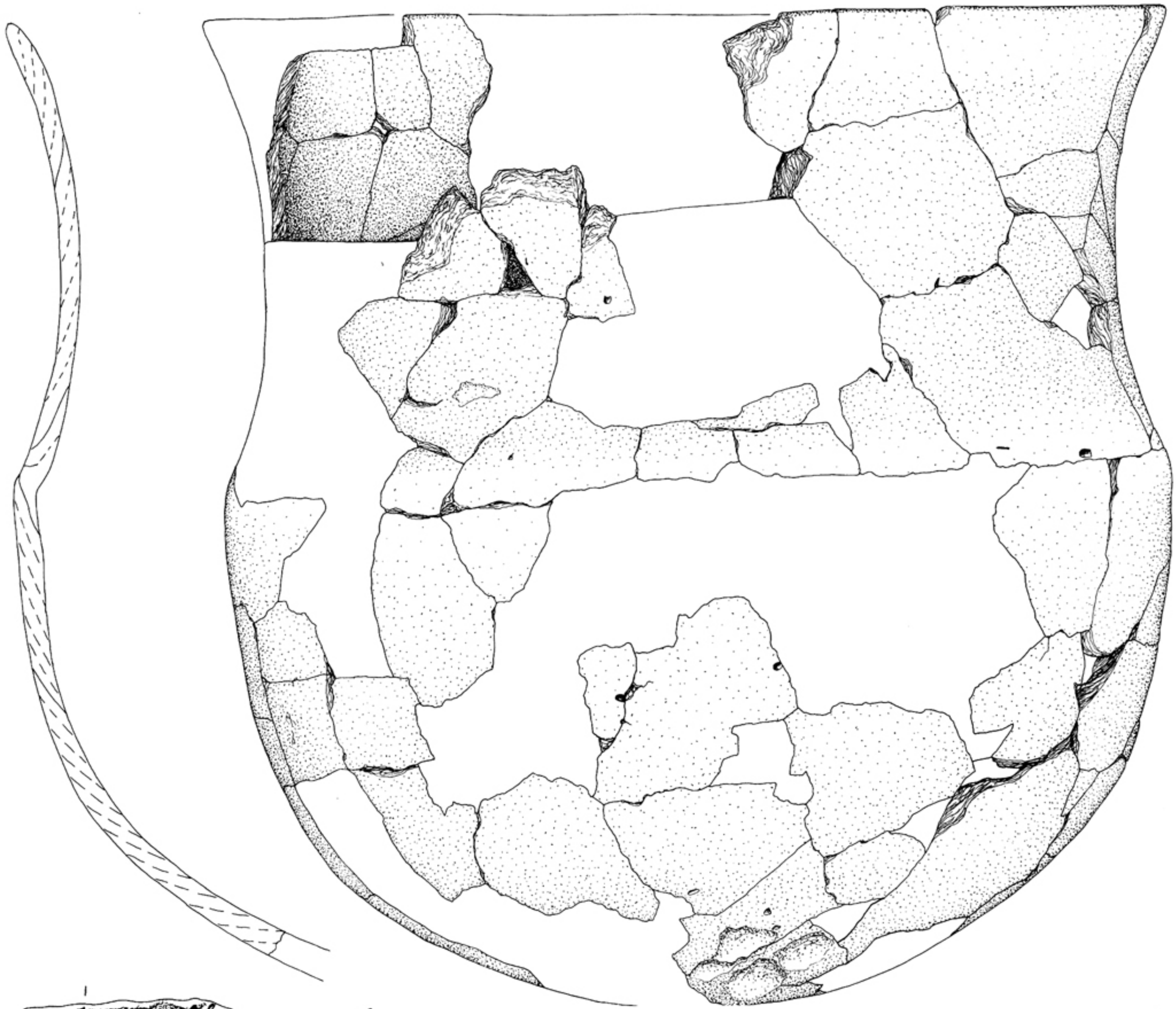
Fig. 35 Finds from the Early Neolithic Funnel Beaker horizon in the "dump zone" in the prehistoric lake. Fragment of a polished thin butted axe (left) and a transverse arrowhead made from a flake taken from a polished, thin butted axe (right). (2:3) F. Bau del.

a semi-product of an axe-handle of hawthorn (*Crataegus sp.*)(fig. 27), an unfinished bow, and two finished bows of very different size and type. Both are made of elm (*Ulmus sp.*) (determined by P. Wagner). The large fragment was of a bow that had originally been ca. 180 cm long with a round cross section. This type is unique in the Danish Mesolithic record being longer, more slender, and having a rounder cross section than other Danish Ertebølle bows. The other bow (fig. 28) is intact (ca. 160 cm long) and identical to bows known from Ertebølle sites like Tybrind Vig (Andersen 1985 p. 64, fig. 16a). A 35 cm long fragment of the front part of a wooden arrow with a club-shaped head of hazel wood (*Corylus avellana*) is also recorded (fig. 29). Three wooden wedges for splitting tree trunks are the first specimens of this type recorded in the Danish Mesolithic (fig. 30). Similar wedges are well known from the Swiss Neolithic (Waterbolk & van Zeist 1991 pp 133-135, fig. 125-129). Slender spears or lances of ash (*Fraxinus excelsior*) - an artefact type well known from other Ertebølle settlements such as Satrup (Schwabedissen 1960 p. 12, Abb. 6 c) and Tybrind Vig (Andersen 1985 pp. 61) are also a part of the Ringkloster inventory in wood (fig. 31). Among this group of implements are also two straight and cylindrical sticks of oak (*Quercus sp.*), respectively 1 and 1.5 m long with diameters of ca. 3 cm (fig. 32). No similar artefacts are known from other Danish Mesolithic settlements; the use of oak is extraordinary and may indicate a function demanding a rather strong wood, e.g. some type of digging stick.

Also a fragment of a dug-out canoe and the lower part of a paddle of ash (*Fraxinus excelsior*) have been recorded (fig. 33).

"Exotica"

One of the more extraordinary objects at Ringkloster were 13 oyster shells (*Ostrea edulis*), which were found scattered in the "dump area" (fig. 34). Only flat shells are represented, and they must be shells deliberately brought to the site from the coastal region. They are best interpreted as being a special type of artefact used for cutting and/or scraping purposes. The strong, sharp and even perimeter of the flat oyster shell could have been used directly as a knife or scraper without further preparation. The use of such "shell scrapers" or knifes was probably very com-



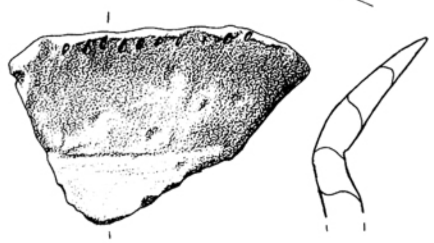


Fig. 36 Undecorated funnel beaker of "Volling" or "B"-type found in direct association with pollenseries " P1" (cf. fig. 10 and 23) (1:2) E. Koch del.
Rim sherd of an Early Neolithic Funnel Beaker with a short neck and ornamented with a row of small stabs below the rim (left) (2:3) Louise Hilmar del.

mon in the Ertebølle culture, but because of the millions of shells in the coastal middens and their lack of secondary working they have understandably been overlooked hitherto. Their presence in the bog is unambiguous evidence of contacts between Ringkloster and the nearby coast.

Amber was used for pendants, of which two were found (fig. 34) - a small, simple bead with a perforation and a large, oval pendant with a carefully polished surface in which there is an incised ornament (a person?) on one side (Andersen 1981, pp. 44, fig. 26).

Fig. 37 Shoulder blade of wild boar (*Sus scrofa*) with a healed lesion from an arrow wound. (1:2) P. Dehlholm photo.

Finds from the Funnel beaker horizon in the bog

The youngest horizon in the "dump-zone" contained thin walled pottery, fire cracked stones, charcoal, some flint debris and a transverse arrowhead made on a flake from a polished flint axe (fig. 35). Among the finds is a ca. 28 cm high, undecorated funnel beaker of Volling type (Early Neolithic I), which gives a clear typological dating of this horizon[9] (fig. 36) (Madsen & Petersen 1984). The finds also include a rim sherd of another Early Neolithic Funnel Beaker with a very short neck - a type which is known from the oldest Neolithic levels in the stratified shell middens, e. g. the nearby Norsminde *køkkenmødding* (Andersen 1991 p. 36, fig. 22)(fig. 36). From the area at the prehistoric lake shore comes the rear part of a broken, thin butted and polished flint axe (fig. 35).

The finds from this horizon are few and must reflect a rather short occupation phase - an observation which is supported by the lack of Early Neolithic material from the excavation on the settlement area on the lake shore.

DATING AND CULTURAL CONTEXT

The archaeological material from Ringkloster shows that the main occupation of the site belongs to the Late Mesolithic Ertebølle culture; there is also a thin horizon from the early Neolithic Funnel beaker cul-

9 The Early Neolithic funnel beaker fig. 36 has earlier been published by H. Tauber (Tauber 1971, p. 395).

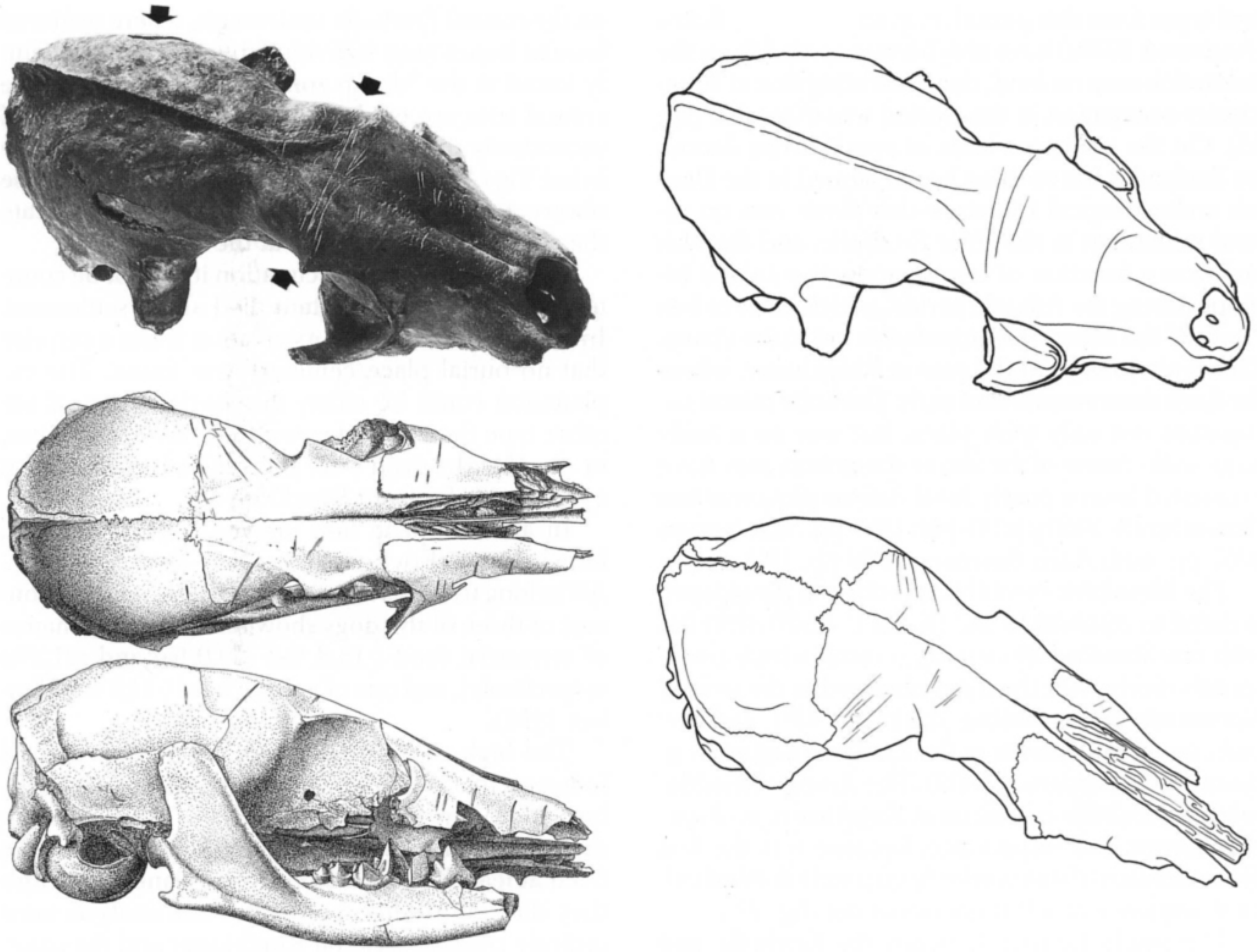


Fig. 38 Cranium of pine marten (*Martes martes*) (top) with clear cut marks across the brow from the use of flint knifes as a result of skinning (arrows) and symmetrical fracturing of the rear of the skull - probably caused by a sort of trap (arrows). A cranium of fox (*Vulpes vulpes*) with similar traces of skinning is seen at the bottom. E. Morville del. P. Dehlholm photo.

ture; furthermore there are a few traces of older (Maglemose and Kongemose culture) activities on the site.

The cultural horizons have been dated both by archaeological typology and by ^{14}C dating, and the results agree well.

The deepest section of the cultural sequence in the lake deposits contains artefacts belonging to the early, "aceramic" Ertebølle phase, which is not ^{14}C dated at Ringkloster, but is well documented by artefact typology. By comparison with the Norslund sequence this phase must be dated to 5400-4700/4800 BC (Norslund layers 3-4)(Andersen and Malmros 1965, 1981), while the finds and several ^{14}C dates from the middle and upper part of the drift gyttja indicate that the Ertebølle occupation period at Ringkloster cover the time span 4710-3990 BC (K-4367 and K-4369)(All ^{14}C dates are given in calibrated years following Stuiver & Reimer 1993)and that the habitation has been especially extensive and intense right through the "ceramic" or middle and younger Ertebølle (4700-4000 BC) (Norslund layer 1-2), lasting until the transition from the late Mesolithic to the early Neolithic.

Of special importance is the clear stratigraphical horizon of the early or "aceramic" Ertebølle culture;

tool types from this period, e. g. scale-worked flakes (Andersen 1979a) have also been recorded from the habitation area on land, demonstrating that at Ringkloster occupation in this period was extensive (fig. 15). On the exclusive basis of results from Åmose on Zealand it has so often been claimed in the Danish archaeological literature that there was no inland settlement in the older Ertebølle, and that this lack was a function of a less productive inland biotope during the Atlantic period, which more or less "forced" the Mesolithic population out to the coasts. This is obviously not the case at Ringkloster, where the finds demonstrate that early Ertebølle inland occupation not only took place, but was on a fairly large scale. Some of the above statements may have originated from a purely local Åmose phenomenon (Troels-Smith 1960 pp. 99-100; 1967 pp. 522; Iversen 1967 pp. 404; Aaris-Sørensen 1988 pp. 197).

The Mesolithic-Neolithic transition at Ringkloster is dated to 3940-3820 BC (K-4371) (3970-3790 BC with one standard deviation), a result which corresponds nicely with the dates obtained at the nearby Norsminde *køkkenmødding* (Andersen 1991) and several coastal settlements in the Limfjord region, e. g. Bjørnsholm (Andersen 1993). The dating of the Mesolithic/Neolithic transition at Ringkloster is of special interest and importance, because it is the first determination of this border from a well-defined cultural sequence at a Danish *inland* site (fig. 23).

The sterile horizon between the Ertebølle and the Funnelbeaker Layers (cf. figs. 10 and 23) and the ^{14}C datings show that there was a short "break" in the occupation at Ringkloster during the Mesolithic-Neolithic transition.

The youngest cultural horizon in the prehistoric lake is typologically dated to the early Neolithic Funnel Beaker culture, which agrees well with the ^{14}C result of 3630-3550 BC (K-4372) (3650-3510 BC with one standard deviation), and ^{14}C dates from other west Danish (coastal) sites such as the stratified *køkkenmøddinger* Norsminde (Andersen 1991) and Bjørnsholm (Andersen 1993) (fig. 23).

^{13}C analysis

Despite the large number of well preserved animal bones (ca. 4. 000), no human skeletal remains were preserved. This was a clear contrast to the situation on the coastal Ertebølle settlements, where scattered human bones (and individual burials) are frequently found in the "dump zone". Human bones at the coastal sites are explained as being the remains of secondarily disturbed Mesolithic graves, e. g. at Tybrind Vig (Andersen 1985). In accordance with these observations, the situation at Ringkloster indicate the absence of such graves at the site.

In view of the long occupation it cannot be countenanced that no inhabitant died at the settlement. In view of the extensive excavation it was a surprise that no burial place/cemetery was found. The explanation could be either that burials were of another type than those known from the coastal sites, or else that the dead were transported and buried at a settlement far from Ringkloster.

In an attempt to find material for ^{13}C analysis, bones from 4 (Ertebølle) dogs have been analysed[10]. All belong to the Ertebølle occupation. The ^{13}C content of three of the dogs showed a clear dominance of terrestrial food (-18,8 ‰, -20,0 ‰ and -21,3‰ respectively), and one of marine food (-11,8 ‰) (Tauber 1981).

The high marine content in one of the animals indicates that this dog (which also was the youngest, but older than 1-2 years) must have lived on a marine diet (at the coast), while the others must have lived at least for some time at the inland site before they died. With due reservation this analysis must indicate contact between Ringkloster and the coast. Similar studies have been made of dog bones from settlements in the Åmose area on Zealand (Noe-Nygaard 1988).

ECONOMY

Hunting is indicated by thousands of bones, mainly of mammals, while bones of birds and fishes are few (Rowley-Conwy 1998 - this volume; Enghoff 1998 - this volume). Of these bones only four demonstrate well defined hunting injuries: a vertebra of a red deer, two left and a right scapula of wild boar (Noe-

[10] K-386: -20, 0 ‰ (adult/ "older dog")
K-387: -11, 8 ‰ (adult/"younger dog")
K-388: -22, 9 ‰ (bone of Cervus elaphus/ Red deer)
K-4132: -21, 3 ‰ (dog)(^{14}C: 4030 - 4000)
K-4133: -18, 8 ‰ (dog)(^{14}C: 4320 - 4260).

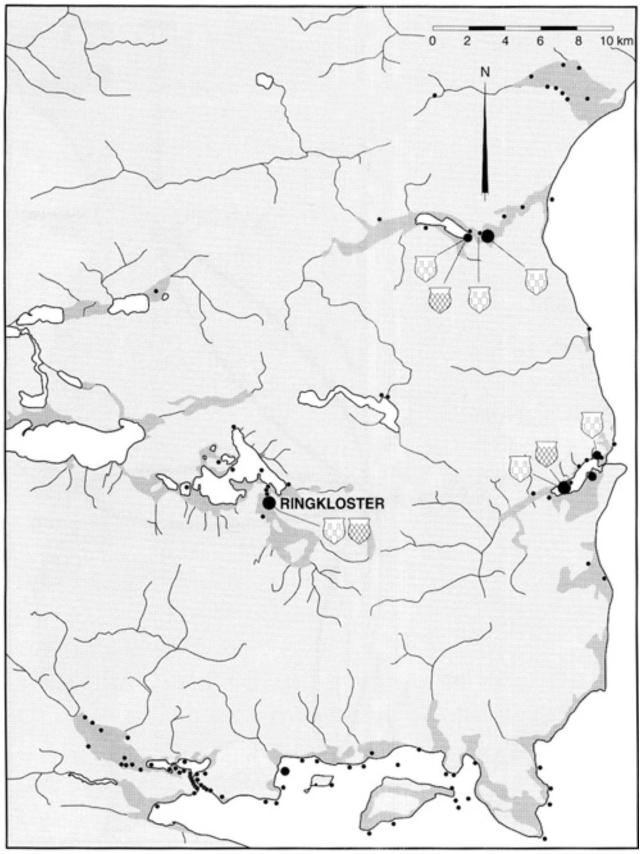


Fig. 39 The occurrence of ornamented pottery on Ertebølle settlements in Eastern Jutland contemporary with Ringkloster. S. Kaae del.

Nygaard 1974 p. 225-226 and fig. 8, pp. 233-234 and fig. 14, Plate VIII a1-2) and (fig. 37).

Stratigraphical analysis of the faunal material demonstrates that in general terms the frequency of wild boar and aurochs remained unchanged through time, while red deer and pine marten appear in more restricted "horizons" - probably reflecting individual occupations or seasonal hunting "episodes". All the evidence therefore points to the economy of the site being constant during the long occupation period. This must mean that the biotope and resource potential remained the same, and that these factors combined with the excellent topographical position may explain why so much settlement material accumulated here and why Ringkloster became so large in contrast with other Jutland Ertebølle inland settlements.

The most common mammal is the wild boar *(Sus scrofa)* followed by the red deer (*Cervus elaphus*), aurochs (*Bos primigenius*) and roe deer (*Capreolus capreolus*); a few bones of elk (*Alces alces*) are also present. The only domesticated animal is the dog (*Canis familiaris*). The faunal remains (and the great number of antler waste and antler tools) demonstrate that hunting of wild boar and red deer was of major importance

Of special interest is a very high frequency of bones of animals with fur, especially pine marten (*Martes martes*). These were normally found articulated and in heaps of several individuals, i. e. they have not been eaten, but have been discarded intact without being cut up. Distinct symmetrical fractures or round holes in the rear of the craniums of these animals, and also transverse cut marks across the front of the snouts, are best interpreted as traces of the traps in which they were caught and of the subsequent skinning with flint knives (fig. 38). These observations tell us that we are not dealing with "normal" use of these animals (for food), but with a more specialised activity; i.e. the reason that the pine martens were hunted was because of the fur. This fits also with the archaeological material. The number of pine martens at Ringkloster surpasses what is known from most other Danish Mesolithic settlement; only the coastal Ertebølle site Tybrind Vig has a similar high number of these animals (Trolle-Lassen 1986). This strongly suggests that trapping for pelts was an essential part of the activities at this site. Other animals in this category are otter (*Lutra lutra*), wild cat (*Felis silvestris*), badger (*Meles meles*) and fox (*Vulpes vulpes*), which were also hunted for their furs. The fact that no less than 28.4% of the red deer and 18.6% of the roe deer are newborn - an aspect of the faunal assemblage in which Ringkloster also differs from other Ertebølle settlements - probably reflects hunting for the fine, white-spotted skins.

The hunting activities fits nicely with the archaeological material, which is dominated by arrowheads, scrapers for skins, bone skinning knives, "oyster-scrapers" and many blades.

The presence of two bones of (wild) horse (*Equus ferus*) is interesting. Their stratigraphical position indicates the Ertebølle period, which means that they must come from wild horses. So far only one horse bone has been found - at the Ertebølle site of Brabrand, not far from Ringkloster (fig. 1 and 3). A ^{14}C

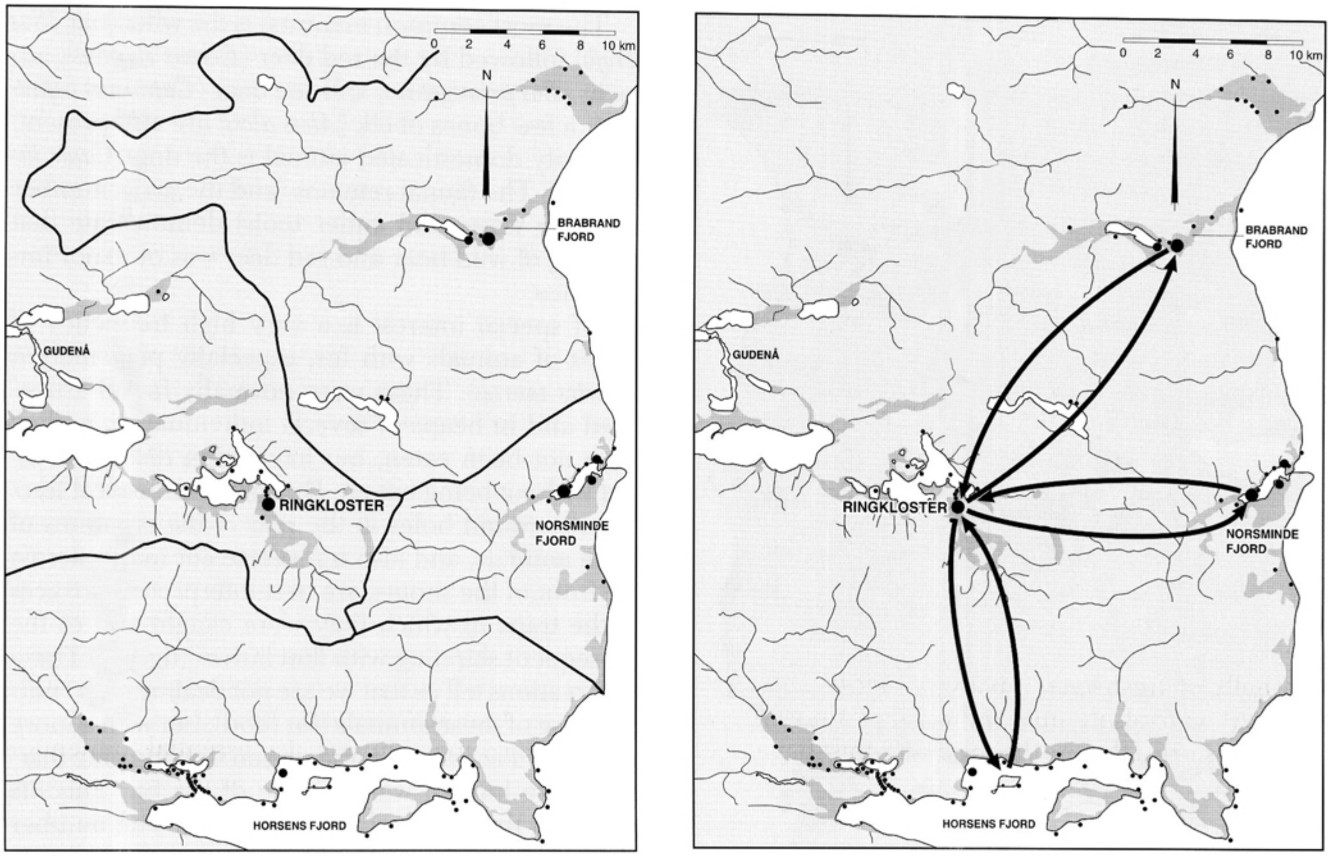


Fig. 40 Models of the Late Mesolithic, Ertebølle settlement system in Eastern Jutland. As two, individual systems, "Forest hunters" and "Coastal Fishermen" (left) and as one, single unit with seasonal movements from the coastal region into the interior (right). cf. fig 3 S. Kaae del.

date places this horse clearly in the Ertebølle culture (4350 BC (K-2651) (4450-4260 BC with one standard deviation). (Davidsen 1978 p. 145), and thereby also supports the assumption that the Ringkloster horse bones are of Ertebølle age, and that there were wild horses in eastern Jutland in the Atlantic period. These findings demonstrate that parts of the biotope of Jutland in the Late Atlantic must have been favourable to this animal, i. e. there were open grass covered areas, rather different from the normal description of the environment of this period as a dark, primeval lime/elm and oak forest (Troels-Smith 1960 p. 98; Iversen 1967 pp. 399-402).

More extraordinary is the presence of 3 bones of bottle-nosed dolphin (*Tursiops truncatus*), which are a further proof of contact(-s) between Ringkloster and the coast.

Birds are surprisingly few - especially if the location of Ringkloster beside a fresh water lake is remembered. They include red throated diver (*Gavia stellata*) (the most common species) as well as sea eagle (*Haliaetus albicilla*) and swan (*Cygnus sp.*).

Fish bones are also found - especially along the prehistoric lake shore where they occur in restricted concentrations - while further out in the lake only scattered and larger fish bones (mainly vertebrae) are recorded (Enghoff 1994 p. 85 ff; 1998 - this volume). Compared with contemporary coastal Ertebølle settlements the number of fish bones and species is small, which also is in accordance with the small number of remains of stationary fish traps and the lack of fish hooks. Other types of fishing equipment are also lacking, which may be compared not only with the coastal sites, but also with contemporary inland settlements in Satrup Moor, such as Rüde 2 and Förstermoor, where both leisters, netfloats and nets are known (Schwabedissen 1960 pp. 14-15, Abb. 8 a-b, Abb. 9 a, c and e).

The archaeological as well as the zoological material seems to indicate that fishing and fowling were of minor importance in the Ringkloster economy.

The fish material is dominated by species living in Danish freshwater lakes, and the majority derive from the Cyprinidae family (roach (*Rutilus rutilus*), whitebream (*Blicca bjoerkna*), rudd (*Scardinius erythropthalmus*) or bream (*Abramis brama*). The second most frequent species is pike (*Esox lucius*), followed by perch (*Perca fluviatilis*), while the remaining species are only represented by a few bones.

During the analysis of the fish bones it came as a great surprise to find that a distinct part consisted of marine species: Cod (*Gadus morhua*), saithe/pollack (*Pollachius sp.*) and plaice/flounder/dab (*Pleuronectes platessa/Platichthys flesus/Limanda limanda)* (Enghoff 1994). Therefore, the fish species also demonstrate contact(s) between Ringkloster and the coast, but it is impossible to tell in which form these fishes came to the site.

Shells of freshwater bivalves (*Anodonta sp.* and *Unio sp.*) were also found in the deepest horizons in the prehistoric lake. As the molluscs must have lived in the Mesolithic lake adjacent to the settlement it is an open question whether their presence at Ringkloster is as waste from food gathering, or whether they are a natural part of the lake sediments (or a mixture of both). From the Åmose region on Zealand small (inland-) "middens" of these species are well documented, but in these cases they are found at the settlement proper (Noe-Nygaard 1983 pp. 135-137; 1995 pp. 63-64, fig. 30). The most reasonable is to assume that the collecting of freshwater bivalves and snails was yet another part of the economy in the Ertebølle period at Ringkloster.

A few Garden Snails (*Cepaea hortensis*) are also recorded from the lake - a species which is also frequently recorded in the kitchen middens, but always in small numbers (Petersen 1987 pp. 77-84).

Gathering is first and foremost documented by the presence of large numbers of hazelnut shells (*Corylus av.*), which were a substantial part of the debris in the "dump-zone". Collecting of hazel nuts has quite obviously been an essential aspect of the economy at this site.

Samples of gyttja from the "dump" have been analyzed for seeds and fruits. The species of dogwood (*Cornus sanguinea*), hawthorn (*Crataegus sp.*), yellow waterlily (*Nuphar lutea*), white water lily (*Nymphaea alba*), yellow flag (*Iris pseudacorus*) and lime (*Tilia* sp.) have been identified (determinations by Jørgensen). Of special interest is a surprisingly high frequency of fruits of hawthorn (*Crataegus sp.*) and lime (*Tilia sp.*) of which the former is only sparsely represented in the pollen diagrams (cf. Rasmussen 1998 - this volume). Their presence in the waste deposits is most probably a reflection of human activity, i. e. the fruits have been collected and used for food in the autumn and winter. The use of hawthorn fruits is well known from the ethnobotanical record and has been documented up to modern times (Brøndegaard 1979 pp. 53).

A renewed examination of the seeds of hawthorn established that 8 out of 68 seeds were charred or showed the effect of exposure to heat (letter from D. Robinson, The National Museum, Natural science Unit of 15/10-1997). This new investigation demonstrated that these seeds were not a "natural" component of the lake sediment in the "dump zone", but quite contrarily that they were food waste from the settlement area proper.

In this connection it is also essential to mention the large number of hawthorn seeds from the contemporary Ertebølle settlement of Møllebgabet II at Ærø (Grøn & Skaarup 1991; Robinson 1992).

THE RINGKLOSTER SETTLEMENT

Seasonal occupation

It is clear from the archaeological record, that the site was not just used for shorts periods during occasional explorations from a main settlement located elsewhere. The amount of artefacts, debris and the many various features point towards repeated or "semi-permanent" use.

Ringkloster has a number of different and clear seasonal indicators. The analysis by Rowley-Conwy (1998 - this volume) demonstrates that the bones of birds and mammals reflect a distinct seasonality of winter and spring occupation, i. e. the main period of habitation was from November to May. Analysis of wild boar, red and roe deer tooth wear and tooth eruption and bone growth all point towards a winter and spring occupation, while the many hazel nuts point towards the fall. These observations also fit with the presence of the many furry animals, for the pelts are best during the winter time. The collecting of hawthorn fruits also point in the same direction. The fishes neither support nor contradict this result, but it should be remembered that pike is easiest to catch during their spawning season from March to May (Enghoff 1998 - this volume). Summer indicators are few, but 8 unshed roe deer antlers demonstrate activities on the site during this season; in the same direction point the very young foetal red deers which could not have been killed before May or May-June. Sporadical visits outside the "normal" autumn-winter season seem therefore to have taken place.

All together the faunal and botanical evidence point towards a main occupation period from autumn to early spring, but the whole year occupation could not be completely ruled out.

Type of settlement - "Forest hunters and coastal fishermen"?

What was the purpose of the occupation at Ringkloster? As stated above, Ringkloster differs in many respects from contemporary coastal Ertebølle settlements. As there are only 2 other excavated inland Ertebølle settlement in Jutland, and they are without faunal remains, we lack a wider base for any sort of comparison[11]. This is also the case with the other Danish and North German inland Ertebølle sites, which are not yet satisfactorily published.

The many structural features at Ringkloster reflect functional differences from the coastal sites rather than a cultural one. Although of a negative order, the lack of graves at Ringkloster is also an element which should not be forgotten.

Both the archaeological and the faunal material from Ringkloster argue in favour of interpreting the site as a seasonal site for the procurement of antler, furs/hides and meat. In this respect Ringkloster is unique not only in the Danish, but in the whole North European archaeological record; no other winter inland Ertebølle settlements have so far been published. Only one other Danish Ertebølle site - the coastal site of Hjerk Nor on the Limfjord - demonstrates a similar high frequency of fur-bearing animals, but as this material has been recovered by dredging in the last century it is not usable in a comparison with Ringkloster (Hatting, Holm & Rosenlund 1973).

This interpretation of Ringkloster is also supported by the dominance of arrowheads, flint scrapers for hides, bone knifes, the "oyster shell scrapers", the low axe ratio, and the few artefacts for fishing. Based on his osteological identifications Peter Rowley-Conwy argues that meat of wild boar, red deer, and aurochs must have been removed from Ringkloster to some other location, and that such (base) camps were where the meat and furs ended up (Rowley-Conwy 1993).

This raises other questions. Where were such base camp(s) located? As mentioned before, we have several different signs of contacts between Ringkloster and the sea coast: the whale bones and the marine fishes, the oyster shells, amber (although this raw material theoretically could have been found along the shores of the inland lakes) and the high value of marine food in one of the dogs. These all point in the same direction - the seashore, which only was 14-18 kms away. No other Danish Mesolithic settlement has so many and various traces of contacts between the interior and the coast as Ringkloster (however one should not forget that contacts from Ringkloster and further west into the interior of Jutland also *could* have taken place, but would be nearly impossible to prove). Also the decorated Ertebølle pottery shows a concentration in eastern central Jutland (fig. 39). Both in the Brabrand Fjord (to the north) and in Norsminde fjord (to the east) 2-3 contemporary Ertebølle sites are characterised by this type of ornamented pottery; similar decorated Ertebølle pottery is not found at the Ertebølle sites in Horsens Fjord to the south, but this could also be a function of a lower research intensity in this area

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[11] Rosenholm. Forhistorisk Museum, J. nr. 872 and 2011. Unpublished excavation of an inland Ertebølle settlement ca. 25 km Northeast of Århus. Unfortunately it was only partially excavated and only flints and a few charred bones were found. Another excavation of an inland Ertebølle site has taken place at Stallerup Sø (Vejle amt), Forhistorisk Museum, J. nr. 2746 (unpublished). This site was excavated *in toto*, but only flints were found.

compared to the other east jutland regions (fig. 39). The highest frequency of such ceramics is known from the large Flynderhage *køkkenmødding* (central site) in Norsminde Fjord (Gabrielsen 1953).

Together these finds demonstrate a series of contacts between the interior and the coast, but it is not possible to explain the character of these connections and at what social level they took place, i. e. are the marine elements on the inland site Ringkloster vestiges of an exchange network connecting an Ertebølle inland settlement system with a contemporary coastal system, or have the marine elements been brought into the inland district by people moving seasonally from their main settlements at the coast and into the Skanderborg Sø area? In other words did we have two independent groups, *"forest hunters"* and *"coastal fishermen"* connected by exchange networks or are we dealing with one large settlement system covering the whole of Eastern Jutland (fig. 40) ?

The present evidence point in both directions: An argument in favour of two independent Ertebølle settlement systems in this region is given by the 3 dogs with a clear terrestrial food content in their bones - although it is still difficult to evaluate the strength of this type of information. Perhaps the many structural features and the high number of ceramics point in the same direction, as they contrast with the situation at the coastal sites. Pointing in the opposite direction are the conclusions based on the faunal elements, and probably also the absence of graves at Ringkloster.

No conclusive answers to these questions can be proposed now, but at present most information seems to be in favour of interpreting Ringkloster as a seasonal site and as a part of one large East Jutland Ertebølle settlement and procurement system, which included both the coast (Brabrand and Norsminde Fjord) and the interior (Ringkloster).

A situation similar to the east Jutland one has been demonstrated in the Åmose basin on Zealand, but here Nanna Noe-Nygaard argues (mainly based on ^{13}C analysis of dog bones) that we are dealing with two independent groups, an inland population and a coastal population, independent, but with contacts in both directions (Noe-Nygaard 1983 p. 140, 1988 p. 93).

Social organisation

Was Ringkloster a seasonal winter hunting/trapping site of a single coastal settlement, or was it a common procurement site for a whole group of coastal sites of the region? An indication that Ringkloster not only was connected with a single coastal settlement comes from the narrow geographical distribution of contemporary settlement sites with decorated Ertebølle pottery in Eastern Jutland. This extraordinary element indicate connections between these sites, but again it is difficult to define at what level such connections were.

Another question is whether it was all the coastal population that moved seasonally inland in the autumn or whether it was just a small hunting/trapping group. The small number of inland settlements and their relatively small extent in comparison with the coastal sites, tells that it only was small hunting parties which visited Ringkloster in the winter time.

If Ringkloster served as a seasonal camp for several different coastal settlements - if it was a part of an economic structure/network - it must inevitably also have brought into existence social contacts/relations independant of whether this was originally intended or not. Ringkloster also functioned as a meeting place with all the options this gave for establishing social contacts between the peoples - a structural role just as essential as the economic one.

CONCLUSION

Ringkloster is the first excavation of an inland Ertebølle settlement in Denmark for nearly 50 years. Besides it is the first inland settlement with preserved organic materials in the western part of Denmark. The excavations have been extensive and cover both a habitation area on dry land and the ajacent "dump zone" in the prehistoric lake deposits. On dry land a large number of structural features such as different types of pits and fireplaces, trenches, postholes etc. have been recorded, while the "dump" yelded a large faunal material as well as a wide range of Ertebølle types in antler, bone and wood. The occupation at Ringkloster covers ca 1800 years, i.e. the whole Ertebølle and the Early Neolithic Funnel Beaker cultures from ca 5400-3550 BC. - and therefore also the Mesolithic - Neolithic transition at ca 3940-3820 BC.

Ringkloster probably functioned as a "central inland site" contemporary with an extensive habitation along the east Jutland coastline. During the long habitation period it gradually became the largest settlement in the lake region of Eastern Jutland as a combination of an optimal location in the exact centre of the lake area and as a function of a high degree of resource stability during ca 1800 years. The most intense occupation with regards to site area and accumulation of debris took place during the younger Ertebølle phase, but it must be stressed that Ringkloster - against normal Danish opinion - also indicates that there was extensive inland habitation during the older Ertebølle period.

The pollen analysis show a distinct contemporary elm and lime decline in the primeval Atlantic forest, which was most probably caused by the Ertebølle population's use of wood for boats, houses etc. Because of the well defined stratigraphy and layers with distinct archaeological types, it has been possible to make direct correlation between archaeological cultures and the botanical evidence. At the beginning of the Subboreal, ca 3900 B.C. the evidence point to an opening of the forest, and at the same time the first pollen of ribwort are recorded - demonstrating the activities of the earliest "Neolithic farmers" in the vicinity of Ringkloster.

The artefact industry at Ringkloster differs markedly in relative frequencies from the contemporary coastal settlements; it is characterised by a dominance of scrapers, burins and transverse arrowheads, while borers, truncated blades and axes are few. Antler implements - especially antler axes - and antler waste are abundant, but bone tools are rare, especially bone points are few at this site. A new type is curved bone knives - interpreted as "skinning knives". Ertebølle pottery is found in large quantities, and a gradual change from a dominance of thick-walled pottery in the deepest horizon to a more thin-walled ware in the upper layer has also been observed. Quite extraordinarily some of the Ertebølle pots were decorated, a feature only known from a small group of contemporary coastal settlements in the central east Jutland region. The new tool types at this site included scrapers of oyster shell.

The analysis of the faunal remains give an explanation for the composition of the artefact industry. Ringkloster is a seasonal (winter) settlement with a specialised economy centred on hunting wild boar, red deer, aurochs and furry animals, especially pine marten and otter. Ringkloster is an inland site for the procurement of meat, skins/pelts and probably also antler. Fowling and fishing seem not to have played a significant economic role. An interesting aspect of the economic activities is that a major part of the meat seems to have been brought to other settlements, probably coastal, for consumption. The presence of bones from dolphins and marine fishes as well as the oyster shells and amber all point to contacts with the coast, and Ringkloster is so far the Danish inland site with the largest number and greatest variety of coastal indicators. However, it is difficult to interpret the nature of these contacts. Are they indicators of seasonal movements of groups between the coast and the interior of Jutland or are they traces of exchange networks between an inland and a coastal population? In other words is Ringkloster an example of an inland Ertebølle settlement system independent of, but connected with a coastal settlement system, or is it a part of a single large east Jutland settlement system with its main settlements based on the coast, but incorporating the interior lake region? At present most evidence point to an interpretation of Ringkloster as the seasonal, winter, inland settlement component of a large settlement system based on the coast. If Ringkloster served as an inland procurement site for more than one of the coastal sites, it must inevitably also have played an important role as a location for social exchange and impulses in East Jutland Ertebølle society.

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REFERENCES

Althin, C. -A. 1954: The Chronology of the Stone Age Settlement of Scania, Sweden. *Acta Arch. Lundensia.* Series in 4°. No. 1. Lund.

Andersen, K. 1983: *Stenalderbebyggelsen i den vestsjællandske Åmose.* Fredningsstyrelsen. København.

Andersen, S. H. 1972: Ertebøllekulturens harpuner. (English summary) *Kuml* 1971: 73-125.

- 1975: Ringkloster, en jysk indlandsboplads med Ertebøllekultur. (English summary) *Kuml* 1973-74: 11-108.
- 1976: Et østjysk fjordsystems bebyggelse i stenalderen; Norsminde Fjord undersøgelsen. In: H. Thrane (ed.) *Bebyggelsesarkæologi.* Skrifter fra Institut for Historie og Samfundsvidenskab no. 17. Odense Universitet.
- 1977: Ertebøllekultur på Vestfyn. En oversigt. *Fynske Minder*: 7-36.
- 1979a: Flade, skælhuggede skiver af Brovst-type. (English summary)*Kuml* 1978: 77-98.
- 1979b: Pelsjægere. *Skalk* 1979, nr. 2: 3-8.
- 1981: Ertebøllekunst. Nye østjyske fund af mønstrede Ertebølleoldsager. (English summary) *Kuml* 1980 (1981), pp. 7-59. Århus.
- 1985: Tybrind Vig. A Preliminary Report on a Submerged Ertebølle Settlement on the West Coast of Fyn. *Journal of Danish Archaeology* vol. 4: 52-69.
- 1991: Norsminde. A "Køkkenmødding" with Late Mesolithic and Early Neolithic Occupation. *Journal of Danish Archaeology* vol. 8, 1989: 13-40.
- 1993: Bjørnsholm. A Stratified Køkkenmødding on the Central Limfjord, North Jutland. *Journal of Danish Archaeology* vol. 10, 1991: 59-96.
- 1994: Kød, pelsværk og skind. *Humaniora.* Nr. 2. 8 årg.: 27-31.
- 1995: Coastal adaption and marine exploitation in Late Mesolithic Denmark - with special emphasis on the Limfjord region. In: A. Fischer (ed.) *Man and Sea in the Mesolithic. Coastal settlement above and below present sea level*, pp. 41-66. Oxbow Monograph 53, Oxford.

Andersen, Søren H. & Malmros 1966: Norslund. En kystboplads fra ældre stenalder. (English summary) *Kuml* 1965: 35-114.

Andersen, Søren H. & N. Sterum 1971: Gudenåkulturen. *Holstebro Museum. Årsskrift* 1970-71: 14-32.

Andersen, Søren H. & Malmros 1981: Appendix. Dateringen af Norslund - bopladsens lag 3 og 4. *Kuml* 1980: 60-62.

Andersen, Søren H. & Johansen 1987: Ertebølle Revisited. *Journal of Danish Archaeology* vol 5, 1986: 31-61.

Bahnson, K. 1892: Meddelelser fra Nationalmuseets danske Samling. Stenalderen. *Aarbøger for nordisk Oldkyndighed og Historie* II Rk. 7 Bd.: 166 (Vålse Vig).

Becker, C.J. 1939: En Stenalderboplads paa Ordrup Næs i Nordvestsjælland. Bidrag til Spørgsmaalet om Ertebøllekulturens Varighed. *Aarbøger for nordisk Oldkyndighed og Historie* : 199-280.

Binford, L. 1983: *In Pursuit of the Past.*

Bleuer, E. et al. 1993: *Jungsteinzeitliche Ufersiedlungen im Zürcher Seefeld. Zürcher Denkmalpflege.* Band 2: Tafeln. Archäologische Monographien 23. Zürich.

Brøndegaard, J. V. 1979: *Folk og flora. Dansk etnobotanik.* 3. København.

Clark, J. G. D. 1954: *Excavations at Star Carr.* Cambridge.

Clason, A. T. 1986: Spoolde, worked and unworked antlers and bone tools. *Palaeohistoria* 25, 1983: 77-130. Rotterdam.

Davidsen, K. 1978: *The Final TRB Culture in Denmark. A Settlement Study.* Arkæologiske Studier V. København.

Deichmüller, J. 1965: Die neolithische Moorsiedlung Hüde I am Dümmer, Kreis Grafschaft Diepholz. Neue *Ausgrabungen und Forschungen in Niedersachsen* 2: 1-18. Hildesheim.

- 1969: Die neolithische Moorsiedlung Hüde I am Dümmer, Kreis Grafschaft Diepholz. *Neue Ausgrabungen und Forschungen in Niedersachsen*: 28-36. Hildesheim.

Enghoff, I. B. 1994: Fishing in Denmark During the Ertebølle Period. *International Journal of Osteology*, Vol. 4: 65-96.

- 1998: Freshwater fishing at Ringkloster, with a supplement of marine fishes. *Journal of Danish Archaeology* vol 12, 1994-95: 99-105.

Fischer, A. 1982: Trade in Danubian Shaft-Hole Axes and the Introduction of Neolithic Economy in Denmark. *Journal of Danish Archaeology* vol. 1: 7-12.

Gabrielsen, S. 1953: Udgravningen på Flynderhage 1945 - 47. *Aarb. udgivne af Historisk Samfund for Aarhus Stift* XLVI, 1953: 5 -16.

Grøn, O. & J. Skaarup 1991: Møllegabet II. A Submerged Mesolithic Site and a "Boat Burial from Ærø. *Journal of Danish Archaeology* vol 10, pp. 38-50.

Grønnow, B. 1987: Meiendorf and Stellmoor revisited. *Acta Archaeologica*, vol. 56: 131-166.

Harder, P. 1908: En østjysk Israndslinie og dens Indflydelse paa Vandløbene. *D. G. U. II rk.* , nr. 19, pp. 108 ff and 121 ff.

Hartz, S. 1996: Älteste Keramik der Erteböllekultur. *Archäologie in Deutschland*, Nr. 2, 1996: 53-54

- 1997: Ertebøllekultur in Travetal. *Stormarner Hefte. Denkmalpflege im Kreis Sormarn* III, 20: 171-186

Hatting, T., E. Holm & K. Rosenlund 1973: En pelsjægerboplads fra stenalderen. *Kaskelot* 1973: 13-20.

Hulthen, B. 1977: *On ceramic technology during the Scanian Neolithic and Bronze Age.* Thesis and Papers in North-European Archaeology 6. Stockholm.

Iversen, Johs. 1967: Naturens udvikling siden sidste istid. In: Nørrevang, A. og T. J. Meyer (eds.) *Danmarks natur.* Bd. 1. Politikens Forlag. København.

Jacobsen, N. Kingo 1976: Natural - Geographical Regions of Denmark. *Geografisk Tidsskrift* 75: 1-7. København juni 1976.

Jennbert, K. 1984: *Den produktiva gåvan. Tradition och innovation i Sydskandinavien för omkring 5300 år sedan.* Acta Arch. Lundensia. Series in 4° No 16.

Jensen, H. Juel 1982a: Analysis of wear on flint tools. Pact 7, pp. 441-445. *Second Nordic Conference on the Application of Scientific Methods in Archaeology.* Helsingør, Denmark, 17-19 August 1981. Strasbourg.

- 1982b: A Preliminary Analysis of Blade Scrapers from Ringkloster, A Danish Late Mesolithic Site. *Studia Praehistorica Belgica* 2 - 1982: 323-327.
- 1986: Unretouched blades in the Late Mesolithic of South Scandinavia. A functional study. *Oxford Journal of Archaeology* 5: 19-33.
- 1989: Plant harvesting and processing with Flint Implements in the Danish Stone Age. A View from the Microscope. *Acta Archaeologica.* Vol. 59, 1988: 131-142.
- 1994: *Flint Tools and Plant Working. Hidden Traces of Stone Age Technology.* Aarhus University Press.

Klindt - Jensen, O. 1947. Udgravningen 1944. In: Haugsted, E. (ed.) *Bopladsen paa Rugholm. Aarhus Museums Undersøgelser ved østenden af Brabrand Sø 1944-45.* Aarhus.

Larsson, L. 1983: Ageröd V. *An Atlantic Bog Site in Central Scania.* Acta Arch. Lundensia. Series in 8°. No 12. Lund.

Legge, A. J. & P. Rowley-Conwy 1988: *Star Carr Revisited. A Re-analysis of the Large Mammals.* London.

Madsen, T. & J. E. Petersen 1984: Tidlig-neolitiske anlæg ved Mosegården. Regionale og kronologiske forskelle i tidligneolitikum. *Kuml* 1982-83: 61-120.

Malmros, C. 1986: *Rapport om bestemmelse af ved, trækul, bark og svampe fra Ringkloster.* Unpublished Report. The National Museum, Natural Science Research Unit. J. Nr. A 5502-92, 19 p. København.

Mathiassen, Th. 1937: Gudenaa-Kulturen. En mesolitisk Indlandsbebyggelse i Jylland. *Aarbøger for nordisk Oldkyndighed og Hist*orie 1937, 1 Halvbind: 1-181.

- 1943: *Stenalderbopladser i Aamosen.* Nordiske Fortidsminder III Bind, 3. Hefte. København.

Mestorf, J. 1904: Wohnstätten der älteren neolithischen Periode in der Kieler Föhrde. Archäologischer Teil. *43 Bericht des Schleswig - Holsteinischen Museums vaterländischer Altertümer bei der Universität Kiel,* 1904: 17- .

Noe - Nygaard, N. 1974: Mesolithic Hunting in Denmark Illustrated by Bone Injuries Caused by Human Weapons. *Journal of Archaeological Science* 1974, 1: 217-248.

- 1983: The Importance of Aquatic Resources to Mesolithic Man at Inland Sites in Denmark. In: C. Grigson & J. Clutton-Brock (eds.) *Animal and Archaeology : 2. Shell Middens, Fishes and Birds,* pp. 125-142. BAR international Series 183.
- 1988: Delta 13 C-Values of Dog Bones Reveal the Nature of Changes in Man's Food Resources at the Mesolithic - Neolithic Transition, Denmark. *Chemical Geology (Isotope Geoscience Section),* 73: 87-96. Amsterdam.
- 1995: Ecological, sedimentary, and geochemical evolution of the late - glacial to postglacial Åmose lacustrine basin, Denmark. *Fossils & Strata.* No 37. 8th June 1995. Scandinavian University Press. Oslo, Copenhagen, Stockholm.

Pedersen, L. 1980: Skolæstøkser. *Skalk,* nr. 4: 27-29.

Petersen, K. S. 1987: The Ertebølle "Køkkenmødding" and the Marine Development of the Limfjord, with Particular Reference to the Molluscan Fauna. *Journal of Danish Archaeolgy* vol. 5, 1986: 77-84.

Petersen, P. V. 1984: Chronological and Regional variation in the Late Mesolithic of Eastern Denmark. *Journal of Danish Archaeology* vol. 3: 7-18.

Pitts, M. 1979: Hides and antlers: a new look at the gatherer-hunter site at Star Carr, North Yorkshire, England. *World Archaeology,* Vol. II, No. I: 32-42.

Rasmussen, Peter 1998: Mid-holocene Vegetation Development at the Inland Ertebølle Settlement of Ringkloster, Eastern Jutland. *Journal of Danish Archaeology* vol 12, 1994-95: 65-85

Regnell, M. , M -J. Gaillard, T. S. Bartholin & P. Karsten, 1995: Reconstruction of Environment and history of plant use during the late Mesolithic (Ertebølle culture) at the inland settlement of Bökeberg III, southern Sweden. *Vegetation History and Archaeobotany,* vol. 4: 67-91.

Robinson, D. 1992: Bestemmelse af planterester fundet i forbindelse med en stammebåd ved Møllegabet II, *Ærø N:N:U: rapport nr. 6*

Rowley - Conwy, P. 1981: Mesolithic Danish Bacon: Permanent and Temporary Sites in the Danish Mesolithic. In: A. Sheridan and G. Bailey (eds.) *Economic Archaeology,* pp. 51-55.BAR International Series 96.

- 1993: Season and Reason: the case for a regional interpretation of mesolithic settlement patterns. In: G. L. Peterkin, H. Bricker and P. Mellars (eds.) *Hunting and Animal Exploitation in the Later Palaeolithic and Mesolithic of Eurasia,* pp. 179-188. Archaeological Papers of the American Anthropological Association no. 4, 1993.
- 1998: Meat, Furs and Skins: Mesolithic Animal Bones from Ringkloster, a Seasonal Hunting Camp in Jutland. *Journal of Danish Archaeology* vol 12, 1994-95: 87-98.

Schindler, R. 1961: Rössener Elemente im Frühneolithikum vom Boberg. *Hammaburg* 7/XIII: 9-29.

Schwabedissen, H., 1960: Die Ausgrabungen im Satruper Moor. *Offa* Bd. 16. 1957-58 (1960): 5-28. Neumünster.

- 1981: Ertebølle/Ellerbek - Mesolithikum oder Neolithikum ? In: B. Gramsch (ed.) *Mesolithikum in Europa.* Veröffentlichungen des Museums für Ur- und Frühgeschichte Potsdam 14/15, 1980: 129-142.

- 1994: Die Ellerbek-Kultur in Schleswig-Holstein und das Vordringen des Neolithikums über die Elbe nach Norden. In: J. Hoika & J. Meurers-Balke (eds.) *Beiträge zur frühneolithischen Trichterbecherkultur im westlichen Ostseegebiet. 1. Internationales Trichterbechersymposium in Schleswig vom 4. bis 7. März 1985*: 361-401. Neumünster.

Stuiver, M. & Reimer, P. J. 1993: Extended ^{14}C data base and revised CALIB 3. 0 ^{14}C age calibration program. *Radiocarbon* 35, 1: 215-230.

Sørensen, I. 1969: Er bæverens tænder benyttet som redskaber i stenalderen i Danmark? *Aarbøger for nordisk Oldkyndighed og Historie* 1969: 116-126.

Tauber, H. 1971: Nye perspektiver i kulstof - 14 dateringsmetoden. *Naturens Verden* 12: 393-401.

- 1981: Kostvaner i forhistorisk tid, In: *"Det skabende menneske 1". Kulturhistoriske skitser tilegnet P. V. Glob 20 februar 1981*, pp. 112 - 126.

- 1971: Nye perspektiver i kulstof-14 dateringsmetoden. *Naturens Verden* 12: 393-401.

Troels-Smith, J. 1960: Ertebølletidens Fangstfolk og Bønder. *Fra Nationalmuseets Arbejdsmark* 1960: 95-119. København.

- 1967: The Ertebølle Culture and its Background. *Palaeohistoria*, vol. 12: 505-528. Groningen.

Trolle-Lassen, T. 1986: Human exploitation of the pine marten (Martes martes (L.)) at the Late Mesolithic settlement of Tybrind Vig in western Funen. In: L. -K. Königsson (ed.) *Nordic Late Quaternary Biology and Ecology.* Striae 24, pp. 119-124.

Vita-Finzi, C. & E. S. Higgs 1970: Prehistoric Economy in the Mount Carmel Area of Palestine. Site Catchment Analysis. *Proceedings of the Prehistoric Society.* Volume XXXVI, Dec. 1970: 1-37.

Waterbolk, H. T. & W. van Zeist 1991: *Niederwil. Eine Siedlung der Pfyner Kultur.* Academica Helvetica. Bd. 1^{IV} : Holzartefakte und Textilien. Bern.

Westerby, E. 1927: *Stenalderbopladser ved Klampenborg. Nogle Bidrag til Studiet af den mesolitiske Periode.* København.

Aaris-Sørensen, K. 1988: *Danmarks forhistoriske dyreverden. Fra istid til vikingetid.* København.

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Radiocarbon datings at Ringkloster

by Kaare Lund Rasmussen

Radiocarbon datings of samples from Ringkloster have been carried out at The Radiocarbon Dating Laboratory at the National Museum of Denmark. The samples consisted of charcoal and bones of dogs. The charcoal was treated routinely with acid, alkaline, and acid (Mook & Waterbolk 1985), which removes any acid soluble carbon contaminants as well as contamination of humic acid. Collagen was extracted from the bone samples. After conversion into carbon dioxide the samples were further purified, and finally counted in a 3 liters proportional counter equipped with a guard counter for at least one day. It should be borne in mind that the datings from Ringkloster have been produced during a rather long period of time, i.e. from 1970 to 1993.

Most samples were measured for the stable isotope ratio, $\delta^{13}C$, on a mass spectrometer. Besides being highly interesting in itself, the $\delta^{13}C$ was used for correcting the radiocarbon ages for isotopic fractionation. The two dog bone samples K-386 and K-387 were too small to allow dating, and were only measured for stable isotope ratio. One of these (K-387) was definitely affected by marine diet ($\delta^{13}C$ = -11.8 $^0/_{00}$ PDB), while the other (K-386) and the two remaining dog bone samples (K-4132 and K-4133) were all clearly terrigenic in isotope ratio ($\delta^{13}C$ = -20.0, -21.3, and -18,8 $^0/_{00}$ PDB). Thus all samples dated could be refered to the terrestrial value of $\delta^{13}C$ = -25 $^0/_{00}$PDB.

Four samples dated before 1971 were not measured for $\delta^{13}C$. For these have been added extra uncertainty to account for the unknown isotopic fractionation. Fortunately all of these samples were charcoal.

Calibration of the results was performed according to the 20 year average of the atmospheric curves in Stuiver and Pearson (1993) using the Calib V3.0.3c program from University of Washington (Stuiver & Reimer 1993). The most likely calibrated date and the calibrated date at ± 1 standard deviation are listed in Table 1. The full calibrated probability distributions for all the samples were generated by the Oxcal v2.18 program from the Oxford Radiocarbon Laboratory (Ramsey 1995) and are shown in Fig. 1.

It can be speculated whether or not K-1765 (or K-1653) are in fact older than K-4368. A hypothesis that the age of K-1765 is identical with the age of K-4368 is accepted within the 95% confidence limit by a statistical T-test. Thus, seen from a statistical point of view K-1765 are indistinguishable from K-4368, and so is K-1653.

K-1654 is from the same stratigraphical level as K-4370, but seemingly somewhat older. Again a statistical T-test shows that a hypothesis that the date of K-1654 is identical to the date of K-4370 is accepted within the 95% confidence limit.

A hypothesis that K-4132 and K-4133 are of identical age is also accepeted within the 95% confidence limit by a T-test.

None of these statistically derived conclusions are surprising if one contemplates Figure 1, where the distributions of calibrated ages are plotted for all the dates. A significant overlap in the probability distributions are seen for each pair noted above.

However, a hypothesis that K-4371 and K-4372 are of identical age is rejected within the 95% confidence limit by a T-test. There is thus a significant jump in time between the last sample in stratigraphical sequence of Mesolithic age (K-4371) and the first sample of Neolithic age (K-4372). This jump is also clearly seen in Fig. 1.

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REFERENCES:

W.G. Mook & H.T. Waterbolk 1985: *Handbook for Archaeologists, No 3, Radiocarbon Dating.* European Science Foundation, ISBN 2-903148-44-9

C. Bronk Ramsey1995: *OxCal v2.0. A Radiocarbon Calibration and Analysis Program. Radiocarbon calibration program OxCal v2.18.* Radiocarbon Accelerator Unit, Research Lab for Archaeology, 6 Keble Rd., Oxford OX1 3QJ

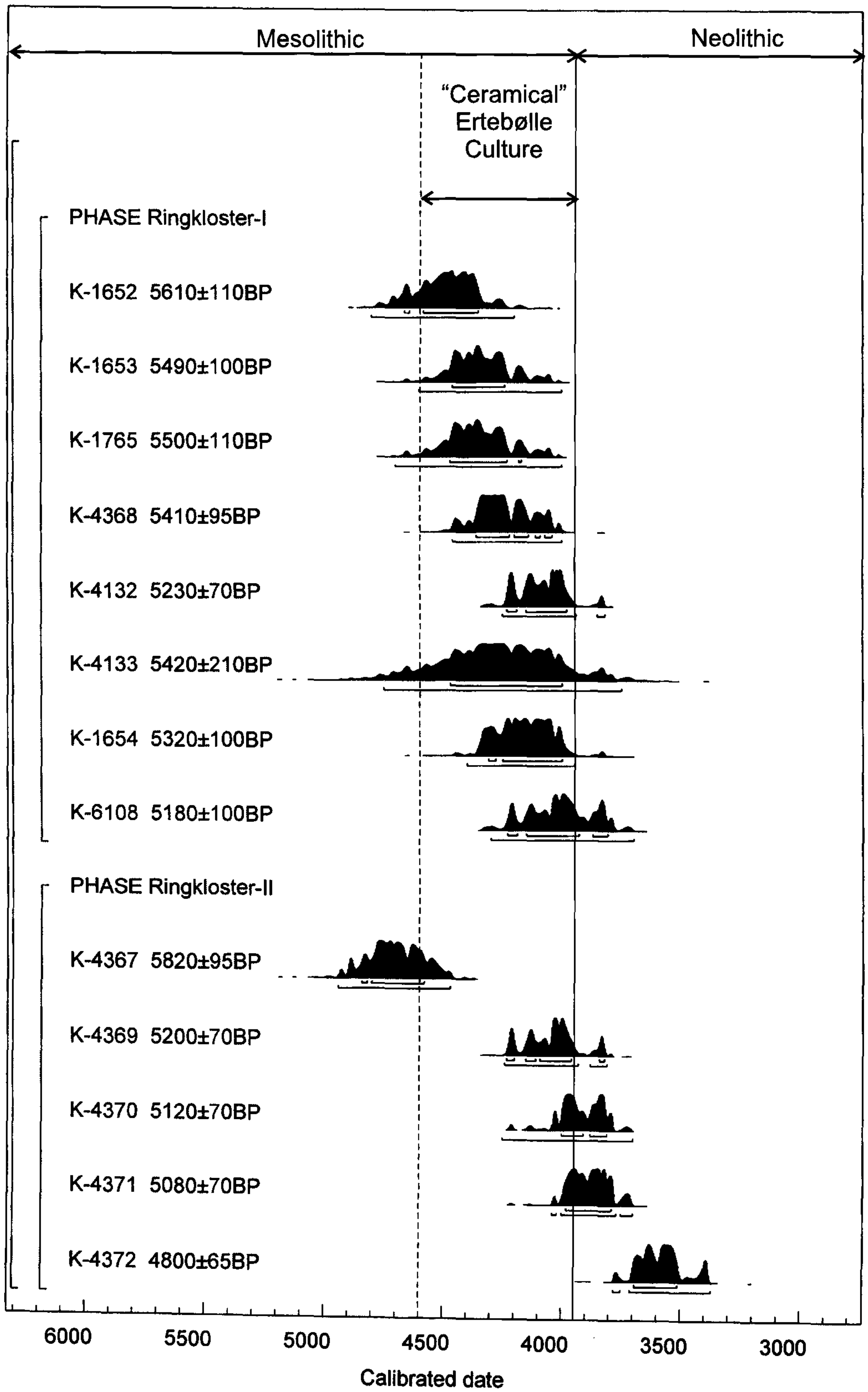
M. Stuiver & G. W. Pearson 1993: High-Precision Bidecadel Calibration of the Radiocarbon Time Scale, AD 1950-500 BC and 2500-6000 BC. *Radiocarbon*, Vol 35, No. 1, pp. 1-25

M. Stuiver & P. J. Reimer 1993:Extended ^{14}C Data Base and Revised CALIB 3.0 ^{14}C Age Calibration Program. *Radiocarbon*, Vol 35, No. 1, pp. 201-230

K-no.	Material	Radiocarbon age	Most likely Calibrated age	Calibrated age at ± 1 std.dev.	$\delta^{13}C$ ‰ PDB
K-386	Bones, dog	-			-20.0
K-387	Bones, dog	-			-11.8
K-1652	Charcoal T	5610±110	4460	4540-4350	
K-1653	Charcoal Q	5490±100	4340	4450-4240	
K-1654	Charcoal FR	5320±100	4220-4110	4320-3990	
K-1765	Charcoal Q	5500±110	4350	4460-4240	
K-4132	Bones, dog	5230±70	4030-4000	4220-3970	-21.3
K-4133	Bones, dog	5420±210	4320-4260	4460-3990	-18.8
K-4367	Charcoal Q	5820±95	4710	4790-4540	-25.3
K-4368	Charcoal CO	5410±95	4320-4250	4350-4100	-26.8
K-4369	Charcoal T	5200±70	3990	4080-3960	-26.8
K-4370	Charcoal AL/U	5120±70	3950	3980-3800	-26.2
K-4371	Charcoal CO/-A-L/FR	5080±70	3940-3820	3970-3790	-25.2
K-4372	Charcoal FR/AL	4800±65	3630-3550	3650-3510	-24.7
K-6108	Charcoal AL	5180±100	3980	4210-3820	-26.7

Table 1. Radiocarbon dates from Ringkloster

Fig. 1 Calibrated age distributions of the samples from Ringkloster using Oxcal v2.18. The terminal phase of the Mesolithic, the Ceramical Ertebølle Culture from Cal BC 4600 to 3950, is marked with vertical lines. Only one sample (K-4372) lies exclusively in the Neolithic.


Mesolithic
Neolithic
"Ceramical" Ertebølle Culture
PHASE Ringkloster-I
K-1652 5610±110BP
K-1653 5490±100BP
K-1765 5500±110BP
K-4368 5410±95BP
K-4132 5230±70BP
K-4133 5420±210BP
K-1654 5320±100BP
K-6108 5180±100BP
PHASE Ringkloster-II
K-4367 5820±95BP
K-4369 5200±70BP
K-4370 5120±70BP
K-4371 5080±70BP
K-4372 4800±65BP
6000
5500
5000
4500
4000
3500
3000
Calibrated date

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Mid-holocene Vegetation Development at the Inland Ertebølle Settlement of Ringkloster, Eastern Jutland

by Peter Rasmussen

ABSTRACT

Two pollen diagrams have been produced from littoral lake sediments close to the Ertebølle settlement of Ringkloster with the aim of elucidating the development of the vegetation during the Ertebølle occupation and at the transition to the Funnel Beaker Culture. One of the diagrams, from radiocarbon-dated refuse layers containing artefacts from the Ertebølle and Funnel Beaker Cultures, provides a particularly good picture of the vegetation. Through a close stratigraphic relationship between the refuse layers and the pollen-analytical investigations, evidence for woodland disturbance contemporary with the occupation of the Ertebølle settlement can be demonstrated. The disturbance is primarily in the form of very early elm and lime declines, which in all probability are anthropogenic in origin. At the transition to the Funnel Beaker Culture, ca. 3900 cal. BC, the woodland cover is reduced and open-habitat herbs increase. At the same time there is the first occurrence of *Plantago lanceolata* and the pollen diagrams register the earliest agricultural activity, pastoral farming, in the vicinity of the Ringkloster settlement. The investigation shows, furthermore, a lowering of the water level in the lake at the Mesolithic/Neolithic transition (Atlantic to Sub-boreal), indicating a shift towards a drier climate.

INTRODUCTION

Archaeological investigations have been carried out between 1969 and 1985 at the Ertebølle settlement site of Ringkloster, which lies south of Skanderborg Sø (fig. 1). The findings have been published by the excavation director, Søren H. Andersen, Institute of Prehistoric Archaeology, University of Aarhus (Andersen 1975; 1979; 1994; 1998 - this volume). Biostratigraphical investigations were carried out in conjunction with the archaeological investigations and samples were collected with the aim of investigating the contemporary vegetation at the site. The biostratigraphical fieldwork was carried out by C. Malmros and C. Christensen of the National Museum, Natural Science Research Unit, and J. Ørnbøl, formerly attached to the Institute of Prehistoric Archaeology, University of Aarhus. All the pollen samples were prepared and counted by J. Ørnbøl.

The final processing and publication of the pollen-analytical data was transferred to the Geological Survey of Denmark and Greenland and the present author, whose presentation here is based exclusively on the already existing pollen data.

With the exception of Djursland, the Holocene vegetation development in eastern Jutland has been scantily investigated and there is in particular a lack of radiocarbon-dated pollen diagrams from this part of Denmark. The pollen diagrams nearest to the Ringkloster settlement are the very early ones from Brabrand near Århus, about 17 km from Ringkloster (Troels-Smith 1937) and Dyrholmen on Djursland, about 49 km from Ringkloster (Troels-Smith 1942) (fig. 1). Both diagrams were produced from deposits associated with archaeological settlements from the Ertebølle Culture, but without any direct correlation

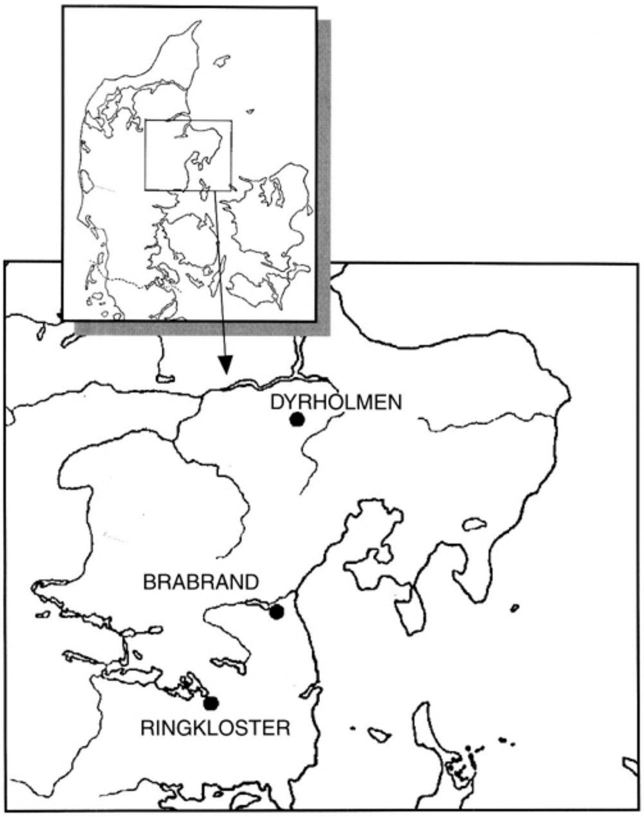

Fig. 1 Map of Denmark showing the location of Ringkloster and the sites of the nearest pollen diagrams: Brabrand and Dyrholmen (after Andersen 1975).

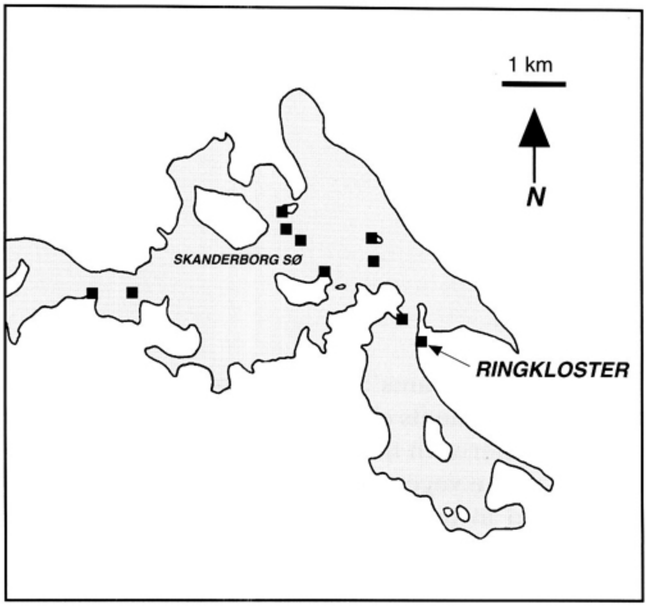

Fig. 2 Skanderborg Sø´s presumed extent in the Mesolithic period. The Ringkloster settlement and all other known Mesolithic settlements are marked (after Andersen 1975).

between the diagrams and the archaeological layers. The diagrams are not radiocarbon dated, as they were produced before the method was introduced.

Like the investigations at Brabrand and Dyrholmen, the pollen-analytical investigations at Ringkloster had, as their main aim, the description of the development of the vegetation during the Ertebølle occupation and at the later transition from the Mesolithic to the Neolithic, i.e. from the Ertebølle Culture to the Funnel Beaker Culture.

THE RINGKLOSTER SETTLEMENT

The Ringkloster settlement is situated by a now overgrown, but earlier open, arm of Skanderborg Sø, which extended about 3 km south-southeast of the present-day lake (fig. 2). The settlement lies at the foot of a clayey moraine slope, facing out over the former lake. Ringkloster is the only inland settlement from the Ertebølle Culture excavated in Jutland so far. The archaeological investigations took place partly on dry land, in the settlement area itself, and partly in the refuse layers extending out from the settlement into the adjacent lake deposits. The refuse layers contained very large numbers of archaeological artefacts which are presumed to have been thrown out into the lake from the settlement (Andersen 1975; 1979). They also contained extremely well-preserved animal remains, which is quite unique for Jutland. Analyses of the latter show that the site was used primarily in the winter (November to May) and that the economy was based primarily on hunting of wild boar (*Sus scrofa*), red deer (*Cervus elaphus*) and pine marten (*Martes martes*) while fishing and gathering was of minor importance Andersen 1975; 1979; 1994; Enghoff 1998 - this volume; Rowley-Conwy 1998 - this volume).

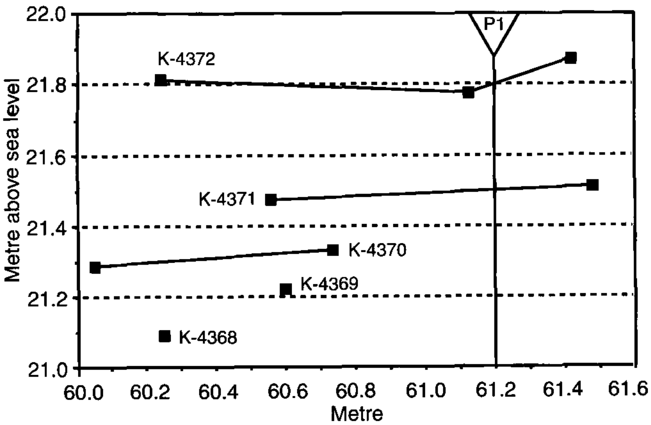

Fig. 3 Vertical and horizontal distribution of the radiocarbon-dated pieces of wood in the lake sediments in relation to the sampling site for the pollen diagram P1. The linked pieces comprise the material used for one date.

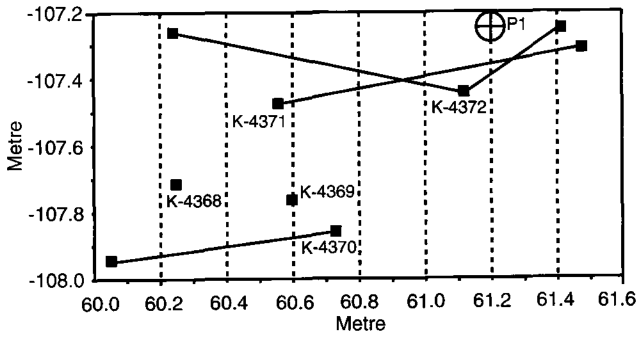

Fig. 4 Horizontal distribution of the radiocarbon-dated pieces of wood in the lake sediments in relation to the sampling site for the pollen diagram P1. The linked pieces comprise the material used for one date.

The settlement belongs primarily to the Ertebølle Culture, but occasional earlier and later finds have also been recovered from the site (Andersen 1975; 1979).

For a detailed description of the stratigraphical relationship between the pollen samples and the archaeological finds, reference is made to S. H. Andersen's paper in this volume (1998).

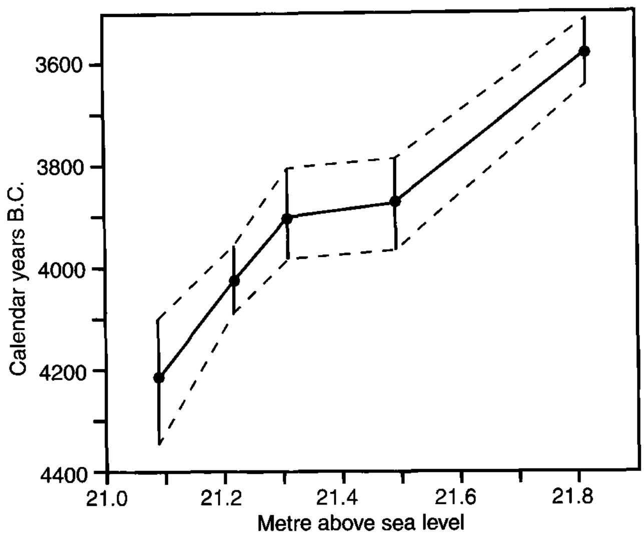

Fig. 5 Time/depth curve for section P1. The limits for one standard deviation are indicated.

METHODS

Coring and sampling

The biostratigraphical investigations were carried out in the littoral sediments immediately adjacent to the settlement, where samples were collected for pollen analysis, partly from open sections, partly by coring. Samples for the two diagrams presented in this article, P1 and B, were collected in the following way: samples for diagram P1 were taken from an open section produced during the excavation of the archaeological layers. The layers adjacent to the sampling point were drawn and described and wood samples were taken for radiocarbon dating. Samples for diagram B were taken further out in the lake basin using a Hiller corer.

Diagram P1 is from the area with archaeological deposits and diagram B is from beyond the archaeological layers. The two sampling sites lie ca. 17 metres and ca. 24 metres respectively from the former shore (see Andersen 1998, fig. 7 - this volume).

In addition to these two diagrams, which are the most important, several other sample series were taken for pollen analysis, as well as a large number of individual samples, which were collected in connection with characteristic Ertebølle artefacts. Some of these samples have been analysed (also by J. Ørnbøl) but the results will not be presented here.

Radiocarbon dating

Five conventional radiocarbon dates have been obtained for charcoal and partly-charred wood found in the lake deposits close to the sampling site for diagram P1. Fig. 3 and fig. 4 show the horizontal and vertical positions of the dated wood relative to the pollen diagram.

The radiocarbon dates were produced by H. Tauber at the Copenhagen Radiocarbon Laboratory. Calibration of the radiocarbon age to calendar years was performed using the CALIB computer programme (version 3.0.3) from the University of Washington with the 20 year averaged atmospheric curve (Stuiver & Reimer 1993).

On the basis of the calibrated dates a time/depth curve has been established for diagram P1 (Fig. 5). The construction of this curve required a single point (age) for each date; the central value in the calibration interval at one standard deviation has been chosen as this point (cf. Molloy & O'Connell 1991).

Pollen analysis

34 pollen samples were analysed from both sampling point B and P1.

The pollen samples were treated with HCl, KOH and acetolysis mixture (a few samples were also treated with HF) and mounted in silicone oil.

The number of pollen counted (pollen sum) in each sample varied greatly. In diagram B the pollen sum varies from 229 to 1266 (average 521), and in diagram P1 from 128 to 7960 (average 1420). The very high sums in the latter diagram were counted in samples dominated by *Alnus* (in the sample with a sum of 7960 pollen counted, 7610 pollen grains were of *Alnus*).

Table 1 gives a list of the plant names used in Latin, English and Danish. The plant nomenclature follows *Flora Europaea* (Tutin *et al.* 1964-1980), apart from Poaceae (= Gramineae); the English names follow Clapham *et al.* (1987), and the Danish names Hansen *et al.* (1981).

The construction of the pollen diagrams

The pollen taxa have been grouped into five categories: Trees, shrubs/dwarf shrubs, terrestrial (dry land) herbs, plants of uncertain habitat and reed swamp species/aquatics.

The pollen percentages are calculated on the basis of the sum of pollen of unambiguous terrestrial plants, i.e. trees, shrubs/dwarf shrubs and terrestrial herbs.

The diagrams have been divided up into 3 local pollen assemblage zones (R1, R2 and R3).

Pollen of *Alnus* occurs in very large numbers both in diagram B (fig. 6 and 7) and P1 (fig. 8 and 9). This is undoubtedly due to the location of the pollen sampling sites close to the shore. *Alnus* was presumably the locally dominant tree species on the wet soils of the lake margin, and as a result this taxon is over-represented in the diagrams. Analysis of the uncarbonised wood from the settlement's refuse layers reveals a great dominance of *Alnus* (Malmros 1986). Most of this wood probably became incorporated in the sediments by natural means. It can therefore be assumed to reflect the woodland composition in the area around the settlement and as such it underlines the evidence from the pollen diagrams with regard to alder's dominant role. The over-representation of *Alnus* made it difficult to choose a pollen sum for calculating the pollen percentages. If *Alnus* is included in the pollen sum it will "depress" the other pollen curves and as a consequence the diagram will give a somewhat distorted picture of the regional vegetation in the area. If *Alnus* is excluded from the pollen sum the picture will also be distorted as *Alnus* has played a role in the regional vegetation. On balance, the decision was made to include *Alnus* in the pollen sum (fig. 6 and 8). For the sake of comparison, the tree pollen curves for the two diagrams are, however, also shown with *Alnus* excluded from the pollen sum (fig. 7 and 9).

Due to the very local nature of the pollen input represented in the diagrams, there is some uncertainty regarding the habitats to which certain taxa should be ascribed. This applies not least to the wild grasses (Poaceae), which in regional pollen diagrams are normally classed as terrestrial (dry land) herbs, but which at this site could equally well come from very local wetland species (such as *Phalaris arundinaceae* and *Phragmites australis*). Accordingly, changes in the curve for wild grasses cannot unequivocally be interpreted as an expression of changes in the regional terrestrial vegetation, there could also have been local changes in the wetland vegetation around the lake.

The pollen diagrams were produced using the programmes TILIA and TILIA-GRAPH (Grimm 1990).

RESULTS

Sediments

The stratigraphy at the two sampling sites (B and P1) is described below (note that all meaurements of depth are given as metres above sea level).

Site B: Sediment core, 2.25 metres long. Description of the sediment stratigraphy and collection of pollen samples carried out by J. Ørnbøl (1984).

19.33-20.48: Reddish-brown fine gyttja with molluscs. Scattered pieces of wood.
20.48-21.58: Reddish-brown fine gyttja. Scattered pieces of wood.

Site P1: Open section, sampled sequence, 3.43 metres long. Description of sediment stratigraphy and collection of pollen samples carried out by C. Malmros and C. Christensen (Malmros 1972) (se also Andersen 1998 - this volume).

-20.46: Dark grey sand with molluscs.
20.46-20.86: Yellowish-brown fine gyttja with molluscs. Few artefacts.
20.86-20.91: Yellowish-brown fine gyttja with molluscs.
20.91-21.41: Dark yellow-brownish-grey coarse drift gyttja with molluscs. Charcoal and stones up to 5 cm.
21.41-21.71: Brownish-yellow coarse drift gyttja without molluscs. Pottery, flint, charcoal and stones.
21.71-21.96: Reddish-brown rather coarse drift gyttja.
21.96-22.36: Reddish-brown gyttja (?) with secondary tree roots.
22.36-23.01: Yellowish-brown alder fen peat.
23.01-23.61: Black highly-humified alder fen peat.
23.61-23.89: Yellowish-brown recent grass turf.

Chronology

The following is a list of the material dated and the results obtained (radiocarbon years bp) for the five samples associated with diagram P1. The identification of the charcoal and partly charred wood dated was carried out by C. Malmros (1984).

K-4372: 4800 ± 65 bp
Sample comprised three pieces of wood:
1 piece of *Fraxinus*; 1592 OBJ; level 21.86
1 piece of *Alnus*; 1592 OCP; level 21.81
1 piece of *Alnus*; 1592 OEC; level 21.77

K-4371: 5080 ± 70 bp
Sample comprised three pieces of wood:
1 piece of *Frangula*; 1592 GNE; level 21.50
1 piece of *Alnus*; 1592 GNE; level 21.50
1 piece of *Corylus*; 1592 GQO; level 21.47

K-4370: 5120 ± 70 bp
Sample comprised two pieces of wood:
1 piece of *Alnus*; 1592 GSN; level 21.33
1 piece of *Ulmus*; 1592 GRO; level 21.29

K-4369: 5200 ± 70 bp
Sample comprised one piece of wood:
1 piece of *Tilia*; 1592 GUW; level 21.22

K-4368: 5410 ± 95 bp
Sample comprised one piece of wood:
1 piece of *Corylus*; 1592 PDD; level 21.09

The five radiocarbon dates have been calibrated to calendar years and on the basis of these, a time/depth curve has been established for diagram P1 (fig. 5). In the list below the five dates are given in radiocarbon years bp, along with the calibration intervals at 1 standard deviation and the central value in the calibration interval which was used in constructing the time/depth curve.

Lab. no.	Av. level	^{14}C-age *yr bp*	Cal ± 1 std *yr BC*	Cal *yr BC*
K-4372	21.81	4800 ± 65	3650-3510	3580
K-4371	21.49	5080 ± 70	3970-3790	3880
K-4370	21.31	5120 ± 70	3980-3800	3890
K-4369	21.22	5200 ± 70	4070-3960	4020
K-4368	21.09	5410 ± 95	4350-4100	4220

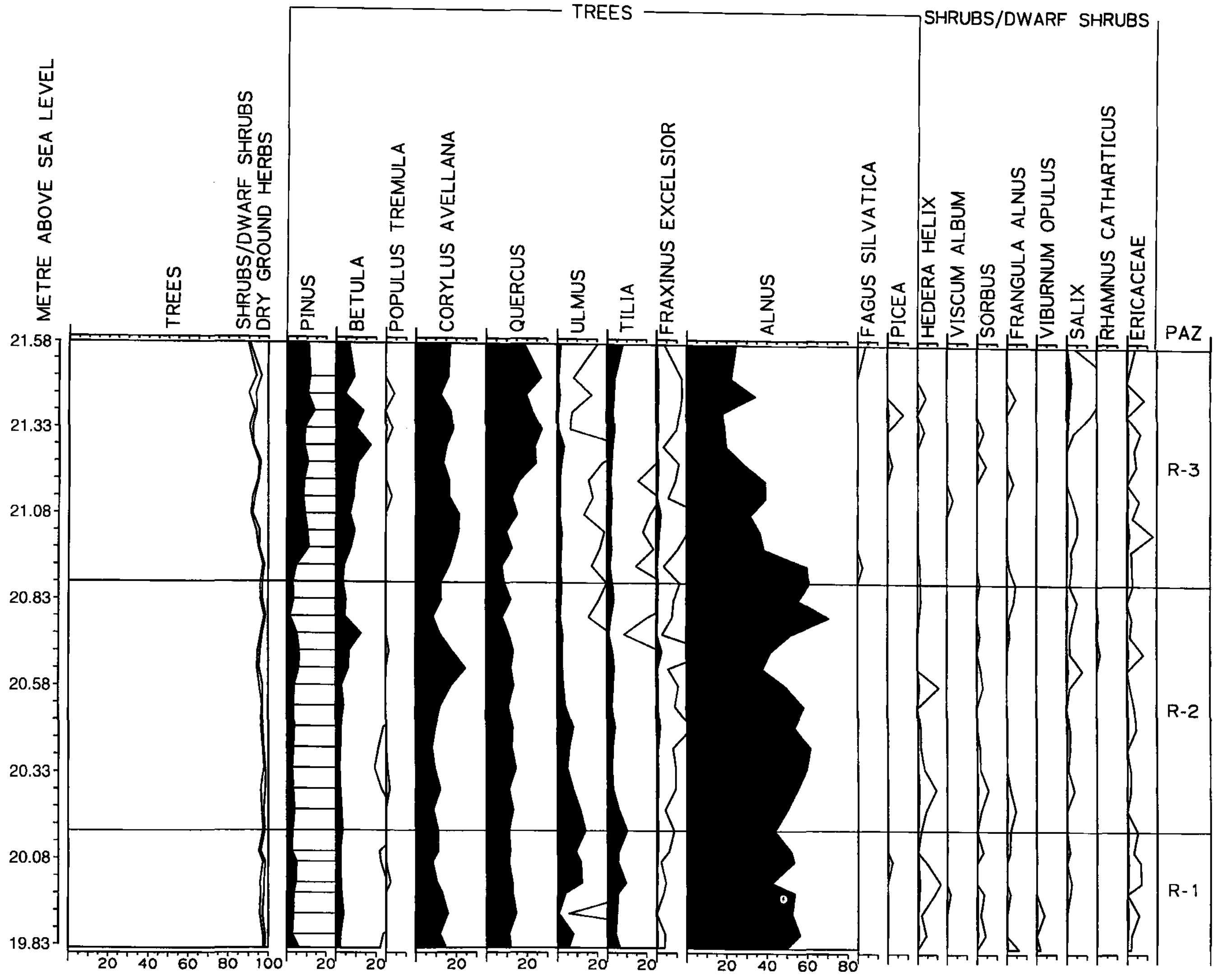

Fig. 6 Pollen diagram B. Percentage diagram calculated on the basis of pollen from the plant categories included in the summary diagram (trees, shrubs/dwarf shrubs and terrestrial (dry land) herbs). The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve.

The pollen diagram and the archaeological layers are dated on the basis of the time/depth curve. The ages given for the archaeological layers in this article can deviate slightly from those mentioned with respect to the same layers in Andersen's paper in this volume as in the latter, reference is exclusively made to individual radiocarbon dates.

Inferred Vegetation

Diagram B (fig. 6 and 7) The diagram is divided up into 3 zones. Zones R1 and R2 cover the Late Atlantic and zone R3 the early Sub-boreal.

Local pollen assemblage zone R-1: High percentage values of *Tilia*, *Quercus*, *Corylus*, *Ulmus* and *Alnus* show that these taxa were common. In addition, the woodland also included modest amounts of *Betula* and

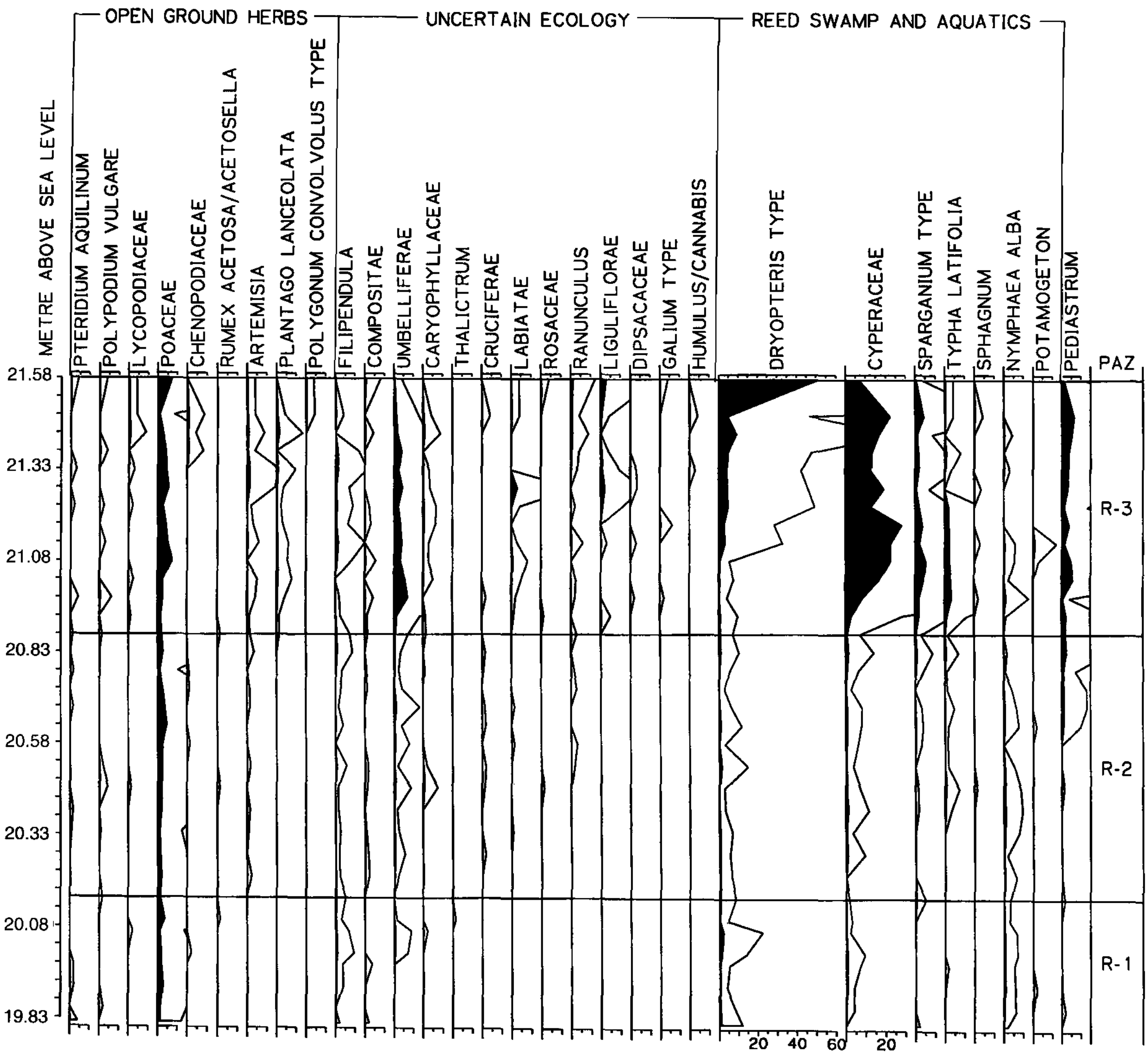

Fig. 6 continued

Fraxinus, along with occasional occurrences of *Populus*. It is difficult to say to what extent *Pinus* grew in the area at this time, as the pine pollen in the diagram could be the result of long-distance transport. *Sorbus* also grew in the woodland as did Ericaceous dwarf shrubs. *Hedera* was common, whilst *Viscum* had a scattered distribution. Total tree pollen values in the zone vary between 95.2% and 97.4% (fig. 6), which shows that the landscape was covered by dense woodland. The vegetation on the woodland floor was sparse; wild grasses were the most common herbs. There were, in addition, scattered occurrences of Chenopodiaceae and *Rumex acetosa/ acetosella*; *Pteridium*, *Polypodium* and members of the Lycopodiaceae grew on acid soils.

Woodland on wet soils close to the lake was completely dominated by *Alnus*; but *Frangula*, *Viburnum* and *Salix* presumably also grew there. The herb vegetation in the alder carr was modest, being represented by *Dryopteris*-type, Cyperaceae, *Sparganium*-type and *Typha*. Several of the herbs of uncertain habitats, such as *Filipendula* and members of the Umbelliferae, probably also grew here. Out in the lake itself there were stands of *Nymphaea* and *Potamogeton* as well as small amounts of the green alga *Pediastrum*.

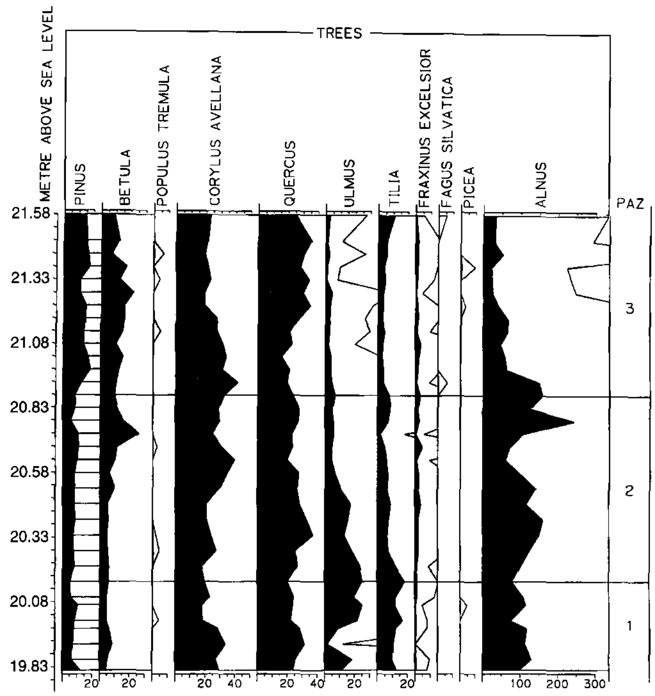

Fig. 7 Diagram B exclusively showing tree pollen curves. Percentage diagram calculated on the basis of total land plant pollen excluding *Alnus*. The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve.

Local pollen assemblage zone R-2: The woodland composition changes significantly in this zone. At the start of the zone there is a clear decline in *Tilia*, and at the same time an elm decline begins. The latter takes place in two stages: a) an initial decline in which values fall from 14% to 5.1%, followed by a slight regeneration, and b) a second decline in which elm values fall from 8% to 1.6% (fig. 6). In the diagram calculated with *Alnus* excluded from the pollen sum, the curves for *Tilia* and *Ulmus* show a similar sequence of events with a marked decline in *Tilia* and a two-stage decline in the elm curve (fig. 7). Contemporary with elm's final decline, *Corylus* becomes more abundant and reaches a small peak (fig. 6). A little later, when *Corylus* declines again, there is a small peak in *Betula*. The frequencies of *Quercus* and *Fraxinus* are more or less constant throughout the whole zone. Apart from the tree species already mentioned there were still occasional scattered occurrences of *Populus* in the woodland. Shrubs are represented by *Sorbus* and *Rhamnus* and dwarf shrubs by members of the Ericaceae. *Hedera* is common at the start of the zone but declines in abundance towards the end. Total tree pollen values lie between 94.3% and 97.9% (fig. 6), and woodland quite clearly still dominated the landscape, even though a slight increase in the frequency of terrestrial herbs is evident. This rise consists primarily of pollen of wild grasses. As mentioned earlier, the possibility cannot be excluded that this is due to an increase in the local input of grass pollen from the wetland vegetation. Terrestrial herbs present included *Artemisia*, Chenopodiaceae and *Rumex acetosa/acetosella*; *Pteridium*, *Polypodium* and members of the Lycopodiaceae grew on acid soils.

The wetland area close to the lake continued to be dominated totally by alder, probably with scattered *Salix* and *Frangula*. The still sparse wetland herb vegetation comprised *Dryopteris*-type, Cyperaceae, *Sparganium*-type, *Typha* and *Sphagnum*, as well as presumably *Filipendula* and members of the Umbelliferae. Aquatic plants in the lake are represented by *Nymphaea* and *Potamogeton* and the green alga *Pediastrum*, which increases in frequency towards the end of the zone.

Local pollen assemblage zone R-3: *Ulmus* declines further, particularly towards the end of the zone, at about which time *Tilia* increases. *Quercus*, *Corylus* and *Betula* all show marked increases relative to the previous zone. Values of *Fraxinus* are relatively constant. The few pollen grains of *Fagus* and *Picea* are due to long-distance transport. *Populus*, *Sorbus* and a good many Ericaceous dwarf shrubs were scattered around in the woodland. There were also scattered occurrences of *Hedera* and *Viscum*. Total tree pollen values lie between 89.8% and 97.4% (fig. 6), and in comparison with the previous zone this represents somewhat of a decline. With the decline in the woodland, there is a corresponding increase in terrestrial herbs, including a general increase in wild grasses. Values of *Artemisia* and Chenopodiaceae rise and *Plantago lanceolata* makes its first appearance. Apart from the light-demanding herbs already mentioned, there are occasional records of *Rumex acetosa/acetosella* and *Polygonum convolvulus* type. *Pteridium*, *Polypodium* and presumably also members of the Lycopodiaceae made up the vegetation on acid soils.

Marked changes are seen in the wetland vegetation by the lake. At the beginning of the zone there is a drastic reduction in the previously dense alder woodland, which is followed by a significant increase in wetland herbs. This applies in particular to Cyperaceae, but is also marked in the case of *Dryopteris*-type, *Sparganium*-type and *Typha* as well as to a lesser extent for *Sphagnum. Filipendula* and members of the Umbelliferae, which are presumed to have been part of the wetland vegetation, also increase markedly. *Nymphaea* and *Potamogeton* continued to grow in the lake and the amount of the green alga *Pediastrum* is more or less constant.

Diagram P1 (fig. 8 and 9). In the open section from where the pollen samples for diagram P1 were taken, ceramics and other archaeological finds were in evidence. At the base of the section there was thick-walled Ertebølle pottery. Above this were uncharacteristic sherds which could not be unequivocally assigned to an archaeological culture, but which on the basis of the radiocarbon dates must belong to the Ertebølle Culture, or possibly the Ertebølle/Funnel Beaker transition. Above this again, and separated by a horizon poor in finds, were a number of potsherds belonging to an early Neolithic funnel beaker of Volling type (Andersen this volume).

Like diagram B, the pollen diagram is divided up into 3 zones. Zones R1 and R2 cover the late Atlantic and zone R3 covers the early Sub-boreal.

Local pollen assemblage zone R-1: There are high values for almost all the woodland tree species: *Tilia, Ulmus, Quercus* and *Corylus*, although *Betula* and, in particular, *Fraxinus* are only relatively modestly represented. *Populus* occurred only sporadically in the woodland. As mentioned earlier, it is difficult to determine whether *Pinus* grew in the area or whether the pollen is present due to long-distance transport. The finding of pine wood (charcoal and uncarbonised wood) in the refuse layers, does however show that this species must have grown locally (Malmros 1986). *Hedera* is frequent throughout the zone and *Viscum* is not uncommon. Shrubs in the woodland are represented by *Crataegus* and *Ilex*, whilst *Salix, Frangula* and *Viburnum* were presumably associated with wetland areas close to the lake. The dwarf shrub vegetation comprised one or more species of Ericaceae. Total tree pollen values are high (96%-99.6%) (fig. 8) and the pollen diagram thus reveals a densely wooded landscape. Terrestrial herbs comprise primarily wild grasses and both *Pteridium* and *Polypodium* were present on acid soils.

Wet areas near the lake supported almost exclusively *Alnus*. The wetland herb vegetation was limited, being represented by Cyperaceae, *Dryopteris*-type, *Sparganium*-type, *Typha, Sphagnum* and *Lythrum*; *Filipendula* and members of the Umbelliferae almost certainly also grew here. *Nymphaea* grew in the lake where there were also small quantities of the green alga *Pediastrum*.

Local pollen assemblage zone R-2: This zone begins with a decline in both *Tilia* and *Ulmus* (fig. 8). *Tilia* declines sharply and rapidly, whereas the decrease in *Ulmus* takes place over a somewhat longer period. Parallel with the decline in *Tilia*, there is also a clear reduction in *Fraxinus*. If *Alnus* is excluded from the pollen sum, the elm decline occurs slightly later than the decline in *Tilia* and *Fraxinus* (fig. 9). The overrepresentation of *Alnus* pollen in the diagram makes it therefore difficult to place the elm decline precisely. In the diagram calculated with *Alnus* in the pollen sum, the elm decline lies at level 20.94 (fig. 8), whereas in the diagram calculated with *Alnus* excluded from the pollen sum it lies 10 cm higher up at level 21.04 (fig. 9). There are no marked changes in the curves for *Quercus, Corylus* and *Betula* relative to the situation in zone R1 (fig. 8). Shrub vegetation in the woodland is represented by *Crataegus, Ilex* and *Juniperus*, whilst *Salix* and *Frangula* would probably have been found on wet soils. Dwarf shrubs are represented by one or more species of the Ericaceae. *Hedera* becomes less abundant at the same time as the *Tilia* curve falls. Total pollen values for the woodland trees are at the same high levels as seen in the previous zone (97.2%-99.4%) (fig. 8), and the woodland was still dense with only a relatively sparse herb vegetation. Values for terrestrial herbs lie between 0.2% and 2.1%, being made up primarily of wild grasses plus modest occurrences of Chenopodiaceae, *Polygonum convolvulus*-type, *Artemisia* and *Rumex acetosa/acetosella* and some *Polypodium*. The very low values for terrestrial herbs apparent in the diagram probably do not give a true picture of the vegetation, as the increased local input of *Alnus* pollen "depresses" the other pollen curves.

On wet soils, *Alnus* became very abundant (up to 91.8%) and there is no doubt that the pollen diagram is strongly influenced by the local vegetation.

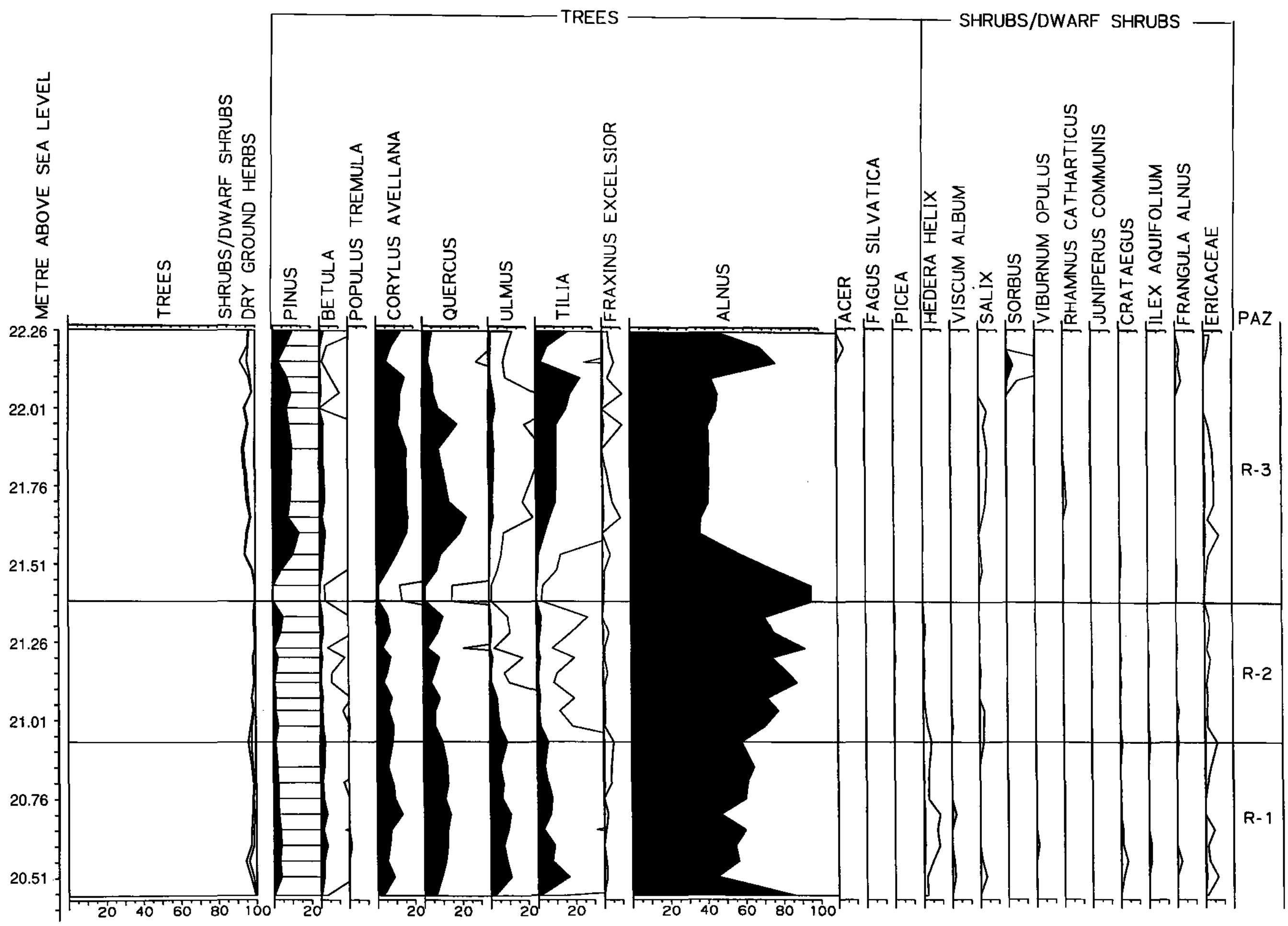

Fig. 8 Pollen diagram P1. Percentage diagram calculated on the basis of pollen from the plant categories included in the summary diagram (trees, shrubs/dwarf shrubs and terrestrial (dry land) herbs). The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve.

The wetland herb vegetation is relatively limited in extent and consists of *Dryopteris*-type, Cyperaceae, *Sparganium*-type, *Sphagnum*, *Typha* and *Lythrum*. *Filipendula* and members of the Umbelliferae, as mentioned earlier, probably also grew in wetland habitats. Out in the lake itself *Nymphaea* and *Nuphar* were in evidence and in the middle of the zone the amount of the green alga *Pediastrum* increases.

Local pollen assemblage zone R-3: Significant changes occur in several of the tree pollen curves. At the beginning of the zone all the pollen curves are depressed by the extremely high values of *Alnus* (up to 95.7%) (fig. 8). Some way into the zone the *Tilia* curve increases very markedly, and at approximately the same time there is a clear increase in *Ulmus*. The pollen curve for *Quercus* is somewhat irregular, reaching rather low values towards the end of the zone, where there is also a reduction in *Betula*. *Fraxinus* is rather modestly represented, whilst values for *Corylus* are relatively high and constant throughout the zone. The curve for *Pinus* rises at the beginning of the zone and maintains relatively high values throughout. In addition to the tree species mentioned above, there are occasional records of *Acer*. With regard to the shrubs, there are occasional records of *Rhamnus*, whilst *Sorbus* is very abundant in one particular spectrum. The dwarf shrub vegetation comprises one or more species of the Ericaceae. The total pollen values for the woodland trees lie between

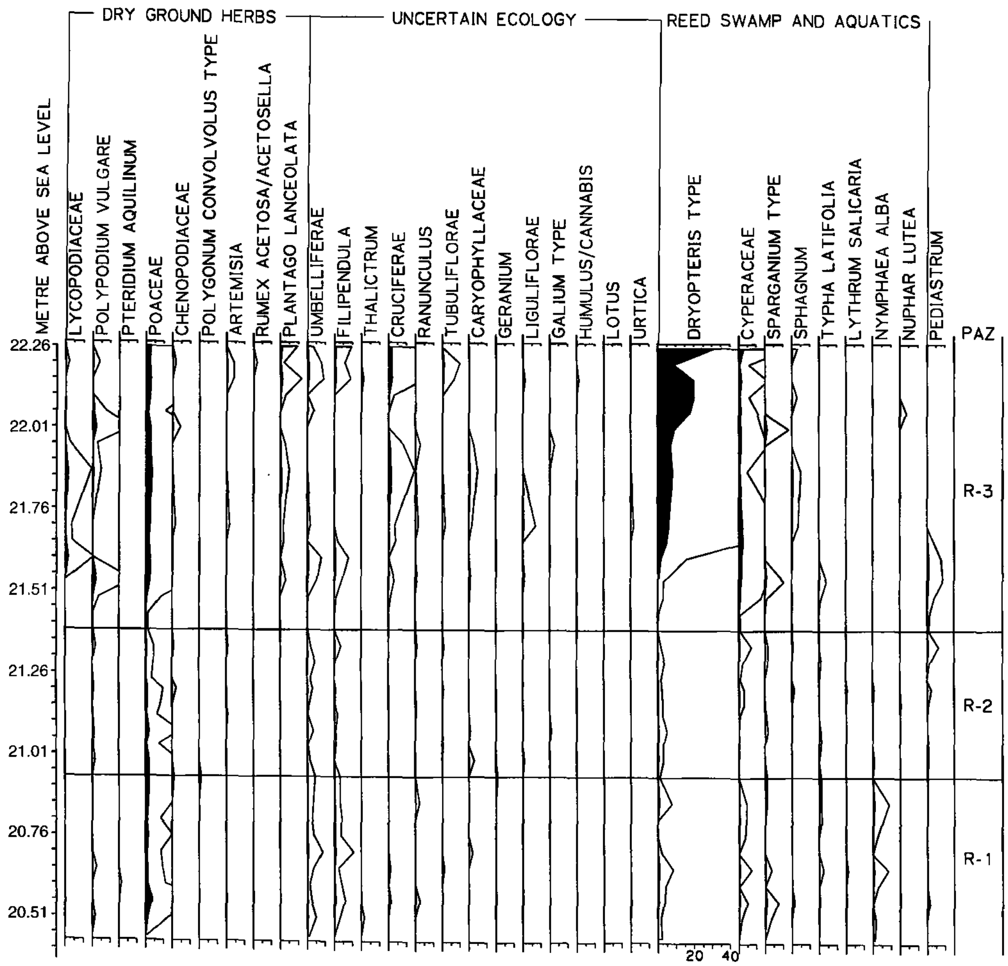

Fig. 8 continued

91.9% and 99.7% (fig. 8), which is a clear reduction relative to zones R1 and R2. There is a corresponding increase in terrestrial herbs, and the frequency of wild grasses in particular increases. *Plantago lanceolata* appear as a new species; initially with low values, but towards the end of the zone there is a small peak in the curve, which coincides with a peak in *Artemisia.* In addition to the terrestrial herbs already mentioned, there are occasional occurrences of Chenopodiaceae and *Rumex acetosa/acetosella,* as well as, in part of the zone, unusually high values of *Polypodium* and members of the Lycopodiaceae.

Significant changes occur in the wetland vegetation. At the beginning of the zone *Alnus* declines abruptly and elements in the wetland herb vegetation increase sharply. This applies in particular to *Dryopteris*-type, but also to some degree to Cyperaceae. There are, furthermore, records of *Sparganium*-type, *Sphagnum* and *Typha.* Aquatic plants in the lake are represented by a single record of *Nuphar.* The green alga *Pediastrum* occurs at the start of the zone only later to disappear completely.

Correlation of diagrams B and P1: The two pollen diagrams (fig. 6 and 8) can be correlated with one another on the basis of the elm decline and the first occurrence of *Plantago lanceolata.*

In both diagrams, zone R1 comprises the period up to the elm decline. A comparison of the length of the zone in the two diagrams is made difficult by the very dissimilar pollen curves. The curve for *Filipendula* is the only one which has an almost identical course in zone R1 in both diagrams. This is of course a very fragile basis on which to correlate, but can be cautiously interpreted as indicating that the zone is of about the same length in both B and P1.

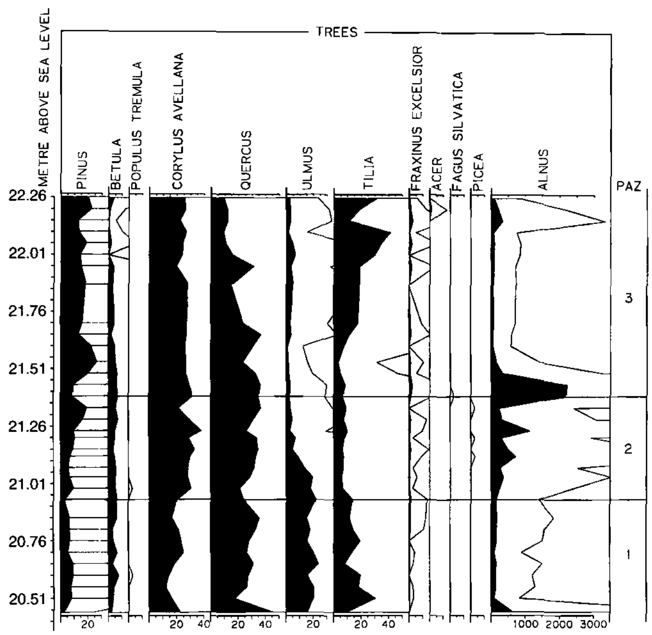

Fig. 9 Diagram P1 exclusively showing tree pollen curves. Percentage diagram calculated on the basis of total land plant pollen excluding *Alnus*. The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve.

Zone R2 covers the period from the beginning of the elm decline until the first appearance of *Plantago lanceolata*. The zone can be assumed to be of the same length in both diagrams.

Zone R3 covers the period from the first occurrence of *Plantago lanceolata* and some way into the Neolithic Period. Here too, a comparison of the length of the zone in the two diagrams is made difficult by the very dissimilar pollen curves, but if use is made of the curve for *Dryopteris*-type, which ends with a sharp rise in both diagrams, it can be cautiously assumed that the zone has approximately the same length in the two diagrams.

As the diagrams in all probability cover approximately the same time period and are located very close to one another, the development of the vegetation reflected in them can be compared directly. In some aspects there are similarities between the two diagrams, but there are also rather large differences. The most important similarities include: the elm decline and the simultaneous reduction in *Tilia*; the first occurrence of *Plantago lanceolata*; the generally high values for *Alnus* in zones R1 and R2; the decline of *Alnus* in zone R3; increased values for *Pinus* and in part *Tilia* in zone R3.

The majority of the above-mentioned similarities are of a general nature. If the pollen curves are examined in detail, great differences are seen. Some of these differences are presumably a consequence of the littoral locations of the sampling sites. This conclusion is supported by, among other things, the *Alnus* curve in the two diagrams. *Alnus* is over-represented in both diagrams, but the values for *Alnus* are very different. In diagram P1 (fig. 8) *Alnus* is much more strongly represented than in diagram B (fig. 6), which can be explained by the fact that P1 lies closest to the shore and thus closest to the alder woodland growing there.

The strongly dissimilar *Tilia* curves in the diagrams in zone 3 are difficult to explain. In the diagram furthest from land (B; fig. 6), the maximum value for *Tilia* is 8.2%, whereas in the diagram closest to the shore (P1; fig. 8) *Tilia* has a maximum value of 23.5%. This discrepancy could be a consequence of the sampling site for the latter diagram being closer to the shore where differing sedimentation conditions prevailed, but the nature of the precise mechanism is unknown.

Another factor which could be involved in the dissimilarities between the two diagrams is the human element. The Ringkloster settlement lies very close to the sampling sites and the occupants of the settlement obviously influenced the lake sediments by way of the many items of flint, stone, bone, antler and pottery which were thrown out into the lake. These activities would naturally have caused disturbances in the layers which could have contributed to the dissimilarities between the diagrams.

DISCUSSION

Diagram P1 provides the best basis for studying the correlation between the archaeological and the vegetational developments at the Ringkloster settlement as the pollen analyses were carried out directly on the archaeological layers.

In the pollen diagram P1 (fig. 10) the horizons containing finds of the various pottery types are marked with continuous lines. Other archaeological artefacts occur in these deposits, but delimitation of the horizons has been carried out solely on the basis of the pottery. Identification of the pottery was carried out by the director of the excavation, S. H. Andersen; for details see Andersen this volume. In the horizon termed *Ertebølle* (level 20.81-21.46), thick-walled pottery of undoubted Ertebølle type appears between level 20.81 and 21.12. Between level 21.27 and 21.46 the potsherds are of an uncharacteristic type which cannot be dated unequivocally archaeologically, but which, judging from the radiocarbon dates, must belong to the Ertebølle Culture, or possibly the Ertebølle/Funnel Beaker transition. In horizon *TRB* (level 21.71-21.97) there are sherds of an early Neolithic funnel beaker of Volling type. The level at which the elm decline occurs (level 20.94) is marked with a horizontal stippled line.

The timescale for the pollen diagram and the archaeological finds is based on the time/depth curve shown in fig. 5. In deposits such as these, the radiocarbon dates should be treated with a measure of caution as the sediments have been exposed to human influence (the throwing out of artefacts). The sedimentation rate cannot be expected to have been constant, and this may explain the abrupt change in the gradient of the time/depth curve. The relatively large pieces of charcoal and partly charred wood which were dated could have been washed out into the lake sediments at any time over a long period. As a consequence, the wood could have been incorporated into younger sediments. Conversely, there is the possibility that large pieces of wood could have sunk down into older sediments. Finally, some of the dated pieces of wood lay relatively far away from the sampling site for the pollen diagram, which in itself could give some uncertainty with regard to the temporal relationship between the two. Despite a series of potential sources of error it would appear however that the time/depth curve gives reliable dates; the dates arrived at for the elm decline and the archaeological finds are as follows:

TRB (Funnel Beaker) pottery:	3430-3670 cal. BC
Ertebølle:	3880-4650 cal. BC
Elm Decline:	4450 cal. BC

The date for the early Neolithic funnel beaker of Volling-type (3430-3670 cal. BC) is in agreement with the dates for other finds of this pottery type from Jutland (Madsen & Petersen 1984; Andersen & Johansen 1992).

The date of 3880 cal. BC for the youngest part of the horizon termed Ertebølle corresponds to the date for the end of the Ertebølle Period, fixed for example in the kitchen middens (køkkenmøddinger) at Norsminde (Andersen 1991) and Bjørnsholm (Andersen 1993).

The age of the oldest part of the horizon with Ertebølle pottery (4650 cal. BC) corresponds approximately to available dates for the oldest "Ceramic" Ertebølle Culture in Jutland (Andersen 1973: note 46).

On the basis of the above comparisons there appears to be good agreement between the expected age based on the archaeological finds and the age determined on the basis of the time/depth curve.

The age of the elm decline and the beginning of the Ertebølle layer must however be viewed with some caution, as they have both been arrived at by extrapolation. The extrapolated date for the elm decline is 4450 cal. BC. This is 500-600 years older than the classical elm decline in Jutland, which is dated to 3800/3900 cal. BC (Andersen 1992a: note 2; Andersen & Rasmussen 1993). As it was arrived at by extrapolation, it is impossible to determine the precision of the date for the Ringkloster elm decline, but several factors suggest that this event does occur significantly earlier here than is normal. There is, for example a radiocarbon date from above the elm decline of 4220 cal. BC. (fig. 10). Similarly, if the stratigraphical relationship between the elm decline and the archaeological finds is examined, it is clear that Ertebølle artefacts occur above the elm decline (fig. 10). This suggests that the elm decline lies prior to the end of the Ertebølle Culture, in contrast to the classical elm decline which radiocarbon dates show is contemporary with its close.

This early date for an elm decline is very unusual in Denmark, but not, however, without parallels both here and in neighbouring countries. In Denmark, a new radiocarbon wiggle-dated pollen diagram from Hassing Huse Mose (Thy) has revealed two declines in the elm pollen curve prior to the classical elm decline (Andersen & Rasmussen 1993). The classical elm decline is here dated to 3870 cal. BC and the two other declines are dated to 4130 cal. BC and 4530 cal. BC respectively. At Hassing Huse Mose the first certain evidence of agriculture (cereal pol-

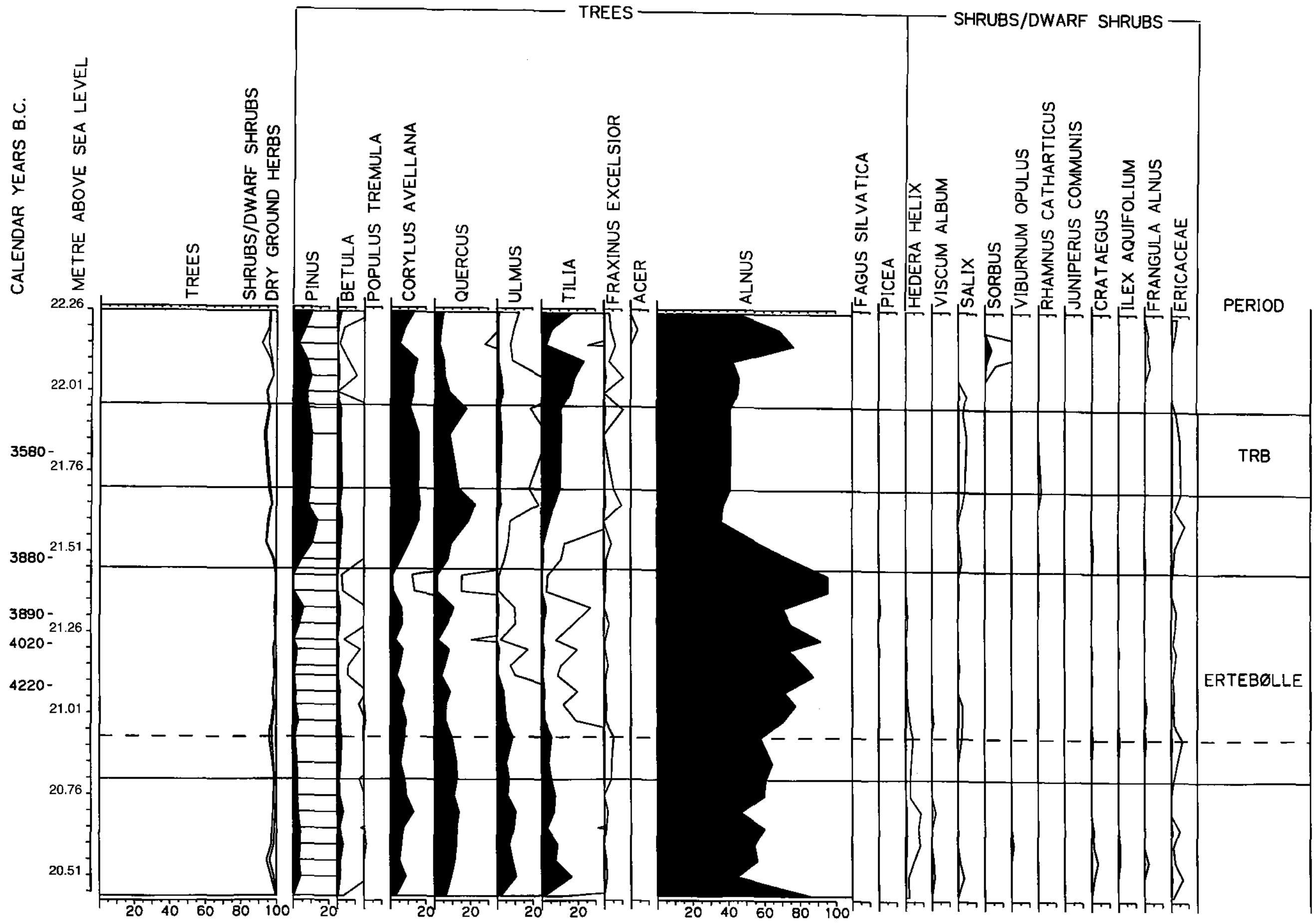

Fig. 10 Pollen diagram P1. Percentage diagram calculated on the basis of pollen from the plant categories included in the summary diagram (trees, shrubs/dwarf shrubs and terrestrial (dry land) herbs). The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve. On the diagram the horizons with different types of pottery belonging to: 1) Ertebølle Culture and 2) early Neolithic Funnel Beaker Culture (TRB) are indicated. The level of the elm decline is marked with a stippled horizontal line.

len of *Hordeum*-type) occurs at the same level as the classical elm decline. Slight increases in a series of apophytes (plants present originally which are favoured by human activity) (*Rumex acetosella*, *Artemisia*, Chenopodiaceae, *Polygonum aviculare*, *Jasione* and Poaceae) are seen in connection with the two other (earlier) declines (Andersen & Rasmussen 1993).

Two declines in the elm pollen curve prior to the classical elm decline have also been demonstrated in a new pollen diagram from close to the Ertebølle site of Bökeberg III in Scania (Regnell *et al.* 1995). Here, the classical elm decline is dated to 3980 cal. BC, and the two declines prior to this, to 4340 cal. BC and 5200-5100 cal. BC, respectively. Finally, in Northern Germany an elm decline has been demonstrated at around 4900 cal. BC, i.e. contemporary with the local Ertebølle Culture (Ellerbek-group) (Kalis & Meurers-Balke 1988).

There are thus a number of parallels to the Ringkloster elm decline, but on one decisive point the latter stands apart from the sites mentioned above, namely the force of the decline and the subsequent lack of regeneration of the elm stands. The classical elm decline around 3800/3900 cal. BC is not seen at Ringkloster because by this time elm had been only sparsely represented for several hundred years.

In the period prior to the Ertebølle occupation at Ringkloster, the pollen diagram reflects dense and

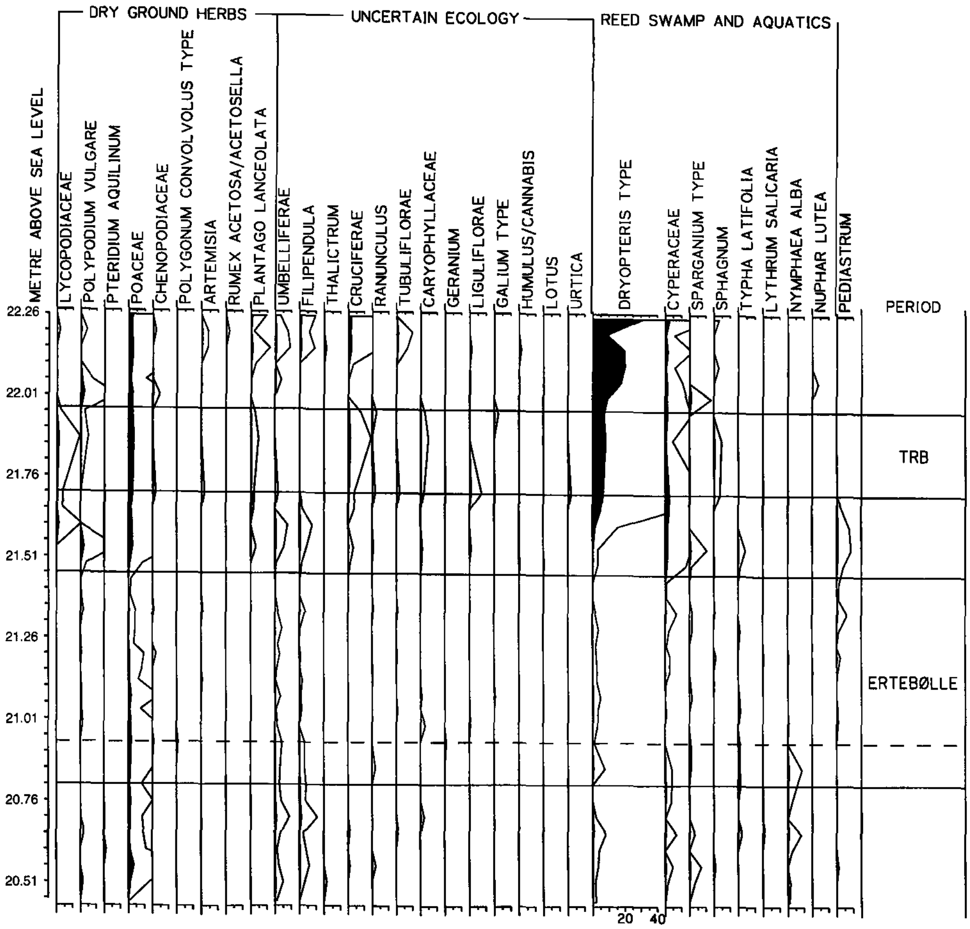

Fig. 10 continued

stable woodland with high pollen values of *Tilia*, *Ulmus*, *Quercus*, *Corylus* and *Alnus*, along with a sparse herb flora consisting primarily of wild grasses. Pollen analyses from small ponds and soil profiles show that in Atlantic times, *Tilia* was dominant on dry well-drained soils, together with *Corylus* and *Quercus*, whilst *Ulmus*, *Alnus* and *Fraxinus* could be found on damp or wet areas, presumably mixed with some *Quercus* and *Corylus* (Iversen 1969; Andersen 1978; 1984; 1991; Aaby 1983). The establishment of the first Ertebølle occupation at Ringkloster, brought about no changes in this stable vegetation, which continued virtually unaltered up until the elm decline.

The elm decline, and the simultaneous reduction in *Tilia*, is followed by a slight rise in a number of apophytes (fig. 6 and 10). In particular, the amount of *Artemisia* increases (especially in diagram B, fig. 6), but also Chenopodiaceae, *Polygonum convolvulus* type and *Rumex acetosa/acetosella* become more frequent. The increased abundance of these herbs, which typically grow on disturbed soils, including paths and ruderal areas, suggests that there was increased human activity in the area. There are no indications in the pollen diagram of agriculture contemporary with the Ertebølle Culture, and the disturbances must have been connected with everyday activities in and around the settlement.

The early Ringkloster elm decline and the simultaneous reduction in *Tilia* are difficult to explain. The causes of the classical elm decline have been discussed for decades and the following possibilities have been proposed: 1) Climatic change (Iversen 1941), 2) Soil deterioration (Iversen in Troels-Smith 1956), 3) Elm disease (Iversen in Troels-Smith 1956), 4) Pollarding of elm trees for the production of leaf fodder for domesticated animals (Fægri 1944; Troels-Smith

1953; 1960) and 5) Clearance (felling) of elm in low-lying areas to promote *Quercus* and thus produce acorns for pigs (Madsen 1982). Both climatic change and soil deterioration can, on balance, now be discounted as primary causes (see discussion in Troels-Smith 1956; 1960 and Andersen 1984). That leaves elm disease and human intervention in one form or another. New pollen analytical investigations from England identify a combination of elm disease and agricultural activity as the most likely cause (Peglar 1993; Peglar & Birks 1993; see also Rackham 1980 & Birks 1986).

The latter interpretation cannot explain the Ringkloster elm decline, as there are no contemporary indications of agriculture at the time of the elm decline. According to research on modern elm trees, elm disease can occur "passively" in an area for a long time, flaring up in periods without necessarily killing the trees (Rackham 1980; Moe & Rackham 1992). If it is assumed a) that this situation was also the case in prehistoric times, and b) that the classical elm decline was caused primarily by elm disease, then the disease could have been present long before the classical elm decline. If we extend this assumption further, it is not improbable that stands of elm in a heavily occupied area such as Ringkloster were exploited and affected to a significant degree (for example by felling or ringing of elm trees; cf. Göransson 1987). This would have created ideal conditions for the attack and spread of elm disease, as damaged elm trees appear to be the most susceptible (Rackham 1980; Moe & Rackham 1992).

The reduction in *Tilia* at the same time as the elm decline can most readily be explained in terms of the activities of the Ertebølle people. These could have taken the form of clearance of the lime woodland and/or ringing of lime trees. Lime was presumably also used for a variety of different purposes (fuel, construction and tools). The simultaneous decline in *Ulmus* and *Tilia* suggests a common cause and it is difficult to find an explanation other than the anthropogenic. In this respect, the analyses of carbonised and uncarbonised wood from the settlement's refuse layers give some interesting information (Malmros 1986). A total of 205 pieces were examined, of which 115 were carbonised. The uncarbonised material was completely dominated by *Alnus* (70%) followed by *Ulmus* (10%) and *Corylus* (9%). Among the carbonised material the four most common taxa were *Ulmus* (24%), *Corylus* (17%), *Quercus* (17%) and *Alnus* (16%) (Malmros 1986). The uncarbonised material probably became incorporated into the lake sediments by way of natural processes, and as a consequence should be seen as reflecting the composition of the woodland vegetation in the immediate vicinity of the settlement. The carbonised material, on the contrary, is evidence for human intervention, and the species composition should therefore be seen as reflecting the Ertebølle people's choice of particular tree species for fuel, tool production etc. The clear dominance of elm (24%) in the carbonised wood therefore suggests that the stands of elm trees in the Ringkloster area were exposed to selective exploitation, and it is obvious to see this as a contributory or direct cause of the low values for elm in the pollen diagrams. No corresponding connection is apparent in the case of lime, as lime is only poorly represented in the wood samples analysed (uncarbonised: 3%; carbonised 6%). Differential preservation could however have played a role here, as lime degrades and disappears much more readily than other tree species (Bartholin *et al.* 1981; Malmros 1986; Møller 1987).

It is very difficult to determine the size of the area reflected in the Ringkloster pollen diagrams. The apparently very local nature of the pollen input suggests that a relatively small area is involved and, furthermore, the Ertebølle population could hardly have had such an impact on the elm and lime woodland over a wider area. All in all, it seems reasonable to presume that the pollen diagrams reflect the vegetation within a relatively limited area around the Ringkloster settlement.

About 3900 cal. BC, i.e. at the transition from the Atlantic to the Sub-boreal, both diagrams show a marked change in the wetland vegetation (fig. 6 and 10). *Alnus* declines sharply, followed by a significant increase in wetland herbs (in particular *Dryopteris*-type and Cyperaceae). In all probability, these changes reflect a reduction in water level in the lake. With a reduced water level, wetland herbs would have been able to expand on to new areas of the lake margin closer to the pollen sampling sites, with high values of *Dryopteris*- type and Cyperaceae as a consequence. This interpretation is supported by the marked increase in *Pinus* (in both diagram B and P1; fig. 6 and 10), which begins at the same time as the above-mentioned changes. Due to its great buoyancy, pine pollen often becomes concentrated in the littoral zone, where the sediments become enriched with this pollen type (Fægri & Iversen 1989; Amman 1994). As the water level fell, the littoral zone (and the concentrations of pine pollen) would, as described above, have moved further out into the basin and thus closer to the sampling sites for the pollen diagrams, where an increased sedimentation of pine pollen took place.

Detailed investigations of sediments in several lakes in southern Sweden have demonstrated a similar reduction in water level of the same date. The phenomenon is seen in lakes over a large geographic area and as a consequence is interpreted as being the result of a shift towards a drier climate (Digerfeldt 1988; 1997; Gaillard & Digerfeldt 1991).

A reduction in water level at Ringkloster, and the subsequent changes in sedimentation linked with this, could have influenced several of the pollen curves in the pollen diagrams. For example, it is probable that the very dissimilar curves for *Tilia* pollen seen in the pollen diagrams B and P1 at this time are the result of altered sedimentation conditions.

At the same time as the above-mentioned change in water level (ca. 3900 cal. BC), a reduction in the woodland trees and an increase in light-demanding herbs (Poaceae, Chenopodiaceae, *Artemisia*, *Rumex acetosa/acetosella*, *Plantago lanceolata* and *Polygonum convolvulus* type) is seen in both diagrams (fig. 6 and 10). These changes are evidence of an opening up of the previously very densely wooded landscape. Apart from a single earlier record of *Plantago lanceolata* (in diagram P1; fig. 10), the change coincides with the appearance of this species, values of which subsequently form a continuous curve. The occurrence of *Plantago lanceolata* documents the first agricultural activity in the area, as the species is closely linked with areas grazed by domesticated animals (Iversen 1941; Behre 1981). The reduction in the woodland can thus be presumed to be due to anthropogenic causes, i.e. the creation of open areas for agricultural purposes. After the first opening up of the woodland, the relationship between forest and open land remains virtually constant throughout the remainder of the pollen diagrams. In diagram P1 (fig. 10) there is a slight increase in *Plantago lanceolata*, Chenopodiaceae and *Artemisia*, which suggests that there was an intensification of agricultural activity at this time. This occurs at the level of the Funnel Beaker vessel and on the basis of the stratigraphical correlation between the vessel and the pollen diagram, it can be established that the agricultural activity in the area is associated with the Funnel Beaker Culture's Volling group.

The precise character of the earliest Neolithic agriculture is difficult to elucidate alone on the basis of a pollen diagram from a lake or a bog. In the case of Ringkloster, the occurrence of *Plantago lanceolata* demonstrates the presence of areas of grazing for domesticated animals. In contrast, evidence of arable farming in the form of cereal cultivation, cannot be seen in the diagrams. The lack of records of cereal pollen can not however be taken as an indication that cereals were not cultivated in the area, as the early cereal types (*Triticum* and *Hordeum*) are self-pollinating (autogamous) and have very poor pollen dispersal (Vuorela 1973; Behre & Kučan 1986). New pollen analytical investigations of old soil horizons in and below Neolithic burial mounds have given a much more detailed picture of Neolithic agriculture than it is possible to obtain from pollen diagrams from lakes or bogs. These investigations show that agriculture consisted of swidden cultivation with arable and pastoral farming, where the burning of secondary woodland (especially *Betula* and *Corylus*), played an important role in creating and fertilising open areas (Andersen 1992b). The extent to which the earliest agriculture at Ringkloster was of this type, and if so the internal relationship between arable and pastoral farming, cannot be determined on the basis of the investigations presented here.

CONCLUSIONS

Two pollen diagrams have been produced (B and P1) from lake sediments close to the Ertebølle settlement of Ringkloster with the aim of elucidating the development of the vegetation. The sampling sites for the two pollen diagrams are located close to the shore, and as a consequence they are both to a lesser or greater extent characterised by the local wetland vegetation (alder carr).

The two diagrams (B: fig. 6 and 7; P1: fig. 8, 9 and 10) cover approximately the same timespan from the end of the Atlantic until the beginning of the Subboreal. The correlation between the archaeological and the vegetational development is best shown in diagram P1 (fig. 10), which was produced from the archaeological layers in the lake deposits directly offshore from the settlement. On the basis of 5 radiocarbon dates for charcoal and partly-charred wood from the lake deposits close to the sampling site, a timescale has been established, which corresponds well with the expected dates for the archaeological finds. In the period prior to the Ertebølle settlement at the site, the landscape was characterised by stable woodland and a modest herb flora. With the establishment of the settlement, no changes are evident in the vegetation pattern. It is first some time after the founding of the settlement that changes in the vegetation become apparent in the form of a marked decline in *Ulmus* and *Tilia*, followed by a slight increase in a number of apophytes. Stratigraphical correlation between the archaeological finds and the elm decline shows that the latter here is contemporaneous with the Ertebølle Culture. The date of the elm decline cannot be established precisely, but its coincidence with the Ertebølle Culture and a radiocarbon date for wood lying above it of 4220 cal. BC, demonstrates that the decline is significantly earlier than the classical elm decline in Jutland, which is radiocarbon-dated to 3800/3900 cal. BC (corresponding to radiocarbon dates for the end of the Ertebølle Culture).

The Ringkloster elm decline and the simultaneous decline in *Tilia*, are interpreted as being the result of the activities of the Ertebølle people (clearance of the woodland and/or ringing of trees and the collection of wood for fuel, construction and tools). The reduction of elm could have been amplified by elm disease.

Around 3900 cal. BC, at the transition from the Atlantic to the Sub-boreal, there are several indications of a reduction in the water level in the lake. A similar reduction of the same age is also known from several lakes in southern Sweden. The phenomenon is seen over a wide geographic area, suggesting that it was caused by a climatic shift towards drier conditions.

From about 3900 cal. BC *Plantago lanceolata* appears as a new species in the pollen diagrams, documenting the presence of agriculture in the area. Simultaneous with the first evidence of agriculture, there is a reduction in woodland, and a general increase in terrestrial herbs. These changes are interpreted as being the result of woodland clearance with the aim of creating open areas for the purposes of agriculture. The earliest agricultural activity cannot be linked stratigraphically to the archaeological evidence. Slightly later activity (about 3600/3700 cal. BC), can be correlated with the finding of an early Neolithic funnel beaker of Volling type, which shows that it was the Funnel Beaker Culture's Volling group, which practised agriculture in the Ringkloster area at this time.

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REFERENCES

Aaby, B. 1983: *Forest development, soil genesis and human activity illustrated by pollen and hypha analysis of two neighbouring podzols in Draved Forest, Denmark.* Danmarks Geologiske Undersøgelse, II. Række, Nr. 114.

Ammann, B. 1994: Differential flotation of saccate pollen - a nuisance and a chance. In A. F. Lotter & B. Ammann (eds.), Festschrift Gerhard Lang. *Dissertationes Botanicæ* 234, pp. 101-110.

Andersen, S. H. 1973: Overgangen fra ældre til yngre stenalder i Sydskandinavien set fra en mesolitisk synsvinkel. In P. Simonsen & G. S. Munch (eds.), *Bonde-Veideman. Bofast - ikke Bofast i Nordisk Forhistorie*, Tromsø Museums Skrifter XIV, pp. 26-44.

- 1975: Ringkloster. En jysk indlandsboplads med Ertebøllekultur. (English summary). *Kuml* 1973-74: 11-108.

- 1979: Pelsjægere. *Skalk* 2: 3-8.
- 1991: Norsminde. A „Køkkenmødding“ with Late Mesolithic and Early Neolithic Occupation. *Journal of Danish Archaeology* 8, 1989: 13-40.
- 1993: Bjørnsholm. A Stratified Køkkenmødding on the Central Limfjord, North Jutland. With a contribution by K. L. Rasmussen. *Journal of Danish Archaeology* 10, 1991: 59-96.
- 1994: Kød, pelsværk og skind. *Humaniora. Et magasin om humanistisk forskning* 2, pp. 27-31.
- 1998: Ringkloster. Ertebølle trappers and wild boar hunters in eastern Jutland. A Survey. *Journal of Danish Archaeology* vol. 12, 1994-95: 13-60

Andersen, S. H. & Johansen, E. 1992: An Early Neolithic Grave at Bjørnsholm, North Jutland. *Journal of Danish Archaeology* 9, 1990: 38-58.

Andersen, S. T. 1978: Local and regional vegetational development in eastern Denmark in the Holocene. *Danmarks Geologiske Undersøgelse, Årbog* 1976: 5-27.
- 1984: Forests at Løvenholm, Djursland, Denmark, at present and in the past. With a contribution by H. J. B. Birks. *Det Kongelige Danske Videnskabernes Selskab,* Biologiske Skrifter 24:1.
- 1991: Natural and cultural landscapes since the Ice Age. Shown by pollen analyses from small hollows in a forested area in Denmark. *Journal of Danish Archaeology* 8, 1989: 188-199.
- 1992a: Pollen Spectra from two Early Neolithic Lugged Jars in the Long Barrow at Bjørnsholm, Denmark. *Journal of Danish Archaeology* 9, 1990: 59-63.
- 1992b: Early- and Middle-Neolithic agriculture in Denmark: pollen spectra from soils in burial mounds of the Funnel Beaker Culture. *Journal of European Archaeology* 1: 153-180.

Andersen, S. T. & Rasmussen, K. L. 1993: Radiocarbon wiggle-dating of elm declines in northwest Denmark and their significance. *Vegetation History and Archaeobotany* 2: 125-135.

Bartholin, T. S. , Berglund, B. E. & Malmer, N. 1981: Vegetation and environment in the Gårdlösa area during the Iron Age. In B. Stjernquist (ed.), *Gårdlösa. An Iron Age community in its natural and social setting. Kungl. Humanistiska Vetenskapssamfundet i Lund,* vol. 75, pp. 45-53.

Behre, K.-E. 1981: The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores* 23: 225-245.

Behre, K.-E. & Kučan, D. 1986: Die Reflektion archäologisch bekannter Siedlungen in Pollendiagrammen verschiedener Entfernung - Beispiele aus der Siedlungskammer Flögeln, Nordwestdeutschland. In K. -E. Behre (ed.), *Anthropogenic indicators in pollen diagrams*: 95-114. Balkema, Rotterdam, Boston.

Birks, H. J. B. 1986: Late-Quaternary biotic changes in terrestrial and lacustrine environments, with particular reference to north-west Europe. In B. E. Berglund (ed.), *Handbook of Holocene Palaeoecology and Palaeohydrology,* pp. 3-65. John Wiley & Sons, Chichester.

Clapham, A. R.; Tutin, T. G. & Moore, D. M. 1987: *Flora of the British Isles.* Third edition. Cambridge University Press, Cambridge.

Digerfeldt, G. 1988: Reconstruction and regional correlation of Holocene lake-level fluctuations in Lake Bysjön, South Sweden. *Boreas* 17, 2: 165-182.
- 1997: Reconstruction of Holocene lake-level changes in lake Kalersjön, southern Sweden, with a contribution to the local palaehydrology at the Elm Decline. *Vegetation History and Archaeobotany* 6: 9-14.

Enghoff, Inge Bødker 1998: Freshwater fishing at Ringkloster, with a supplement of marine fishes. *Journal of Danish Archaeology* vil 12, 1994-95: 99-105

Fægri, K. 1944: On the introduction of agriculture in western Norway. *Geologiska Förenings i Stockholm Förhandlingar* 66, 3: 449-462.

Fægri, K. & Iversen, J. 1989: *Textbook of Pollen Analysis.* IV Edition by K. Fægri, P. E. Kaland & K. Krzywinski. John Wiley & Sons, Chichester.

Gaillard, M.-J. & Digerfeldt, G. 1991: Palaeohydrological studies and their contribution to palaeoecological and palaeoclimatic reconstructions. In B. E. Berglund (ed.), *The cultural landscape during 6000 years in southern Sweden - the Ystad Project.* Ecological Bulletins 41, pp. 275-282.

Grimm, E. C. 1990: TILIA and TILIA•GRAPH: PC spreadsheet and graphics software for pollen data. *INQUA, Working Group on Data-Handling Metods, Newsletter* 4: 5-7.

Göransson, H. 1987: Neolithic man and the forest environment around Alvastra pile dwelling. *Theses and papers in North-European Archaeology* 20. Lund University Press, Stockholm.

Hansen, K. *et al.* 1981: *Dansk feltflora.* Gyldendalske Boghandel, Nordisk Forlag A/S, Copenhagen.

Iversen, J. 1941: *Landnam i Danmarks Stenalder.* Danmarks Geologiske Undersøgelse, II. Række, Nr. 66.
- 1969: Retrogressive development of a forest ecosystem demonstrated by pollen diagrams from fossil mor. *Oikos,* supplementum 12: 35-49.

Kalis, J. & Meurers-Balke, J. 1988: Wirkungen neolithischer Wirtschaftsweisen in Pollendiagrammen. *Archäologische Informationen* 11, 1: 39-53.

Madsen, T. 1982: Settlement systems of early agricultural societies in east Jutland: A regional Study of change. *Journal of Anthropological Archaeology* 1: 197-236.

Madsen, T. & Petersen, J. E. 1984: Tidlig-neolitiske anlæg ved Mosegården. Regionale og kronologiske forskelle i tidligneolitikum. *Kuml* 1982-83: 61-120.
Malmros, C. 1972: *Ringkloster. Rapport over undersøgelsen 30/ 7-10/8 1970.* Unpublished report, National Museum, Natural Science Research Unit, J. nr. A5502-24. 37 p.
- 1984: *Bestemmelse af trækul fra mesolitisk boplads Ringkloster.* Unpublished report, National Museum, Natural Science Research Unit, J. nr. A5502-86. 2 p.
- 1986: *Rapport om bestemmelse af ved, trækul, bark og svampe fra Ringkloster.* Unpublished report, National Museum, Natural Science Research Unit, J. nr. A5502-92. 19 p.
Moe, D. & Rackham, O. 1992: Pollarding and a possible explanation of the neolithic elmfall. *Vegetation History and Archaeobotany* 1: 63-68.
Molloy, K. & O'Connell, M. 1991: Palaeoecological investigations towards the reconstruction of woodland and land-use history at Lough Sheeauns, Connemara, western Ireland. *Review of Palaeobotany and Palynology* 67: 75-113.
Møller, J. D. 1987: Vedanatomisk analyse af vogndele. In P. O. Schovsbo *Oldtidens vogne i Norden. Arkæologiske undersøgelser af mose- og jordfundne vogndele af træ fra neolitikum til ældre middelalder.* Med bidrag af Jette Dahl Møller og Henrik Tauber, pp. 185-193. Bangsbomuseets Forlag. Bangsbomuseet 1987.
Peglar, S. M. 1993: The mid-Holocene *Ulmus* decline at Diss Mere, Norfolk, UK: a year-by-year pollen stratigraphy from annual laminations. *The Holocene* 3, 1: 1-13.
Peglar, S. M. & Birks, H. J. B. 1993: The mid-Holocene *Ulmus* fall at Diss Mere, South-East England - disease and human impact?. *Vegetation History and Archaeobotany* 2: 61-68.
Rackham, O. 1980: *Ancient Woodland. Its history, vegetation and uses in England.* Edward Arnold, London.
Regnell, M., Gaillard, M.-J., Bartholin, T. S. & Karsten, P. 1995: Reconstruction of the environment and history of plant use during the late Mesolithic (Ertebølle culture) at the inland settlement of Bökeberg III, south Sweden. *Vegetation History and Archaeobotany* 4: 67-91.
Rowley-Conwy, Peter 1998: Meat, Furs and Skins: Mesolithic Animal Bones from Ringkloster, a Seasonal Hunting Camp in Jutland. *Journal of Danish Archaeology* vol. 12, 1994-95: 87-98
Stuiver, M. & Reimer, P. J. 1993: Extended ^{14}C data base and revised CALIB 3.0 ^{14}C age calibration program. *Radiocarbon* 35, 1: 215-230.
Troels-Smith, J. 1937: *Pollenanalytisk datering af Brabrandfundet.* Danmarks Geologiske Undersøgelse, IV. Række, Bd. 2. Nr. 16.
- 1942: Geologisk datering af Dyrholm-fundet. *Det Kongelige Danske Videnskabernes Selskab. Arkæologisk-Kunsthistoriske Skrifter,* Bd. 1, Nr. 1.
- 1953: Ertebøllekultur - Bondekultur. Resultater af de sidste 10 Aars Undersøgelser i Aamosen, Vestsjælland. *Aarbøger for Nordisk Oldkyndighed og Historie 1953*: 5-62.
- 1956: Vandstandssvingninger i indsøbassiner og havtransgressioner og -regressioner. Mødereferat. *Meddelelser fra Dansk Geologisk Forening* 13: 127-128.
- 1960: *Ivy, Mistletoe and Elm, Climate Indicators - Fodder Plants.* Danmarks Geologiske Undersøgelse, IV. Række, Bd. 4, Nr. 4.
Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M. & Webb, D. A. (eds.) 1964-1980: *Flora Europaea.* Cambridge University Press, Cambridge.
Vuorela, I. 1973: Relative pollen rain around cultivated fields. *Acta Botanica Fennica* 102: 1-27.
Ørnbøl, J. 1984: *Pollenanalytiske undersøgelser fra Ringkloster ved Skanderborg Sø.* Unpublished report.

Latin	English	Danish
Acer	Maple	Løn
Alnus	Alder	El
Artemisia	Mugwort	Bynke
Betula	Birch	Birk
Campanula	Bellflower	Klokke
Caryophyllaceae	Pink Family	Nellikefamilien
Chenopodiaceae	Goosefoot family	Gåsefodfamilien
Compositae	Composite family	Kurveblomstfamilien
Corylus avellana	Hazel	Hassel
Crataegus	Hawthorn	Tjørn
Cruciferae	Crucifer family	Korsblomstfamilien
Cyperaceae	Sedge family	Halvgræsfamilien
Dipsacaceae	Teasel family	Kartebollefamilien
Dryopteris	Male-fern	Mangeløv
Ericaceae	Heather family	Lyngfamilien
Fagus sylvatica	Beech	Bøg
Filipendula	Meadow sweet	Mjødurt
Frangula alnus	Alder buckthorn	Tørst
Fraxinus excelsior	Ash	Ask
Galium	Bedstraw	Snerre
Geranium	Cranesbill	Storkenæb
Hedera helix	Ivy	Vedbend
Hordeum	Barley	Byg
Humulus/Cannabis	Hop/Hemp	Humle/Hamp
Ilex aquifolium	Holly	Kristtorn
Iris	Iris	Iris
Jasione montana	Sheep's bit	Blåmunke
Juniperus communis	Juniper	Ene
Labiatae	Mint family	Læbeblomstfamilien
Liguliflorae	Ligulate composites	Tungeblomstrede
Lotus	Trefoil	Kællingetand
Lycopodiaceae	Clubmoss family	Ulvefodfamilien
Lythrum salicaria	Purple loosestrife	Kattehale
Nuphar lutea	Yellow water-lily	Gul Åkande
Nymphaea alba	White water-lily	Hvid Åkande
Pediastrum	Pediastrum	Pediastrum (grønalge)
Phalaris arundinaceae	Reed-grass	Rørgræs
Phragmites australis	Reed	Tagrør
Picea	Spruce	Gran
Pinus	Pine	Fyr
Plantago lanceolata	Ribwort plantain	Lancet-Vejbred
Poaceae	Grass family	Græsfamilien
Polygonum aviculare	Knotgrass	Vej-Pileurt
Polygonum convolvulus	Black bindweed	Snerle-Pileurt
Polypodium vulgare	Polypody	Alm. Engelsød
Populus tremula	Aspen	Bævreasp
Potamogeton	Pondweed	Vandaks
Prunella	Self-heal	Brunelle
Pteridium aquilinum	Bracken	Ørnebregne
Quercus	Oak	Eg
Ranunculus	Buttercup	Ranunkel
Rhamnus catharticus	Buckthorn	Vrietorn
Rosaceae	Rose family	Rosenfamilien
Rumex acetosella	Sheep´s sorrel	Rødknæ
Rumex acetosa/acetosella	Dock/Sheeps´sorrel	Skræppe/Rødknæ
Salix	Willow	Pil
Sorbus	Rowan	Røn
Sparganium	Bur-reed	Pindsvineknop
Sphagnum	Bog moss	Tørvemos
Thalictrum	Meadow rue	Frøstjerne
Tilia	Lime	Lind
Triticum	Wheat	Hvede
Tubuliflorae	Tubulate composites	Rørblomstrede
Typha latifolia	Cat's tail	Bredbladet Dunhammer
Ulmus	Elm	Elm
Umbelliferae	Umbellate family	Skærmplantefamilien
Urtica	Nettle	Nælde
Viburnum opulus	Guelder-rose	Kvalkved
Viscum album	Misteltoe	Mistelten

Table 1. List of Latin plant names used in the article and their equivalents in English and Danish.

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Meat, Furs and Skins:
Mesolithic Animal Bones from Ringkloster, a Seasonal Hunting Camp in Jutland

by Peter Rowley-Conwy

INTRODUCTION

The site of Ringkloster belongs to the late mesolithic Ertebølle period, and dates from the 4th millennium BC in uncalibrated radiocarbon years. The Ertebølle is best known for its numerous large shell middens, but inland sites are also known. The excavations at Ringkloster represent the first modern excavation of an inland Ertebølle site in Denmark, and the first excavation ever of such a site in Jutland. Ringkloster lies some 15 km inland from the present coastline of eastern Jutland, although at the time of occupation sea level was a little higher than at present and the sea shore consequently somewhat closer (for more information see Andersen 1975; 1998 - this volume).

The site lies on the shore of a former lake, now infilled with fen peat. Little or no animal bone material survives on the actual area of occupation itself. However, the inhabitants disposed of large quantities of animal bones and other items by throwing them into the adjacent lake, where they were subsequently covered by the growing fen peat. In this respect the site is similar to other well-known mesolithic lake edge sites such as the Maglemose settlements of Zealand, and Star Carr in Britain.

Preservation of animal bone in such contexts is superb, and Ringkloster is exceptional even when compared to other bog sites. Dog bones are present in the assemblage, and some other bones show visible traces of gnawing. These are relatively rare, however, so it is felt that dogs have probably not modified the assemblage as much as is usually the case. Once bones had been discarded into the lake, dogs would no longer have had access to them (cf the similar arguments advanced for Star Carr by Legge & Rowley-Conwy 1988: 70).

The peat deposits from which the bones were recovered were not amenable to systematic large scale sieving. Bone fragments were therefore recovered by hand during the excavation. It is believed, however, that recovery was as good as could be achieved under the circumstances. The excavators (among them for several seasons the author of this paper) worked slowly and carefully and made every effort to recover all items. Some samples of material from the bog were sieved as a check on the degree of recovery, and very little material was found to have been overlooked by the excavators. For the most part one may therefore be reasonably confident that the assemblage is representative of what was in the deposits. However, the near absence of items such as astragali and phalanges of small carnivores (other bones of which are very common) must be due to their not being recovered.

A substantial part of the animal bone assemblage was previously examined by Dr. Ulrik Møhl, and a preliminary report presented (in Andersen 1975: 84-89, 94). The present author has examined the entire assemblage, and aspects of it have been referred to in other contexts (Rowley-Conwy 1993; in press). It must be stressed here that this report is preliminary, and that some analysis remains to be carried out. Although the main conclusions will not change, details of quantification etc. may differ in the final report.

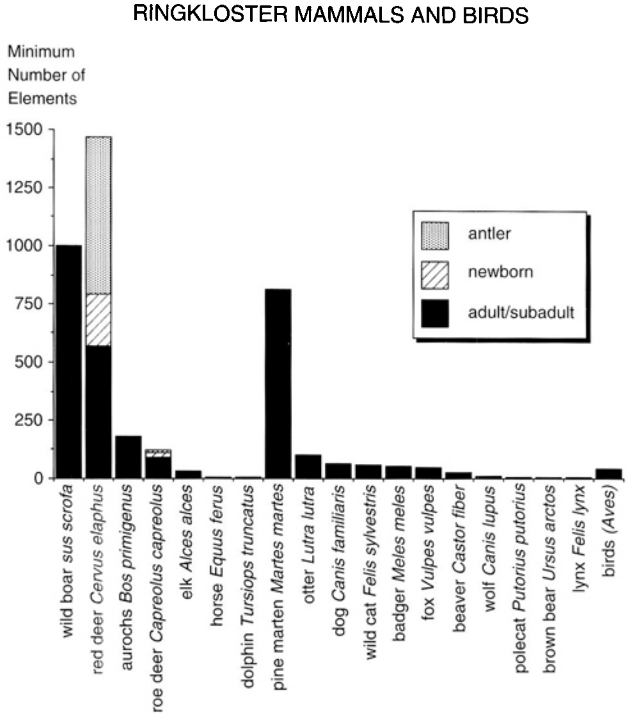

Fig. 1 Results of a preliminary quantification of the Ringkloster mammal and bird bones. For method of quantification see text.

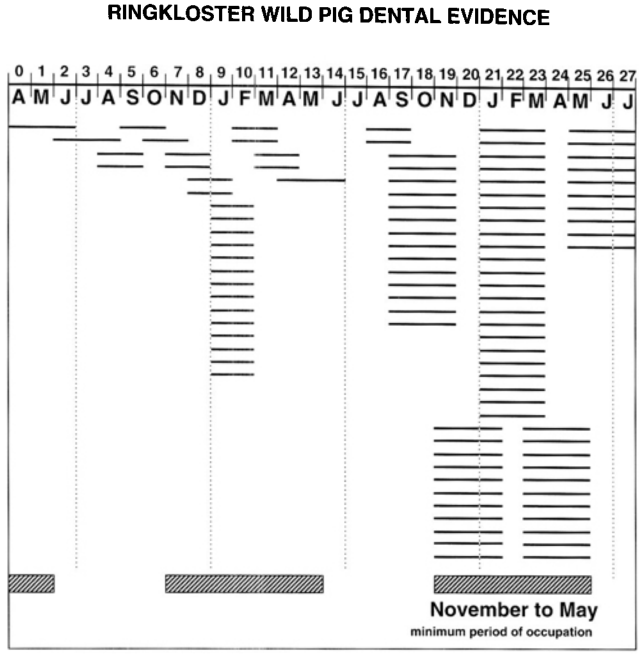

Fig. 2 Seasonal evidence from dentition of wild boar (*Sus scrofa*) from Ringkloster (preliminary version).

SPECIES REPRESENTED

Fig. 1 shows in graphic form the frequencies of mammals and birds at Ringkloster. The method of quantification that this is based upon is a variant of the Minimum Number of Elements (MNE) method presented by Binford (1978: 69-72; 1984: 50-51). This is preferable to both a simple count of fragments (NISP or Number of Identified Specimens) and any calculation of minimum numbers of individuals (MNI). MNI counts are usually based on only a small part of the assemblage such as the most common element, so that interspecific comparisons of even quite large assemblages may be based on small numbers. NISP counts suffer from problems of anatomical differences between species and differential fragmentation.

There are two stages in calculating MNE totals: firstly, the minimum number of each element (for example, distal humerus) must be estimated from the fragments found; secondly, these numbers must be adjusted because not all bones are equally represented in a skeleton. For example, a ruminant has one atlas vertebra, two distal humeri, and eight proximal phalanges; the count for atlas vertebrae is therefore doubled, and that for proximal phalanges divided by four, to bring them into line with the long-bone articulations.

This is preferable to NISP and MNI calculations in a number of ways. Firstly, all jaw and teeth fragments are not counted separately, but have been used to calculate the minimum number of mandibles and maxillae they could have come from. Although imprecise, this is preferable to counting each fragment separately, because at Ringkloster the large mammal jaws were often broken. One smashed jaw liberates many identifiable teeth into the archaeological deposits, and if each tooth was counted separately biases would be introduced both within and between species. Secondly, among the animals considered here, pigs have more metapodials than do the ruminants. For the purposes of comparability, the totals for metapodials III and IV are therefore halved, and the lateral metapodials and phalanges are ignored. Metapodial totals of carnivores are similarly adjusted to make them comparable to the ruminants. Thirdly, differential fragmentation is to some extent circumvented by counting each long-bone articulation separately. Many newborn deer limb bones and the overwhelming majority of carnivore limb bones were unbroken, while almost all the subadult and adult large mammal limb bones were broken. In a NISP count a complete pine marten humerus would count as one fragment, while a smashed pig humerus could be represented by two or more fragments. This bias is removed by counting the complete pine marten humerus as two elements in the MNE count, one for each articulation.

No method of quantification gives a magic solution to interspecific comparisons. However, the method outlined here probably gives a truer general picture of animal frequencies than most (subject of course to cultural biases such as differential transport of species or skeletal parts - see below). In light of this, various comments may be made with regard to fig. 1.

Wild boar is clearly the most common large mammal. Red deer is the second species in this category, only exceeding wild boar if the large number of antler fragments are taken into consideration. It is remarkable that bones of pine marten should be so common; these exceed those of red deer (excluding the antlers) and are second in frequency only to wild boar. The only domestic animal present is the dog; no sign has yet emerged from the analysis that the wild boar or aurochs are in any sense "proto-domestic". Three scapulae of wild boar have healed shot wounds, indicating that these animals at least were hunted. The presence of two horse bones is unexpected but not entirely implausible, since a horse first phalanx from the Ertebølle site of Brabrand has been directly dated to 3550 ± 75 BC uncalibrated (K-2651), thus placing it squarely within the Ertebølle period (Davidsen 1978, 145). Direct radiocarbon dates will be taken from the Ringkloster specimens to ascertain their contemporaneity with the rest of the cultural material. Finally, the presence of a rib of bottle-nosed dolphin at Ringkloster was noted by Dr. U. Møhl (in Andersen 1975: 88). In this author's analysis two further bones of small whales were found. Both are vertebrae, and were identified (with Dr. Møhl's help) as coming from the same species.

SEASONALITY

A major question with regard to any hunter-gatherer site is whether the site was seasonally occupied, and if so in which season. Ringkloster has a number of clear indications of seasonal occupation; it will be argued here that all the evidence indicates a winter/spring occupation, from about November to about May.

Wild Boar Tooth Eruption

Tooth eruption provides one of the clearest methods of determining the season of hunting and therefore of occupation. The large number of wild boar jaws in the Ringkloster assemblage provide more information than perhaps any other European mesolithic assemblage can do.

The method uses only dentally immature animals; once the third cusp of the third molar is in wear, the animal is no longer so precisely ageable. Two pieces of information are required: (1) the age at which the various teeth erupt in modern animals; and (2) the time of year in which the modern animals are born. Two assumptions are then made: (1) that prehistoric animals erupted their teeth at the same ages as their modern counterparts; and (2) that prehistoric animals were born at the same time of year as their modern counterparts. Modern wild boar have been relatively well studied. Three sets of eruption ages for different modern wild populations are known to the author (Bull & Payne 1982; Briedermann 1967; Matschke 1967). These all agree closely with each other and with the modern domestic ages put forward by Silver (1969). Can these figures be safely extrapolated back to the mesolithic? Silver (1969) also quotes figures for domestic animals in the last century; these differ from the modern figures and Silver suggests that plane of nutrition determines tooth eruption speed. However, recent work on cattle and sheep has indicated that 19th century data are suspect or spurious, and that tooth eruption is unlikely to be much affected by nutrition (Payne 1984; Legge, Williams & Williams 1992). In view of this, and of the similarity between the various sets of pig data mentioned above, it is likely that modern figures for tooth eruption can be extrapolated back with some confidence. In Denmark

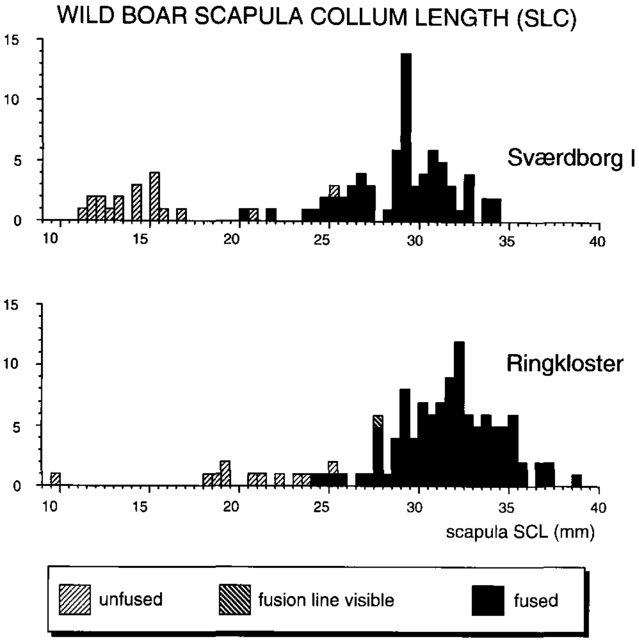

Fig. 3 Scapula measurement SLC of wild boar (*Sus scrofa*) from Ringkloster, compared to the same measurement from Særdborg I. Measurement definition from von den Driesch (1976).

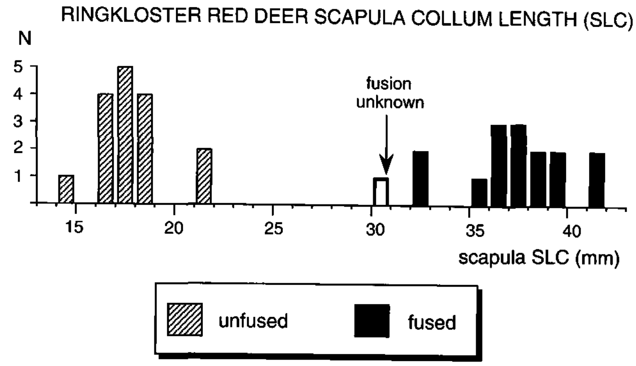

Fig. 4 Scapula measurement SLC of red deer (*Cervus elaphus*) from Ringkloster. Measurement definition from von den Driesch (1976).

wild boar give birth in March and April (Møhl 1978), and this too has probably changed little within the Holocene.

Fig. 2 shows the preliminary results. The ages used are those put forward by Higham (1968) using an earlier edition of Silver's (1969) ages. Each jaw ageable within Higham's scheme is given a line covering its determined age in months. Months in the year are calculated taking April 1 as mean date of birth. A line on fig. 2 means that an animal was killed somewhere within the timespan; it does not of course indicate human activity throughout the months covered. It is clear that there are two separate peaks of killing, one in each winter. The fact that these peaks coincide, both falling in the winter, is a further point in favour of extrapolating back the tooth eruption ages of modern pigs: if eruption ages were substantially different in the mesolithic, the two peaks should indicate different times of year.

The minimum period of occupation necessary to include almost all the second winter animals is November to May; this includes the "inner" ends of both the 17-19 month and the 25-27 month groups. This theoretical minimum is indicated in fig. 2, opposite both the first and second winters and the first spring. Of exactly 100 ageable jaws in fig. 2, all but 5 could have been killed within the November to May minimum.

Does the minimum necessary occupation coincide with the actual period of occupation? At Ringkloster there are two grounds for suggesting so. Firstly, other indicators all agree (see below). Secondly, the gaps in fig. 2 support this. If, for example, occupation had regularly begun as early as September, many more animals of 4-5 months and 16-17 months would have been expected; but they are virtually absent. The minimum necessary occupation period is thus a useful tool which may help to indicate concentrations in data of this sort. For example, Trolle-Lassen (1990: fig. 5) plots red deer data from Tybrind Vig, and states that the animals were killed "at all times of the year" (1990: 10). The minimum necessary period to account for 25 of the 26 Tybrind Vig specimens (excluding antler) is however a limited period from June to October. At Tybrind Vig, red deer hunting therefore appears to have been a seasonal activity. In view of the fact that the numerous pine martens at Tybrind Vig were also killed in the autumn (Trolle-Lassen 1986), it would be interesting to know what evidence there is for occupation at other times of the year.

Red Deer Tooth Eruption

The majority of red deer bones from Ringkloster comes from mature animals, a fact already noted by

Møhl (in Andersen 1975: 86). However, one class of juvenile also noted by Møhl appears in quantity: very young fawns. Seventeen mandibles from such animals were recovered. In two cases, deciduous m3 is nearly fully erupted but is unworn; in the other fifteen jaws, deciduous m3 is only half erupted. None of these teeth is thus worn, but very faint hairline wear was observed on four of the m2 teeth in these jaws. The animals from which these came can be no older than one or two weeks, and they could indeed be foetal.

Red deer in Europe today give birth mainly in May and June. Births in any one area are usually fairly concentrated, and variations between areas are probably due to local vegetational development (Ahlen 1965). During the Atlantic period, Denmark was over 2°C warmer than today (Degerbøl & Krog 1951). Vegetation is thus likely to have developed relatively early in the year, which may suggest that Ertebølle period red deer births would concentrate in May rather than June. Adding a month before this for the possibility that the little deer were foetal, the season that the Ringkloster fawns indicates is tentatively placed as April and May. The fact that no jaws have wear beginning on m3 indicates an abrupt ending of hunting, best explained as the start of a seasonal absence by the hunters.

Wild Boar Bone Growth

Bone growth is a method which has recently been used to diagnose seasonality (Legge & Rowley-Conwy 1987; Rowley-Conwy 1993; in press). Gaps in distributions are good evidence of a cessation of killing and thus of seasonal killing, but do not by themselves indicate which season is involved.

Where sites can be diagnosed by tooth eruption, the bone growth patterns lend support. An example is given in fig. 3. The Maglemosian site of Sværdborg I is classified as a summer site on the basis of among other things pig tooth eruption, because of the presence of many piglets of about 2-5 months age (Rowley-Conwy 1993). The group of unfused scapulae from this site (fig. 3) must correspond to these. There is then a gap (containing only three specimens), separating the very young and the more mature specimens. This gap reinforces the conclusion that people were mostly absent from Sværdborg I during the winter. Ringkloster is exactly complementary: a single tiny scapula is even smaller than the Sværdborg juveniles, indicating a newborn specimen probably killed in about April. There is then a gap opposite the summer juvenile size range at Sværdborg; killing at Ringkloster resumed opposite the winter gap at Sværdborg. Wild boar bone growth thus supports the conclusions derived from the jaws.

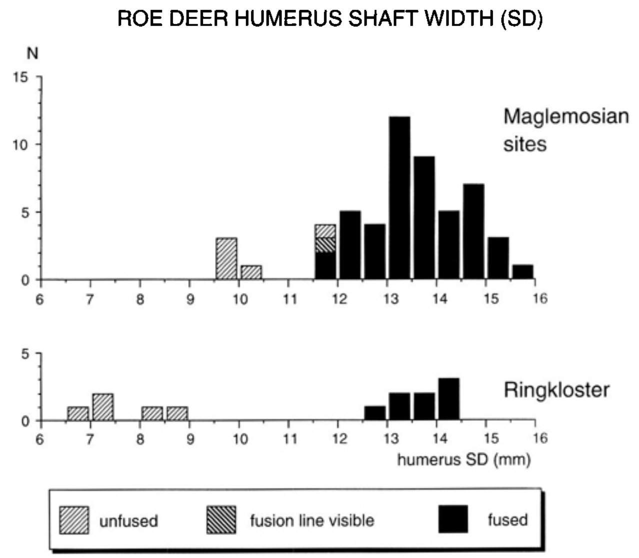

Fig. 5 Humerus measurement SD of roe deer (*Capreolus capreolus*) from Ringkloster, compared to the same measurement from Sværdborg I, Holmegaard I and IV and Mullerup. Measurement definition from von den Driesch (1976).

Red Deer Bone Growth

The Ringkloster red deer scapulae show a similar pattern to those of wild boar (fig. 4), though no Maglemosian comparative specimens are available. However, the major gap between the fused and the unfused specimens must indicate seasonal cessation of killing. The little scapulae must correspond to the newborn or foetal jaws described above, while the fused ones derive from subadult or adult animals.

Roe Deer Bone Growth

Bones of very young roe deer were also present at Ringkloster, although only one newborn or foetal jaw was found. These bones cannot therefore be so clearly seasonally diagnosed by means of evidence from Ringkloster. However, sufficient Maglemosian comparative material is available to provide a pattern.

The sites of Sværdborg I, Holmegaard I and IV and Mullerup produced many roe deer bones, a few of which were from very young animals. The sites in question are all diagnosed as summer sites, occupation probably starting around June (Rowley-Conwy 1993). If the above discussion about the birth season of red deer applies also to roe deer, the roe would have been up to a month old in June. Bones of very young roe deer are rare at Maglemosian sites, but four humeri were measured from the four sites mentioned above. They are plotted in fig. 5, and form a clearly separate group.

The Ringkloster unfused specimens are even smaller than the Maglemosian ones (fig. 5). This indicates that they were killed at a still earlier stage of growth. Once again the possibility that they were foetal animals cannot be ruled out, so once again the period April-May is put forward as the most likely time of death.

Seasonality: Discussion

The wild boar, red deer and roe deer provide about the best seasonal evidence from any mesolithic site in Europe, and all converge on winter and spring as the main period of occupation. It is worth stressing that summer occupations at other sites are clearly visible using the techniques applied here (Legge & Rowley-Conwy 1988; Rowley-Conwy 1993); the winter/spring concentration at Ringkloster is not the result of some methodological bias.

Absence is much harder to prove than presence, and consideration must be given to the possibility of "invisible" occupation in the summer months. It is argued here that such a possibility is unlikely. If most of the main food animals were killed in winter and spring, what resources could have been used at other times? The other animals on the list could have provided meat in the summer, although there is no evidence that they did so. The pine martens are numerous but small; their bones were frequently found still articulated, indicating that they had been disposed of into the lake intact and unbutchered. This would suggest they were not eaten, and the pelts were probably the reason the animals were hunted (see below). The pelts are at their best in the colder months of the year, so the presence of so many animals at Ringkloster might thus be further evidence of occupation in this season. Detailed seasonal analysis of the kind carried out by Trolle-Lassen (1986) at Tybrind Vig has not, however, yet been undertaken.

Birds are present but in small numbers. Such evidence as they provide also indicates winter. Of the 45 identified bones, 13 (or 29%) come from red throated diver (*Gavia stellata*), sea eagle (*Haliaetus albicilla*) and swan (*Cygnus* sp). The first two are cold-season visitors to Denmark (Bruun and Singer 1970). The swans are likely to be either Bewick's Swan (*Cygnus bewickii* - to which species two of the five swan bones were tentatively referred) or whooper swan (*Cygnus cygnus*) both of which are winter visitors. No finds of the permanently resident mute swan (*Cygnus olor*) are known from this period of prehistory (Løppenthin 1967).

Other resources that might have played a part are fish and plants. Pike and cyprinids predominate among the fish (Enghoff 1998 - this volume). However, the fish provide no direct evidence for season of kill; both taxa are difficult to catch in midwinter but could certainly have been caught in spring (Enghoff 1998 (this volume) and pers. comm.; Rowley-Conwy 1993: 183). Plants would certainly be more available in summer and autumn. However, apart from hazel nuts and acorns such resources provide relatively low energetic returns, and their importance in the mesolithic may have been exaggerated (Rowley-Conwy 1986). It is unlikely that "invisible" foodstuffs could have been so important in summer that exploitation of the winter/spring resources stopped as abruptly as it appears to have done. It is concluded therefore that the gap in the hunting of large mammals most probably reflects a seasonal absence from the site.

If this is correct, it must be asked where the inhabitants spent the rest of the year. In view of the short distance to the sea, I have earlier suggested that the sea shore was the most likely place (Rowley-Conwy 1983; 1993). Recently, however, a totally different scenario has been put forward by Price (1993), using the work of Noe-Nygaard (1988):

"In the later mesolithic, both inland and coastal sites are recorded; the question of residential sedentism vs. mobility and relationships between the coastal and inland sites is important for understanding the transition to the neolithic in this area. New information from bone chemistry has helped to resolve this question. Noe-Nygaard (1988) used the $\delta^{13}C$ levels in dog bones at inland and coastal mesolithic sites as a proxy for humans. Dogs at coastal sites consumed a diet dominated by marine foods, while dogs at inland sites ate an almost exclusively terrestrial diet. Such evidence indicates that the dogs, and most likely their human owners, spent most of the year inland. This study provides strong evidence for a sedentary pattern in both areas, as well as a distinction between coastal and inland settlements." (Price 1993: 242-243)

This is a considerable oversimplification. Taking the eleven definite middle and late mesolithic dogs only (Kongemose and Ertebølle periods) from Noe-Nygaard (1988: table 1), the following pattern emerges:

a) at coastal sites there are six dogs with a marine diet (Carstensminde, Bloksbjerg, Maglemosegårds Vænge, Vedbæk, Sølager and Ertebølle);
b) at coastal sites there are two dogs with a terrestrial diet (Kassemose and Ølby Lyng)
c) at inland sites there is one dog with a terrestrial diet (Præstelyngen);
d) at inland sites there are two dogs with marine diets (the two specimens from Kongemose).

The situation is thus not as straightforward as Price states. A variety of interpretations of these data are possible, not all supporting the dichotomy between inland and coastal settlement. Furthermore, there is absolutely no reason why the dog data should imply sedentism. Finally, a variety of circumstances can be envisaged whereby the diets of individual dogs might differ from each other and from humans, so too much weight should not be placed on dog $\delta^{13}C$ data. There may well have been separate human populations in the deep interior of Jutland. However, a regional perspective is essential if mesolithic settlement is to be understood (Rowley-Conwy 1993). From this perspective the presence of a highly productive sea coast less than 15 km away from Ringkloster cannot be ignored. Such a coast would have a relatively high population density, and these populations would inevitably make extensive use of the adjacent hinterland as well. This is in fact what Noe-Nygaard suggested for the Kongemose dogs: the site is not coastal but the dogs had marine diets (see above). The site was only 12 km from the contemporary sea coast, so "the dogs might thus stem from a coastal group of hunters on inland hunting expeditions" (Noe-Nygaard 1988: 91). This is exactly what is here argued for Ringkloster.

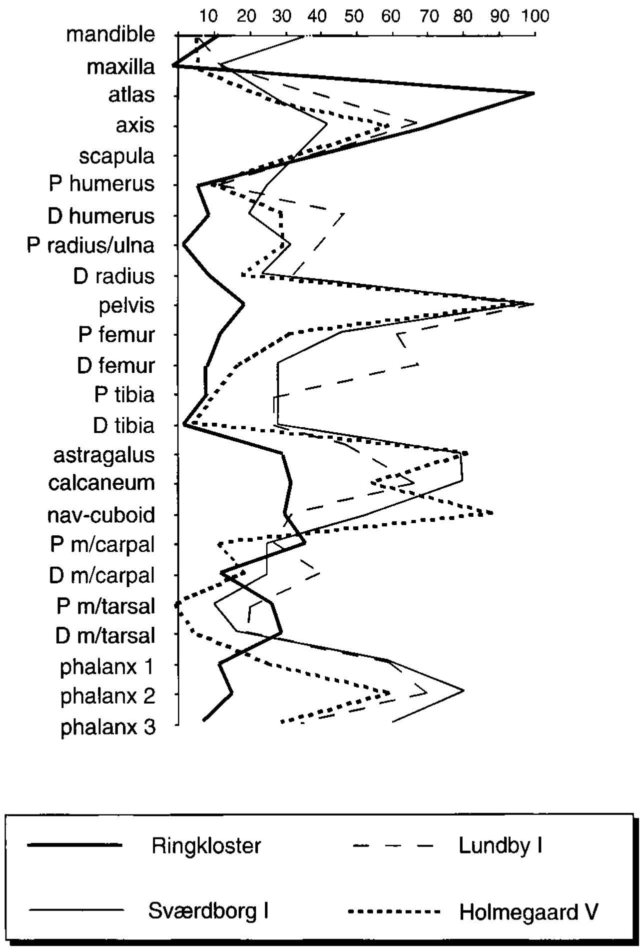

Fig. 6 Skeletal element frequency of aurochs (*Bos primigenius*) from Ringkloster, compared with that from Sværdborg I, Lundby I and Holmegaard V.

PURPOSE OF OCCUPATION

It will be argued in this section that the Ringkloster assemblage differs in a number of respects from what would be expected at a base camp. The site was

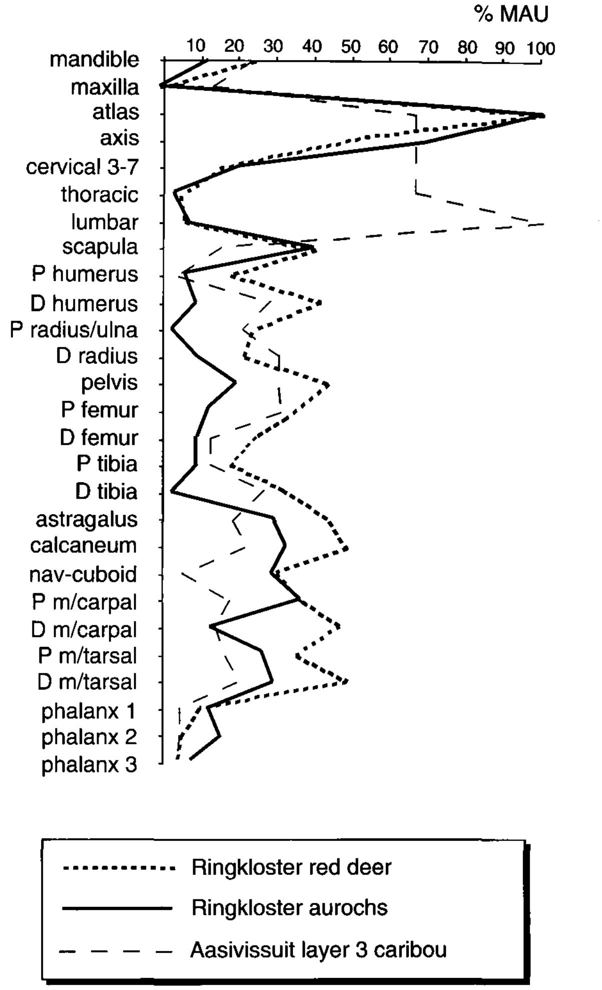

Fig. 7 Skeletal element frequency of aurochs (*Bos primigenius*) and red deer (*Cervus elaphus*) from Ringkloster, compared with that of caribou (*Rangifer tarandus*) from layer 3 at Aasivissuit. Aasivissuit figures from Grønnow *et al.* (1983: fig. 83).

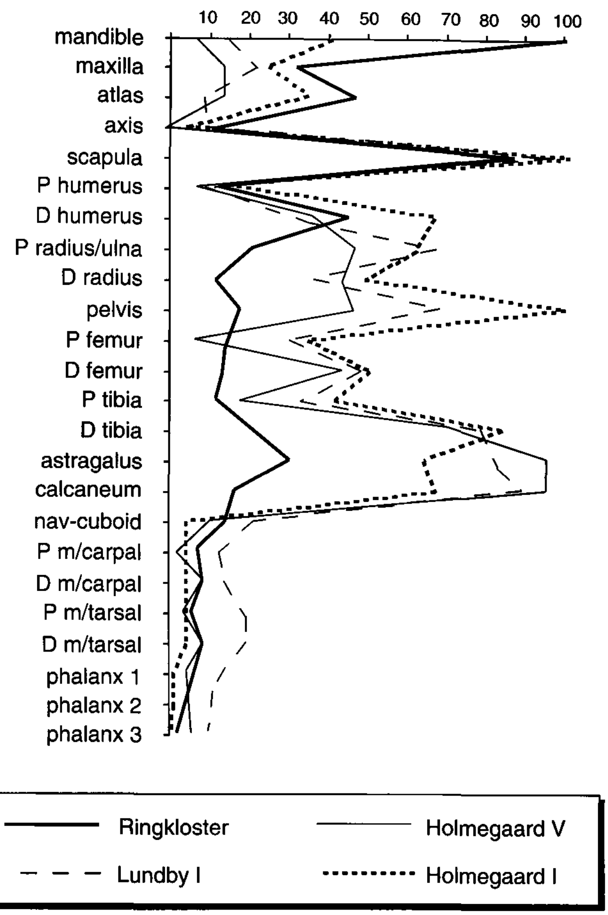

Fig. 8 Skeletal element frequency of wild boar (*Sus scrofa*) from Ringkloster, compared with that from Lundby I and Holmegaard I and V.

probably a hunting camp specialising on the procurement of meat, furs and skins.

Meat: Aurochs and Red Deer

The relative frequencies of skeletal parts of wild boar, red deer and aurochs at Ringkloster are markedly unusual, and have led to the suggestion that not all parts of these animals were always consumed at the site but rather that significant quantities of meat were exported. The argument is presented in full elsewhere (Rowley-Conwy 1993) and will therefore be summarised here.

Quantification of skeletal elements was discussed above. The method used to compare skeletal element frequencies uses the Minimum Number of Elements totals as follows: the most common MNE is expressed as 100%, and all other frequencies are expressed as percentages of the most common MNE. This is the "Percent Minimum Animal Unit" (%MAU) method described by Binford (1984: 50-51). Newborn animals are not included in the following discussion; only bones of subadult and adult animals are included in figs. 6, 7 and 8.

Fig. 6 plots the %MAU of the Ringkloster aurochs compared to those of three Maglemosian settlements: Lundby I, Sværdborg I and Holmegaard V (Rowley-Conwy unpublished). Two things are immediately apparent: (1) the Ringkloster assemblage is heavily dominated by atlas and axis vertebrae, all other elements having low values; (2) Ringkloster is very different from the other sites in this regard. Fig. 7 plots the Ringkloster aurochs and red deer; the lines are closely similar.

Under what circumstances will an assemblage be dominated by atlas and axis vertebrae? Measurements of aurochs bone hardness are not available, but bison atlas and axis vertebrae are remarkably hard bones (Kreutzer 1992), so if the same is true of aurochs these bones might be expected to survive quite well even if other bones did not. However, it is difficult to see how a non-cultural taphonomic effect could be responsible for the Ringkloster patterns. Firstly, the Ringkloster red deer have an identical pattern (fig. 7), but atlas and axis are among the softest bones in the deer skeleton (Kreutzer 1992). Secondly, as mentioned conditions of preservation in the lake peats at Ringkloster were excellent, so it is unlikely that all the other elements have been destroyed. Thirdly, similar conditions of preservation at the Maglemosian sites plotted in fig. 6 have not produced similar assemblages, and nor have any other sites known to the author. Fourthly, the pig pattern is quite different (see below).

Cultural factors may thus be responsible for the Ringkloster pattern. One possible factor emerges from a consideration of fig. 7, where the red deer and aurochs are compared to the caribou bone representation from layer 3 of the Inuit site of Aasivissuit in western Greenland (Grønnow *et al.* 1983). Aasivissuit is dominated by lumbar vertebrae, not the first two cervical vertebrae, but is otherwise remarkably similar to the Ringkloster patterns. At Aasivissuit it is ethnographically recorded that caribou were killed nearby, and much of the meat removed to the coastal settlement from which the people came (Grønnow *et al.* 1983). The Aasivissuit assemblage is thus what remains after animals have been processed at a hunting camp and much meat transported further to a base camp.

The similarity between Ringkloster and Aasivissuit does not of course prove that a similar cause is involved at both. However, it is difficult to see why people should introduce just the first two neck vertebrae to a site. These bones have no marrow, and carry less meat and fat than most other bones (Binford 1978). It is much more likely that some practice similar to that recorded at Aasivissuit is responsible, and that meat was removed from Ringkloster to some other location.

Meat: Wild Boar

The wild boar skeletal element pattern differs from that of the red deer and aurochs (fig. 8). The assemblage is dominated by mandible and scapula, with maxilla, atlas and distal humerus also common. All other elements are represented by low values.

Once again it is difficult to see how this might come about for non-cultural reasons. The Maglemosian sites in fig. 8 have similarly good preservation, but none resemble Ringkloster in element frequency; frequencies are variable but most elements are much more common than at Ringkloster. Cultural practices are more likely to be involved. It is probable that wild boar hindquarters were removed from Ringkloster; however, the forequarters of these animals must have been consumed at the site to account for the presence of so many scapulae and mandibles.

Fur: Pine Martens

The unusually large proportion of pine martens at the site (fig. 1) is more compatible with Ringkloster being a special-purpose procurement camp than a base camp. Apart from the spectacular assemblage from Tybrind Vig (Trolle-Lassen 1986) no other site in Denmark is known with so many of these animals, and this strongly suggests specialised procurement rather than normal usage.

It was mentioned above that skeletons were sometimes found articulated rather than butchered. Many skulls do however show transverse cut marks across the front of the skull, characteristic of skinning. A Ringkloster specimen was illustrated by Andersen (1975: fig. 72), and others are known from Tybrind Vig (Trolle-Lassen 1986: fig. 3). A total of eighteen such cases have been observed at Ringkloster. A single fox skull had similar transverse cuts. One badger skull, four dog skulls and one beaver skull had longitudinal cuts in the same region, probably indicating a variant on the same skinning method. Finally, a bear skull had transverse cuts across the nasal bone and longitudinal cuts running up the front of the skull. This consistency argues for highly routinised processing of the carcasses.

Skins: Red Deer and Roe Deer Fawns

The large numbers of red and roe deer fawns is yet another way in which Ringkloster differs from more "normal" mesolithic assemblages. Using the quantification method described above, 28.4% of red deer and 18.6% of roe deer were newborn or foetal. This indicates specialised procurement of these animals, and is thus another argument in favour of Ringkloster being a hunting camp. It is unlikely that deer populations under continuous predation could sustain a cull of these proportions.

Bones of red deer fawns have been noted elsewhere in the Danish mesolithic, though not in the high proportions found at Ringkloster, and it has been suggested that the spotted skins of these animals were desirable raw material for clothing (U. Møhl personal communication). At Ringkloster few of the bones showed evidence of butchery, but some of the metapodials had cut marks across the rear of the distal end. This is consistent with skinning.

CONCLUSIONS

It has been argued that Ringkloster was a seasonal hunting camp, occupied mainly in winter and spring, and specialising in the procurement of meat, furs and skins for removal to a base camp elsewhere. The combined evidence in favour of a winter/spring occupation is superior in quantity and clarity to seasonal evidence from most sites known to the author, while the evidence for resource specialisation is second to none.

It is unclear from the animal bones whether Ringkloster was visited by the inhabitants of just one base camp, or from several; if the latter, the site could have played a social role as a gathering place that went beyond its strictly economic role. One may speculate that not all the inhabitants of the base camp(s) need have visited Ringkloster: quite small hunting and trapping parties on visits of as short as a few days would be sufficient to generate the archaeological remains if the visits took place frequently enough and over a long enough period.

Specialised hunting may help to account for one other unusual aspect of the site: the large quantities of red deer antler. A total of 677 fragments were recovered (see fig. 1), of which no fewer than 386 (57%) were worked in some way. The site is similar in this respect to Star Carr and Stellmoor (Legge & Rowley-Conwy 1988; Grønnow 1987), both argued to be specialised hunting sites and both having large quantities of worked antler disposed of or cached in lakes adjacent to the site.

This again raises the question of where the base camp(s) were located. It was argued above that the coast was the most likely region, and that view is reiterated here. Judging by the rarity of most of the red deer and aurochs skeletons, removal of meat of these species was maximised. Pork contains more fat than beef or venison, so hunters leading an active life would be more likely to choose to eat wild boar at a winter hunting camp (cf Speth & Spielmann 1983). Nevertheless the hindquarters, the most transportable and probably the fattest parts, were also transported away from Ringkloster. This suggests fairly intensive exploitation of the resources in question. This is also the impression gained from the large numbers of pine martens and the high proportions of newborn or foetal red and roe deer.

Such intensive and specialised procurement may suggest that the regional population exploiting the resources was quite dense. This points once again to the sea coast, where population densities would be relatively large. It is likely (though it cannot be proved) that Ringkloster was visited by groups from one or more coastal base camps, and that such coastal base camps were where the meat, furs and skins ended up. Such coastal base camps would be the hub of a radial system of exploitation which would include both coastal and hinterland regions. Further elucidation of the system is a major goal for future research.

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In memory of Dr. Ulrik Møhl

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REFERENCES

Ahlen, I. 1965: Studies on the red deer, Cervus elaphus L. in Scandinavia. III. Ecological investigations. *Viltrevy* 3: 177-376.

Andersen, S. H. 1975: Ringkloster: en jysk indlandsboplands med Ertebøllekultur (English summary). *Kuml* 1973-4: 11-108.

- 1998: Ringkloster Ertebølle trappers and wild boar hunters in eastern Jutland. A Survey. *Journal of Danish Archaeology* 12, 1994-95: 13-59.

Binford, L. R. 1978: *Numamiut Ethnoarchaeology.* New York: Academic Press.

- 1984. *Faunal Remains from Klasies River Mouth.* New York: Academic Press.

Briedermann, L. 1968: Schwarzwild. In E. Wagenknecht (ed.) *Die Alterbestimmung der Erlegten Wilden* pp. 76-86. Deutsche Landwirtschaftsverlag, East Berlin.

Bruun, B. & Singer, A. 1970: *Fugle i Europa.* Gyldendal, København.

Bull, G. & Payne, S. 1982: Tooth eruption and epiphyseal fusion in pigs and wild boar. In B. Wilson, C. Grigson & S. Payne (eds.) *Ageing and Sexing Animal Bones from Archaeological Sites,* pp. 55-71. British Archaeological Reports, British Series 109, Oxford.

Davidsen, K. 1978. *The Final TRB Culture in Denmark.* (Arkæologiske Studier V). Akademisk Forlag, København.

Degerbøl, M. & Krog, H. 1951: Den europæiske sumpskildpadde (Emys obicularis L.) i Danmark (English summary). *Danmarks Geologiske Undersøgelse II,* 78, 1-130.

Driesch, A. E. von den, 1976: *A Guide to the Measurement of Animal Bones from Archaeological Sites.* Peabody Museum Bulletin 1.

Enghoff, Inge Bødker 1998: Freshwater fishing at Ringkloster, with a supplement of marine fishes. *Journal of Danish Archaeology* vol. 12, 1994-95, p. 99-105

Grønnow, B. 1987: Meiendorf and Stellmoor revisited. *Acta Archaeologica* 56: 131-166.

Grønnow, B. , Meldgaard, M. & Nielsen, J. B. 1983: Aasivissuit - the Great Summer Camp. Archaeological, Ethnographical and Zoo-Archaeological Studies of a Caribou-Hunting site in West Greenland. *Meddelelser om Grønland, Man and Society* no. 5.

Higham, C. F. W. 1968: Stock rearing as a cultural factor in prehistoric Europe. *Proceedings of the Prehistoric Society* 33, 84-106.

Kreutzer, L. A. 1992: Bison and deer bone mineral densities: comparisons and indications for the interpretation of archaeological faunas. *Journal of Archaeological Science* 19: 271-294.

Legge, A. J. & Rowley-Conwy, P. 1987: Gazelle killing in stone age Syria. *Scientific American* 257 (2): 88-95.

Legge, A. J. & Rowley-Conwy, P. 1988: *Star Carr Revisited. A Re-analysis of the Large Mammals.* London: Birkbeck College, Centre for Extra-Mural Studies.

Legge, A. J. , Williams, J. & Williams P. 1992: The determination of season of death from the mandibles and bones of the domestic sheep (Ovis aries). In: R. Maggi, R. Nisbet & G. Barker (eds.) *Archeologia della Pastorizia nell'Europa Meridionale* vol II, pp. 49-65. Rivista di Studi Liguri A, 57. Istituto Internazionale di Studi Liguri, Bordighera.

Løppenthin, B. 1967: *Danske Ynglefugle i Fortid og Nutid.* Odense University Press.

Matschke, G. H. 1967: Ageing European wild hogs by dentition. *Journal of Wildlife Management* 31: 109-113.

Møhl, U. 1978: Aggersund-bopladsen zoologisk belyst. Svanejagt som årsag til bosættelse? (English summary). *Kuml* 1978: 57-76.

Noe-Nygaard, N. 1988: $\delta^{13}C$-values of dog bones reveal the nature of changes in man's food resources at the mesolithic-neolithic transition, Denmark. *Chemical Geology (Isotope Geoscience Section)* 73: 87-96.

Payne, S. 1984: The use of early 19th century data in ageing cattle mandibles from archaeological sites, and the relationship between the eruption of M3 and P4. *Circaea* 2, August 1984: 77-82.

Price, T. D. 1993: Issues in palaeolithic and mesolithic research. In: G. L. Peterkin, H. Bricker & P. Mellars (eds.) *Hunting and Animal Exploitation in the Later Palaeolithic and Mesolithic of Eurasia,* pp. 241-244. Archaeological Papers of the American Anthropological Association no. 4.

Rowley-Conwy, P. 1983: Sedentary hunters: the Ertebølle example. In: G. Bailey (ed.) *Hunter-Gatherer Economy in Prehistory,* pp. 111-126. University Press, Cambridge.

- 1986: Between cave painters and crop planters: aspects of the temperate European mesolithic. In: M.

Zvelebil (ed.) *Hunters in Transition*, pp. 17-32. University Press, Cambridge.

- 1993: Season and reason: the case for a regional interpretation of mesolithic settlement patterns. In: G. L. Peterkin, H. Bricker & P. Mellars (eds.) *Hunting and Animal Exploitation in the Later Palaeolithic and Mesolithic of Eurasia*, pp. 179-188. Archaeological Papers of the American Anthropological Association no. 4.
- (in press): Cemeteries, Seasonality and Complexity in the Ertebølle of Southern Scandinavia. To appear in: M. Zvelebil, L. Domanska & R. Dennell (eds.) *The Origins of Farming in the Baltic Region.* Oxbow Books, Oxford.

Silver, I. A. 1969: The ageing of domestic animals. In: D. Brothwell and E. S. Higgs (eds.) *Science in Archaeology* (second edition), pp. 283-302. Thames and Hudson, London.

Speth, J. D. & Spielmann, K. A. 1983: Energy source, protein metabolism, and hunter-gatherer subsistence strategies. *Journal of Anthropological Archaeology* 2: 1-31.

Trolle-Lassen, T. 1986: Human exploitation of the pine marten (*Martes martes* (L.)) at the late mesolithic settlement of Tybrind Vig in western Funen. In: L.-K. Königsson (ed.) Nordic Late Quaternary Biology and Ecology, *Striae* 24: 119-124.

1990: Butchering of red deer (*Cervus elaphus* L.) - a case study from the late mesolithic settlement of Tybrind Vig, Denmark. *Journal of Danish Archaeology* 9: 7-37.

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Freshwater fishing at Ringkloster, with a supplement of marine fishes

by Inge Bødker Enghoff

INTRODUCTION

During the Atlantic period, the stone age settlement Ringkloster was situated at Lake Skanderborg in Jutland, Denmark. Lake Skanderborg drains towards the west through the river Gudenå and is situated 15-20 km from the nearest seacoast (Kattegat to the east). At the time when the Ringkloster settlement was inhabited Lake Skanderborg was much larger and much more ramified than today.

The Ringkloster settlement was situated at the shore of a prehistoric arm of the lake, just where the arm was connected with the rest of the lake through a narrow passage. Conditions for fishing must have been good here, because fish concentrate at such places when passing from one basin to the other.

Pollen analysis indicates that the area off the settlement has been an alder (*Alnus*) swamp, not reed-swamp which would have been an obstacle for fishing (Rasmussen 1998 - this volume). The bottom of the lake off the settlement falls steeply towards west. In addition to Ringkloster, there were several other stone age settlements at Lake Skanderborg. Ringkloster is, however, so far the only inland settlement from the Ertebølle period in Jutland which has been systematically excavated, and from where bones have been preserved. For this reason, Ringkloster is of particular interest. For an archaeological treatment of the Ringkloster settlement, see Andersen (1975; 1998 - this volume).

MATERIAL AND METHODS

The Ringkloster settlement was excavated during the period 1969-1983 under the supervision of Søren H. Andersen (Institute of Prehistoric Archaeology, University of Aarhus). The site includes a settlement area on land (ca. 200 X 75 m) and a refuse zone in the former lake which is now a swamp. 105 m^2 of the refuse zone have been excavated. The settlement was excavated systematically, but the sediment was not consistently sieved in the field. This has presumably reduced the number of recovered fishbones considerably. However, selected samples were sieved (2½ mm mesh) as a routine in order to control the presence of small objects. These samples gave the impression that there were only few fishbones in the former lake, except near the shore where fishbones were locally numerous. Owing to a highly complicated stratigraphy only few squares were, however, excavated in this zone. In the settlement area conditions for preservation were very bad and almost no organic remnants have been preserved. Thus, the majority of the fishbone material derives from the refuse zone in the near-shore zone of the former lake. The vertebrae in the material are well-preserved, but fish headbones are generally not.

$_{14}$C datings are available from bottom to top of the refuse zone and cover the interval 4110-4460 B.C. The dates are calibrated according to Stuiver & Pearson (1993) by U. Rahbek, The C-14 Dating Laboratory, The National Museum, Copenhagen.

Lab. No.	$_{14}$C-age BP	B.C. cal.	± 1 std. dev.
K-1652	5610 ± 110	4460	4540-4350
K-1765	5500 ± 100	4350	4460-4250
K-1653	5490 ± 100	4340	4450-4240
K-1654	5320 ± 100	4220-4110	4320-3990

As the fishbone material was recovered from the former lake, it cannot be assumed *a priori* to repre-

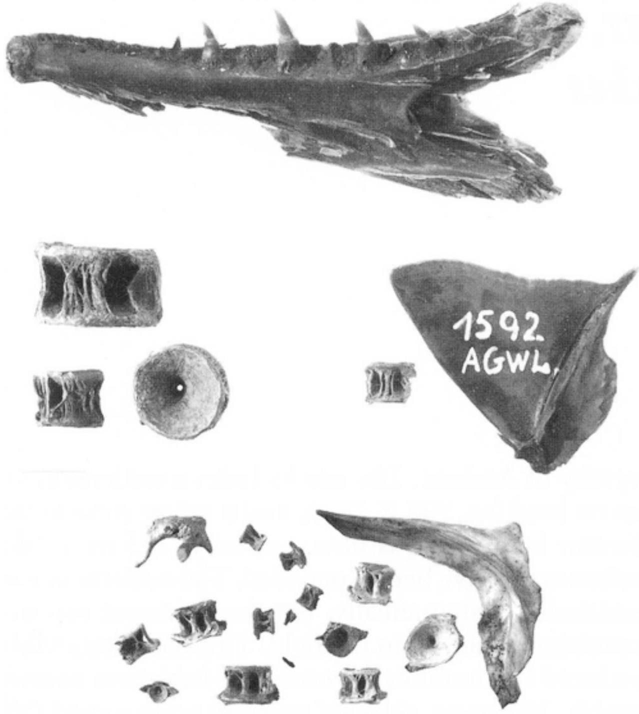

Fig. 1 Fishbones from Ringkloster, representing the most frequent species. Top: Dentale of Pike. Middle left: three vertebrae of Pike. Middle right: One vertebra and one operculum of Perch. Bottom: One pharyngeal bone, 12 vertebrae, and one cleithrum of cyprinids (1:1). G. Brovad photo.

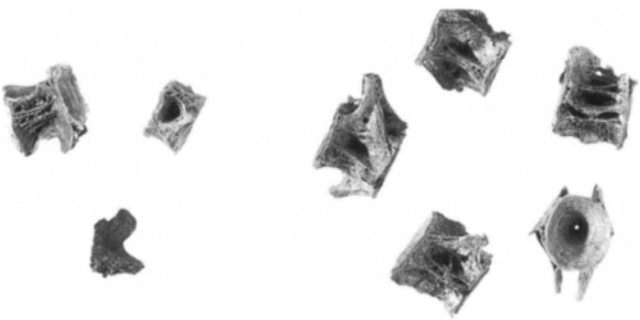

Fig. 2 Bones of marine fishes from Ringkloster. Top left: two vertebrae of Cod. Bottom left: Burnt praemaxillare of Cod. Right: Five vertebrae of Plaice/ Flounder/Dab (2:1) G. Brovad photo.

	No. of bones	% of total
FRESHWATER SPECIES		
Pike, *Esox lucius*	253	26.89
Cyprinids, Cyprinidae, TOTAL	536	56.96
Roach, *Rutilus rutilus*	(19)	(2.02)
Rudd, *Scardinius erythrophthalmus*	(3)	(0.32)
White bream, *Blicca bjoerkna*	(4)	(0.43)
Common bream, *Abramis brama*	(1)	(0.12)
Cyprinidae unspecified	(509)	(54.09)
Perch, *Perca fluviatilis*	114	12.11
Ruffe, *Gymnocephalus cernuus*	2	0.21
MIGRATORY SPECIES		
Trout/Salmon, *Salmo* sp.	2	0.21
Eel, *Anguilla anguilla*	8	0.85
SALTWATER SPECIES		
Gadids, Gadidae, TOTAL	15	1.59
Cod, *Gadus morhua*	(11)	(1.17)
Pollack/Saith, *Pollachius* sp.	(1)	(0.12)
Gadids, unspecified	(3)	(0.32)
Plaice/Flounder/Dab, *Pleuronectes platessa/ Platichthys flesus/ Limanda limanda*	11	1.17
Total	941	

Table 1 Species of fish in the Ringkloster material. Numbers of identified bones of each species, and their frequency in percent of a total of 941 identified fishbones, are given.

sent refuse from human meals. The bones might as well derive from fish dead from natural causes (Noe-Nygaard 1988).

However, the fishbones were found in layers with clear characteristics of a midden, containing flint refuse, mammal and bird bones, sherds, charcoal, wood etc. Datings from this refuse layer form a vertical chronological sequence, and the layer is delimited above and below by sterile layers (Andersen 1975).

All artefacts from the refuse layer are of the Ertebølle type and resemble the artefacts from the settlement area. The majority of the fishbones were found at places with maximum concentration of Ertebølle artefacts.

Some of the fishbones derive from marine fish species (see below) which could not have lived in

	Pike	Cyprinids	Perch	Ruffe	Trout/ Salmon	Eel	Gadids	Plaice/ Flounder/Dab
Head bones								
Parasphenoideum	4	1					1	
Frontale	1							
Basioccipitale	6	2	1					
Praemaxillare							1	
Maxillare	1	1						
Dentale	25	2						
Articulare	1		3					
Quadratum	2							
Palatinum	2							
Ectopterygoideum	1							
Praeoperculare		2	1					
Operculare		6	3					
Hyomandibulare	1							
Keratohyale	4	7	3					
Epihyale	1							
Os pharyngeum inferius		50						
Keratobranchiale	1							
Detached teeth	15	10						
stumps with teeth sockets	11							
Shoulder girdle								
Supracleithrum	2		7					
Cleithrum	7	1	5					
Scapula		3						
Pelvic girdle								
Basipterygium		2						
Vertebrae	168	446	88	2	2	8	13	11
Others								
Os suspensorium		3						
Scales	1	95	2					
unspecified bones			3					
Total	253 + 1 scale	536 +95 scales	114 + 2 scales	2	2	8	15	11

Table 2 Specification of 941 identified fishbones from Ringkloster. Numbers of different bones of each kind of fish are given. Detached teeth of Pike derive from oral bones, those of cyprinids from *os pharyngeus inferius.* Of the cyprinid bones, 19 *Os pharyngeum inferius* belonged to Roach; 1 *Os pharyngeum inferius*, 1 detached tooth and 1 *basioccipitale* to Rudd; 4 *Os pharyngeum inferius* to White bream; 1 *cleithrum* to Common bream; the remainder could not be identified to species. Of the gadid bones, 11 vertebrae, 1 *praemaxillare*, and 1 *parasphenoideum* belonged to Cod, 1 vertebra to Pollack/Saith; 3 vertebrae could not be identified to species.

the lake. A few fishbones, including one of the "marine" bones, are burnt, their connection with a settlement being therefore beyond doubt.

Finally, the refuse zone contained many long, straight hazel sticks with one pointed end; they most probably are remains of stationary fish traps (see Discussion). If the Ringkloster people set up fish traps, they certainly caught and ate fish.

On the basis of this evidence I regard at least the majority of the fishbones to be human refuse, i.e. remains from meals, deriving from the Ertebølle settlement on the shore. An insignificant contamina-

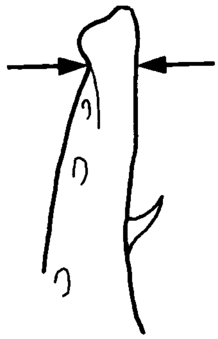

Fig. 3 Dentale of Pike (lateral view), showing the measurement used for estimation of total body length.

tion with bones from fish died from natural causes can of course not be excluded.

Enghoff (1995) gave a brief account of the Ringkloster fishbone material.

SPECIES OF FISH AND THEIR RELATIVE FREQUIENCIES

The fishbones were identified by comparison with recent skeletons from the collection of the Zoological Museum, University of Copenhagen. 28 bones had previouly been identified by U. Møhl as belonging to Pike, Perch and Common bream (in Andersen 1975).

The fishbone material contains the 12 species listed in Table 1 together with the relative frequency of each species. The percentages have been calculated on the basis of 941 identified bones. Detailed specification of the fishbone material is given in Table 2. Fig. 1 shows selected bones of the most frequent species.

The majority of the bones, viz. 57%, derive from the family Cyprinidae which is represented by Roach, White bream, Rudd and Common bream at Ringkloster. The former three species were identified by means of pharyngeal bones (plus basioccipitale for Rudd). Common bream was identified by means of cleithrum. The remaining cyprinid bones are mostly vertebrae, a closer identification of which was not attempted. The vertebrae are, however, assumed to derive from the same four species. The White bream is of particular interest, as it is new for the Danish subfossil fauna. In our days, the White bream is known from all of Denmark (including Lake Skanderborg) but is less frequent than its close relative the Common bream.

The second most frequent species is Pike, 27% of the bones. It is followed by Perch, 12%. Each of the remaining species on the list is only represented by a few bones. It is, however, noticeable that the material includes two bones of Ruffe, a species that is otherwise known as a subfossil in Denmark from the Eem interglacial only.

The relative frequencies of bones of different species cannot be taken as an exact measure of the relative importance of the species, see Enghoff (1987) and references therein. Also the fact that sieving has not been consistently used during the excavation has contributed to an uneven representation of the species. It is worth noticing that 3/4 of the fishbones were recovered from four out of 198 samples. These four samples, which were all taken in the former shore zone and which were all sieved, each contained many species. Apart from these samples, the fishbone material chiefly consists of scattered finds of one or a few bones, in particular from Pike. Out of the 198 samples, no less than 172 contain Pike bones - an indicator of the general availability of this species. 30 samples contain cyprinid bones, and 16 contain Perch bones.

The most interesting aspect of the species list from this inland site undisputedly is the element of marine species. Bones of Cod, Saith/Pollack and Plaice/Flounder/Dab have been found (Fig. 2). All in all, the marine bones constitute no less than 3% of the total number of identified fishbones. 96% of the bones are from freshwater fishes, and 1% from migratory ones. All species are common in Denmark today.

The marine fish in the Ringkloster material

All but one of the 26 bones from the marine fish species, Cod, Saith/Pollack and Plaice/Flounder/Dab, derive from the above mentioned fishbone-rich samples from the shore zone. The marine bones are scattered over a horizontal distance of ca. 35 m, indicating that they may represent several independent fishing episodes.

By comparison with recent specimens, the Cod bones can be seen to derive from individuals of just

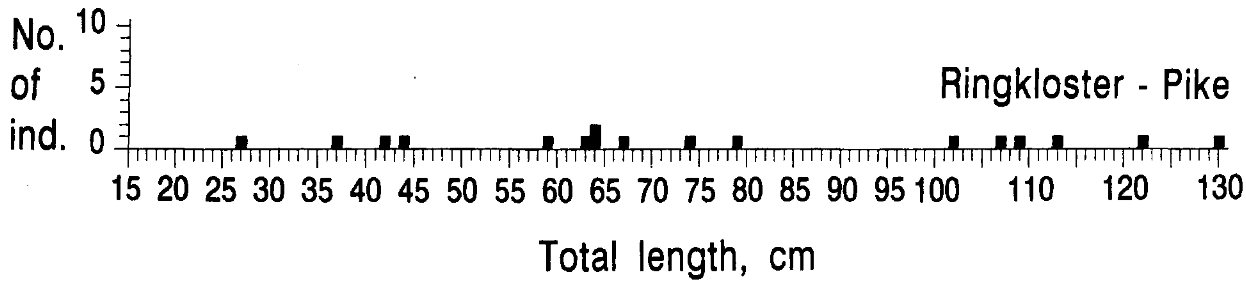

Fig. 4 Size-frequency diagram of Pike from Ringkloster. Length estimated on the basis of measurements of dentale.

below 20 to 35 cm total length. This is exactly the most common size of Cod at coastal Danish Ertebølle settlements (Enghoff 1994). Bones from both head and body are present. If information on size of the Cod and on the distribution of the bones is combined, at least five specimens of Cod are indicated.

A single vertebra represents Saith/Pollack, a specimen of ca. 25 cm total length. Unfortunately the vertebrae cannot be identified to species.

All 11 bones from Plaice/Flounder/Dab are vertebrae and derive from a single square. However, the sizes of the vertebrae indicate that at least two specimens are represented, one of ca. 30 cm total length, one much smaller.

One of the marine fishbones, a praemaxillare from Cod, is black-burnt (Fig. 2) - a clear proof that at least this particular marine bone has definitely formed an integral part of the settlement's activities. Any contention that the marine bones are just regurgitated pellets from gulls coming in from the coast, is hereby falsified.

Size of the pike

Bones of Pike are a characteristic and constant element in the Ringkloster material. Therefore an attempt was made to estimate the size of the subfossil Pikes.

The total length was estimated from subfossil dentale (lower jaw bones) using the equation

$$TL = 119.3059\ D^{0.9048}$$
$$(n = 30, r = 0.9947)$$

where TL = total length in mm, D = measurement of dentale in mm (see Fig. 3), n = number of recent individuals on which the formula is based, and r = the coefficient of correlation.

The total lengths of the subfossil Pikes thus estimated were scattered from 27 to 130 cm (17 measurements), see Fig. 4.

Furthermore, the total length of the Pikes was roughly estimated by comparing the subfossil vertebrae with vertebrae from Recent Pikes with a known length. Vertebrae were much more numerous in the material than was dentale but are not suited for accurate size estimation because of difficulties with referring subfossil vertebrae to their exact position in the vertebral column. Two thirds of the vertebrae were found to derive from Pikes of 50-96 cm total length, and one third from larger individuals.

The Ringkloster material thus contains quite a number of bones from very big Pikes, up to 130 cm. The largest Pike ever taken in Denmark was 150 cm long.

DISCUSSION

In the preliminary publication on Ringkloster (Andersen 1975) fishing was considered to have been of minor importance for the economy of the settlement - only 28 fish bones had been found then. This point of view needs revision in the light of the new fishbone material: 941 identified fishbones although sieving was only sporadically done during the excavation.

As mentioned in the introduction, the Ringkloster settlement was well situated for fishing, just like the coastal Ertebølle settlements that in general are concentrated at good fishing sites (Fischer 1986; 1987; 1995; Fischer & Sørensen 1983; Johansson 1964;

1995). The widespread occurrence of straight, pointed hazel sticks in the former lake suggests that stationary fish traps/weirs were used, like those known from several inland and coastal sites (Becker 1943; Kapel 1969; Pedersen 1992; 1995; Fischer pers. comm.). This is a sign of fishing during an extended period at Ringkloster.

These three lines of evidence: a larger fishbone material, position of the settlement at a good fishing site, and the occurrence of pointed hazelwood stakes, all indicate that the inhabitants at Ringkloster considered fishing as a significant contribution to their economy.

Cyprinids, Pike, and Perch - the commonest fishes in fresh water in Denmark, not surprisingly, dominate the fishbone material. The species in question are not very particular about the type of lake they live in and thus give no hints about Lake Skanderborg during the Ertebølle period. A guess is that the lake has been soft-bottomed and has had a rich underwater vegetation, since this is the type of lake preferred by the fishes. Some of the Pikes have been gigantic (up to 130 cm long). The bottom of the lake off the settlement slopes steeply down to depths where the large Pikes could have lived. Unfortunately the species of fish provide no direct information on possible seasonality of the fishing. However, knowledge of the habits of the fishes (see Otterstrøm 1912; 1914; Muus & Dahlstrøm 1967) may provide an indication of the most probable season of catch.

The Pike occurs in the vegetation zone during the summer but stays on deeper water in winter. Pike is most easily caught during the spawning season from March to May where they swim into very shallow water (to 20 cm). Noe-Nygaard (1988) showed that Pike fishing at the Danish Mesolithic site Præstelyngen was most intense during exactly these months.

Cyprinids spawn during spring (April-June) on shallow water and in general occur in the vegetation zone during summer (as far as Bream is concerned, this is true only for individuals in their first two years). During winter the cyprinids stay on deeper water. Several cyprinid species are inactive during winter.

Perch occur in schools, either in the vegetation zone or on deeper water. During spawning, Perch are easily caught in fish traps.

Rowley-Conwy (1998 - this volume) argued that the evidence from mammal and bird bones from Ringkloster indicates a winter/spring occupation from about November to about May. As is evident from the discussion above, the fishing might well fit into this picture. The fish have been especially easily caught in the spring months.

One of the most interesting aspects of the Ringkloster fishbone material is the element of marine fishes: Cod, Saith/Pollack, and Plaice/Flounder/Dab, which constitute 3% of the identified fishbones. The fishbones are not the only marine indicators from Ringkloster but are accompanied by about five shells of oyster (*Ostrea edulis*) and a rib and two vertebrae of Bottle-nosed Dolphin (*Tursiops truncatus*) (Rowley-Conwy 1998 - this volume). Today, the Bottle-nosed Dolphin has a southern distribution: although it reaches as far as Scotland, it is rare north of the English Channel (Evans 1991). Its occurrence in the Ringkloster material therefore indicates a warmer climate during the Atlantic period, like for instance the southern fish species from Bjørnsholm (Enghoff 1993).

The above-mentioned marine indicators are a proof for a contact to the seacoast. The Ringkloster settlement is situated equally far away from the contemporaneously coastal settlements at Brabrand, Norsminde and Horsens Fjord on the East Coast of Jutland. Enghoff (1991) analysed the fishbone material from Norsminde and the most frequent fishes were Flounder and gadids, exactly the ones which are represented at Ringkloster. However, these are very common fishes which have probably also been caught at Brabrand and Horsens Fjord. It is, however, noteworthy that the Norsminde material is totally devoid of bones from freshwater fishes. Whatever the nature of the contact between inland and coast has been, there is no evidence for transport of freshwater fish from the inland to Norsminde. The small whale, Bottle-nosed Dolphin, is also represented on the contemporaneous settlements from Flynderhage (Norsminde Fjord) and Brabrand (C. Kinze, pers. comm.).

A parallel to the marine fish element in the Ringkloster material is the occurrence of spines of the shark species Spurdog (*Squalus acanthias*) on inland settlements in Åmosen, Zealand (Noe-Nygaard 1971; P. Vang Petersen, pers. comm.).

The marine fishbones from Ringkloster do not throw full light over the contact between coast and inland, but the marine fishes seem to have arrived at Ringkloster at several occasions. This is in agreement with Rowley-Conwy's (1998 - this volume) idea that Ringkloster was a seasonal hunting camp visited repeatedly by the inhabitants from one or several basecamp(s) situated by the seacoast.

CONCLUSION

The fishing at Ringkloster seems to have been more important than previously assumed. Cyprinids, Pike and Perch, possibly taken in fish traps during spring, dominated the catch.

A significant element of marine fishes in the bone material substantiated the indication of a contact to the coast.

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REFERENCES

Andersen, S.H. 1975: Ringkloster, en jysk indlandsboplads med Ertebøllekultur. *KUML* 1973-1974: 11-108.

- 1998: Ringkloster. An inland Ertebølle settlement in Jutland. *Journal of Danish Archaeology*, 12, 1994-95: 13-60.

Becker, C.J. 1943: Et 6000-årigt Fiskeredskab. *Fra det gamle Gilleleje* 1943: 70-87.

Enghoff, I.B. 1987: Freshwater fishing from a sea-coast settlement - the Ertebølle locus classicus revisited. *Journal of Danish Archaeology*, 5, 1986: 62-76.

- 1991: Fishing from the Stone Age settlement Norsminde. *Journal of Danish Archaeology*, 8, 1989: 41-50.
- 1993: Mesolithic eel-fishing at Bjørnsholm, Denmark, spiced with exotic species. *Journal of Danish Archaeology*, 10, 1991: 105-118.
- 1994: Fishing in Denmark during the Ertebølle period. *International Journal of Osteoarchaeology*, 4: 65-96.
- 1995: Fishing in Denmark during the Mesolithic period. In Fischer, A. (ed.): *Man and sea in the Mesolithic - coastal settlement above and below present sea level.* Oxford, Oxbow Monographs 53: 67-74.

Evans, P.G.H. 1991: Whales, dolphins and porpoises: Order Cetacea. Pp. 299-350 in Corbet, B.G. & Harris, S. (eds.): The handbook of British mammals. Oxford.

Fischer, A. 1986: Stenalderbopladsen på Argusgrunden - en 7.000-årig bebyggelse på bunden af Smålandsfarvandet. *Fortidsminder, antikvariske studier* 8. Copenhagen: Fredningsstyrelsen.

- 1987: Stenalderbopladser på bunden af Smålandsfarvandet. Copenhagen: Skov- og Naturstyrelsen.
- 1995: An entrance to the Mesolithic world below the Ocean. Status of ten years' work on the Danish sea floor. In Fischer, A. (ed.): *Man and sea in the Mesolithic - coastal settlement above and below present sea level.* Oxford, Oxbow Monographs 53: 371-384.

Fischer, A. & Sørensen, S.A. 1983 Stenalder på den danske havbund. In: *Antikvariske studier* 6. Copenhagen: Fredningsstyrelsen.

Johansson, A. 1964: Sydsjællands oldtidsbebyggelse. En foreløbig meddelelse. *Historisk samfund for Præstø Amt, Årbog 1964.* Næstved.

- 1995: The Ertebølle culture in south Zealand, Denmark. In Fischer, A. (ed.): *Man and sea in the Mesolithic - coastal settlement above and below present sea level.* Oxford, Oxbow Monographs 53: 87-94.

Kapel, H. 1969: En boplads fra tidlig-atlantisk tid ved Villingebæk. *Nationalmuseets Arbejdsmark* 1969: 85-94.

Muus, B.J. & Dahlstrøm, P. 1967: *Europas ferskvandsfisk.* G.E.C. Gad, København.

Noe-Nygaard, N. 1971: Spur dog spines from prehistoric and early historic Denmark. An unexpected raw marterial for precision tools. *Bulletin of the geological Society of Denmark* 21: 18-33.

- 1988: Taphonomy in Archaeology with special emphasis on Man as a biasing factor. *Journal of Danish Archaeology*, 6: 7-62.

Otterstrøm, C. 1912: Fisk I. Pigfinnefisk. *Danmarks Fauna*, 11: 1-198.

- 1914: Fisk II. Blødfinnefisk. *Danmarks Fauna*, 15: 1-351.

Pedersen, L. 1992: Ålegård. *Skalk*, 1992 (6): 3-7.

- 1995: 7000 years of fishing: stationary fishing structures in the Mesolithic and afterwards. In Fischer, A.

(ed.): *Man and sea in the Mesolithic - coastal settlement above and below present sea level.* Oxford, Oxbow Monographs 53: 75-86.

Rasmussen, P. 1998: Mid-holocene Vegetation Development at the Inland Ertebølle Settlement of Ringkloster, Eastern Jutland. *Journal of Danish Archaeology*, 12, 1994-95: 65-85.

Rowley-Conwy, P. 1998:Meat, Furs and Skins: Mesolithic Animal Bones from Ringkloster, a Seasonal Hunting Camp in Jutland. *Journal of Danish Archaeology*, 12, 1994-95: 87-98.

Stuiver, M. & Pearson, G.W. 1993: High-precision bidecadal calibration of the radiocarbon time scale, A.D. 1950 - 500 B.C. and 2500-6000 B.C. *Radiocarbon*, 35(1): 1-25.

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Pollen analytical investigations of barrows from the Funnel Beaker and Single Grave Cultures in the Vroue area, West Jutland, Denmark

by Svend Th. Andersen

INTRODUCTION

Archaeological investigations in the Vroue area in West Jutland (see Fig. 1) have been performed since the beginning of this century. Single Grave barrows on Resen Heath were excavated 1901-1902 by H. C. Blinkenberg and H. Kjær for the National Museum. These investigations were later published by Jørgensen (1977a). The famous passage grave at Hagebrogård was excavated 1910 and was re-investigated by E. Jørgensen in 1969 (Jørgensen 1977a). Early Neolithic long-barrows, passage graves, stone-heap graves and Single Grave barrows in the Sjørup Plantation and on Vroue Heath were excavated by E. Jørgensen 1970-1985 (Jørgensen 1973; 1977a; 1977b; 1981, 1985). A number of well-dated barrows extending in age from the Early Neolithic to the Single Grave Culture and concentrated to a small area in the Sjørup Plantation and on Vroue and Resen Heaths thus are thoroughly known (Fig. 3). One grave mound from the Bronze Age occurs in that area (Jørgensen 1977a).

In recent years experience with pollen analysis of soil horizons buried below barrows and enclosed in fill material from Early Neolithic mounds, Middle Neolithic passage graves and Bronze Age mounds in East and North Denmark has been gained (Andersen 1988; 1990; 1992; in print a; in print b). Based on these investigations, information about small-scale vegetation composition and prehistoric land-use at the burial mounds prior to and at the time of their erection was gained. S. Jørgensen (1965) and Odgaard and Rostholm (1989) investigated soils beneath a few Single Grave Culture barrows in West Jutland. Information about vegetation and land-use around barrows from the Funnel Beaker Culture and a wider range of Single Grave Culture barrows in West Jutland is still missing.

The general vegetational development and human impact on the vegetation in North West Jutland is well known from the investigations of Odgaard (1994). It was therefore a promising task to study the well-dated barrows in the Vroue area by pollen analysis. It was expected to obtain pollen diagrams to indicate small-scale changes in vegetation prior to the erection of the mounds and vegetation and land-use at the time of the barrows. These results might also elucidate the transition from the Funnel Beaker Culture to the Single Grave Culture.

1994, sections were opened in four Early Neolithic long barrows, three passage graves and a round barrow from the Early Middle Neolithic, five barrows with undergraves and three barrows with ground graves of the Single Grave Culture in the Vroue area. Pollen diagrams were worked out for these sites. No soils occur underneath the stone-packing graves from the Middle Neolithic and there were no primary barrows with overgraves.

Soils in Neolithic barrows in Denmark were first investigated by Müller (1884) and Sarauw (1898). Later, pollen analysis was applied by Jørgensen (1965), Andersen (1988; 1992) and Odgaard and Rostholm (1989). Neolithic soils in North Germany were studied with pollen analysis by Groenman-van Waateringe (1979) and Averdieck (1980). In the Netherlands, soils underneath Neolithic barrows were first studied with pollen analysis by Waterbolk (1954; 1958),

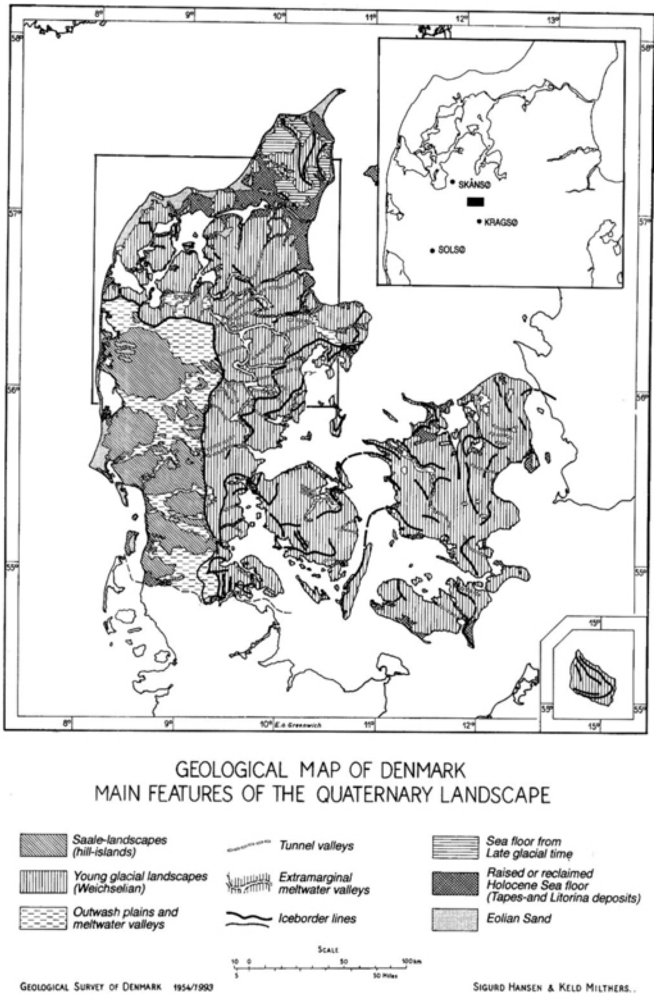

Fig. 1 The main surface deposits of Denmark. The insert map shows the investigation area at Vroue (black square) and three lake sites investigated by Odgaard (1994).

later by van Zeist (1955) and Casparie and Groenman-van Waateringe (1980). Pollen diagrams from Early and Middle Neolithic barrows from Wiltshire, South England, were presented by Dimbleby and Evans (1974; see also Smith 1984), and from West Ireland by Molloy (1985). A comprehensive discussion about pollen investigations of archaeological soils was given by Dimbleby (1985).

GEOLOGY OF THE VROUE AREA

The investigation area at Vroue comprises tills north of the "main stationary line" of Ussing (1903) from the Weichselian glaciation and meltwater terraces along the Karup Valley. The stationary line of Ussing extends west-east from the North Sea to Dollerup, where it turns southward (Fig. 1). The Sjørup Moraine north of the stationary line is a plateau with undulating dead-ice topography. It consists of sandy till and rises to about 55 m altitude in the Sjørup Plantation. To the south it is delimited by a steep slope.

The Karup heath plain consists of meltwater sand transported from outflows at the main stationary line towards west (Fig. 1). The northern part ("Alhede") is situated at 45-75 m altitude (Ussing 1903, Fig. 2). The original Karup valley was eroded at a time, when an outflow to the north was opened up due to melting of ice north of the plain (Ussing 1903, Fig. 2). A plain of meltwater sand was deposited in the Karup valley reaching altitudes of 30-45 m. The remnants of this heath plain to-day form an upper terrace in the Karup valley (Ussing 1903; Milthers 1935, Fig. 2). Vroue Heath and Resen Heath south of the Sjørup Moraine in the present investigation area are situated on this upper terrace (Fig. 3). The base level of the meltwater stream in the Karup valley was later lowered due to the opening of a new outflow to Skive Fjord (Ussing 1903; Milthers 1935). A lower terrace at 15-30 m altitude was formed in the valley and a side-valley running eastward along the Sjørup Moraine was eroded in the upper terrace (Ussing 1903; Milthers 1935, Fig. 2). This valley separates Vroue Heath to the north, and Resen Heath south of the valley, and contains the brook Sejbæk (Fig. 3). The present Karup valley was eroded in the lower terrace. Neolithic grave mounds are found on the Sjørup Moraine and on Vroue and Resen Heaths on the upper Karup valley terrace. The passage grave at Hagebrogård occurs on the lower terrace.

SECTIONS IN THE BARROWS

The barrows were selected and identified in the field by E. Jørgensen. Profiles were exposed in trenches dug in the mounds April and October 1994. Fill layers, soil layers and subsoil were described and measured in vertical sections, and samples for pollen analysis were extracted. The soil layers seen beneath the mounds were referred to the Central European system (Scheffer *et al.* 1976) on a basis of colours ob-

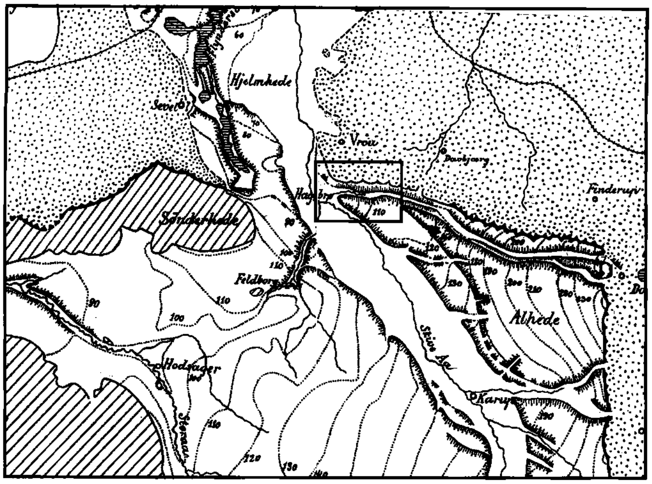

Fig. 2 Detail of N.V. Ussing's geomorpholocical map of West Jutland (Ussing 1903) showing the Weichselian glacial landscape (dotted), heath plains and meltwater terraces along the Karup valley (areas with height curves, in feet), and the Karup River (Skive Aa) valley (white). The investigation area south of Vroue is indicated by a rectangle.

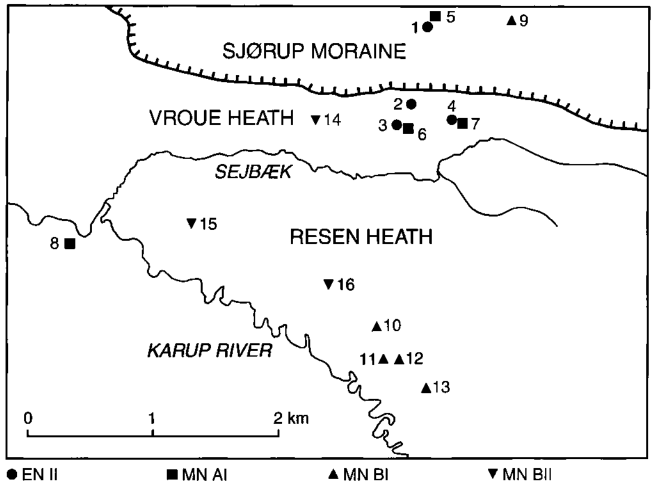

Fig. 3 The investigated Neolithic barrows on the Sjørup Moraine, and on Vroue and Resen Heaths. Early Neolithic barrows (EN II): 1, Sjørup 1a; 2, Vroue Heath 8; 3, Vroue Heath 4a; 4, Vroue Heath 1b. Early Middle Neolithic barrows (MN AI): 5, Sjørup 1b; 6, Vroue Heath 4b; 7, Vroue Heath 1a; 8, Hagebrogård. Single Grave Culture barrows with undergraves (MN BI): 9, Sjørup 2; 10, Koldkur 10; 11, Mølgård 7; 12, Mølgård 1; 13, Mølgård 13; Single Grave Culture barrows with ground graves (MN BII): 14, Vroue Heath 7; 15, Koldkur 1; 16, Koldkur 7; The passage grave at Hagebrogård (8) is situated on the lower terrace of the Karup valley.

served in the field (see the descriptions below). The *Ah horizon* here denotes a top layer of brown or black colour (humic horizon). It contains decomposed plant litter transported from the surface by the soil fauna. The *Ae horizon* is white or grey and is depleted of humus, iron and aluminium by leaching (eluvial layer). The *Bv horizon* is brownish-red due to accumulation of humic matter and iron transported from above (illuvial horizon, *verbraunt* in German). The *C horizon* is untransformed parent material of yellow or grey colour.

Podzols are characterized by the presence of an eluvial layer (Ah-Ae-Bv-C profile). The Ae horizon is absent in brown earth (in Danish *muld*). Brown earth may be neutral or somewhat acid (oligotrophic brown earth, *fattigmuld* in Danish). A highly organic layer formed by decomposed litter may accumulate on top of soils, where downmixing of organic litter has ceased due to disappearance of burrowing animals (Ao horizon, *mor* in Danish). No Ao horizons were observed in the present sections. Podzols are characteristic of heathlands and acid grassland, and of woodlands with an acid humus layer, (oligotrophic beech or oak forests). Brown earth occurs in many vegetation types on more or less fertile soil.

Sections from the barrows examined are described below. The figures in brackets refer to the map in Fig. 3. Depth and colour of the soil horizons are summarized in Table 1. The datings of the barrows were provided by E. Jørgensen.

Late Early Neolithic barrows (EN II, 3300-3500 BC)

Sjørup Plantation 1a (1) (Vroue parish sb. 121, Jørgensen 1977b). A long-barrow with an earth grave. A trench was opened east of the grave. Fill, 100 cm deep, consisted of grey-brown or light-grey finesand with some pebbles. A soil was developed in finesand beneath the fill (Ah, Ae, Bv horizons) and above subsoil of red-yellow finesand with some pebbles (C horizon). The topmost soil layer (Ah) was somewhat diffused. A diffused soil horizon (Ae) over yellow sand

	horizon Ah		horizon Ae		horizon Bv		horizon C
	cm	colour	cm	colour	cm	colour	colour
EN II barrows							
Sjørup 1a	9	grey-brown	4	light grey	4	red-brown	red-yellow
Vroue 8			7	white-grey			
Vroue 4a	6	brown-grey			28	red-brown	yellow
Vroue 1b	10	grey-brown			29	red-brown	yellow
MN AI barrows							
Sjørup 1b	7	brown			17	brown-yellow	yellow
Vroue 4b	10	brown-grey			15	red-brown	yellow
Vroue 1a	6	red-brown			15	brown-yellow	yellow
Hagebrogård	7	black-brown			21	red-brown	grey-yellow
MN BI barrows							
Sjørup 2	16	black-grey					yellow
Koldkur 10	6	brown-grey					red-yellow
Mølgård 7	16	brown			36	red-brown	grey
Mølgård 1	1	dark brown			24	red-brown	yellow
Mølgård 13	6	black-grey			12	brown	yellow
MN BII barrows							
Vroue 7	7	grey-black			30	red-brown	yellow
Koldkur 1	3	yellow-brown			12	brown-yellow	yellow
Koldkur 7	1	brown-black			44	red-brown	grey-yellow
	3	grey-brown					

Table 1 Thickness and colour of horizons within the soils found beneath the barrows of the investigation area.

(C) was seen in a trench at the western end of the barrow.

Vroue Heath 8 (2) (Vroue parish sb. 123, Jørgensen 1977b). A long-barrow with 3 earth graves. A trench was opened west of the centre of the barrow, east of the southernmost grave. Fill, 95 cm deep, consisted of blackish-grey sand (topmost) and yellow sand with irregular spots of grey-brown sand and a few smears of turf-like structure. A soil was developed in sand beneath the fill (Ae horizon) and above subsoil of yellow slightly clayey and stony sand (C horizon).

Vroue Heath 4a (3) (Vroue parish sb. 19, Jørgensen 1977a). A long-barrow with a dolmen chamber. A trench was opened at the eastern end of the barrow. Fill, 169 cm deep, consisted of grey-brown sand with some brownish spots and brown-yellow sand. A soil was developed in sand with pebbles beneath the fill (Ah and Bv horizons) and above subsoil of yellow sand with pebbles (C horizon).

Vroue Heath 1b (4) (Vroue parish sb. 89, Jørgensen 1977a). A long-barrow with a dolmen chamber. A trench was opened in the northern part of the barrow, east of the grave. Fill, 131 cm deep, consisted of grey-black sand (topmost) and brown-yellow sand with a few pebbles and diffused spots of grey-brown sand. A soil was developed in sand beneath the fill (Ah and Bv horizons) and above subsoil of yellow sand (C horizon). The topmost soil layer (Ah) was somewhat diffused.

Early Middle Neolithic barrows (MN AI, 3100-3300 BC)

Sjørup Plantation 1 b (5) (Vroue parish sb. 127, unpublished). A round-barrow with an earth grave, covered by a Late Neolithic barrow. Fill from the Late Neolithic barrow was 98 cm deep. Fill from the primary barrow, 9 cm deep, consisted of black-brown sand. A stone pavement occurred beneath the fill. A soil was developed in sand beneath the stone pavement (Ah and Bv horizons) and above subsoil of yellow sand (C horizon).

Vroue Heath 4 b (6) (Vroue parish sb. 20, Jørgensen unpublished). A round-barrow with a passage grave. A trench was opened behind an upright north of the entrance to the passage. Fill, beneath disturbed soil and 42 cm deep, consisted of grey-brown and brown-grey sand with some pebbles. A soil was developed in sand with pebbles beneath the fill (Ah and Bv horizons) and above subsoil of grey-yellow sand with pebbles (C horizon).

Vroue Heath 1 a (7) (Vroue parish sb. 88, Jørgensen 1977a). A round-barrow with a passage grave. A trench was opened east of the chamber. Fill, 125 cm deep, consisted of grey-black sand, black sand (topmost), and brown-yellow sand with grey-brown spots. A soil was developed in sand beneath the fill (Ah and Bv horizons) and above subsoil of yellow sand (C horizon).

Hagebrogård (8) (Hagebro parish sb. 42, Jørgensen 1977a). A round-barrow with a passage grave. A trench was opened 2 m south of the passage. Fill, beneath disturbed soil and 40 cm deep, consisted of brown-yellow and yellow-brown sand with pebbles and contained brown-yellow spots. A soil was developed in sand with a few pebbles beneath the fill (Ah and Bv horizons) and above subsoil of grey-yellow sand. The upper surface of the soil was somewhat disturbed by burrowing animals. The uppermost part of the Bv horizon contained a layer of pebbles, at 7-11 cm below the surface of the soil. This layer probably indicates a lower boundary for former intensive earthworm activity (cp. Fobian 1995).

Single Grave Culture barrows with undergraves (MN BI 2600-2800 BC)

Sjørup Plantation 2 (9) (Vroue parish sb. 125, Jørgensen 1981). A round-barrow with an undergrave. A trench was opened in the western part of the barrow. Fill, 86 cm deep, consisted of black-grey and yellow finesand with a few pebbles. A soil was developed in finesand with a few pebbles beneath the fill (Ah horizon) and above subsoil of yellow finesand with pebbles (C horizon).

Koldkur 10 (10) (Resen parish sb. 60, Jørgensen 1977a). An over-plowed round-barrow with an undergrave. A trench was opened in the remnants of the barrow. The remnants of the fill contained a diffused layer of grey-brown sand. A soil was developed in sand beneath the fill (Ah horizon) and above subsoil of brown-yellow and red-yellow sand (C horizon).

Mølgård 7 (11) (Resen parish sb. 25, Jørgensen 1977a). A round-barrow with an undergrave covered by an undated barrow. A trench was opened in the barrow. Fill of the younger barrow was 160 cm deep. The fill of the primary barrow, 33 cm deep, consisted of brown-grey and yellow-brown sand and contained an upper surface layer of grey-black sand, 5 cm deep. A soil was developed in sand beneath the fill (Ah and Bv horizons) and above subsoil of grey sand (C horizon) .

Mølgård 1 (12) (Resen parish sb. 22, Jørgensen 1977a). An overplowed round barrow with an undergrave. A trench was opened near the centre of the mound. Fill, beneath a plowed layer and 17 cm deep, consisted of red-yellow sand with dark-brown turf layers. A soil was developed in clayey sand with pebbles beneath the fill (Ah and Bv horizons) and above subsoil of yellow gravelly sand (C horizon).

Mølgård 13 (13) (Resen parish sb. 14, Jørgensen 1977a). A round-barrow with an undergrave covered by an undated barrow. A trench was opened in the barrow. Fill of the younger barrow was 148 cm deep. The fill of the primary barrow, 94 cm deep, consisted of brown sand with spots of black-grey sand and contained an upper surface of grey-black sand, 4 cm deep. A soil was developed in sand beneath the fill (Ah and Bv horizons) and above subsoil of yellow sand (C horizon).

Single Grave Culture barrows with ground graves (MN BII 2350-2600 BC)

Vroue Heath 7 (14) (Vroue parish sb. 29, Jørgensen 1985). A round-barrow with a ground grave. A trench was opened in the eastern part of the barrow. Fill, 273 cm deep, consisted of black-grey sand (uppermost) and red-yellow slightly clayey sand with a few pebbles. The fill contained many irregular, inverted turves of grey-black sand beneath red-brown sand. A soil was developed in sand with a few pebbles beneath the fill (Ah and Bv horizons) and above subsoil of yellow sand (C horizon).

Koldkur 1 (15) (Resen parish sb. 44, Jørgensen 1977a). A round-barrow with a ground grave. A trench was opened in the eastern part of the barrow. Fill, beneath disturbed soil and 75 cm deep, consisted of yellow, slightly clayey sand with diffused brown-yellow spots. A soil was developed in slightly clayey sand beneath the fill (Ah and Bv horizons) and above subsoil of yellow, slightly clayey sand (C horizon).

Koldkur 7 (16) (Resen parish sb. 55, Jørgensen 1977a). An overplowed round-barrow with a ground grave. A trench was opened in the central part of the barrow. Fill, beneath a plowed layer and 25 cm deep, consisted of brown-yellow slightly clayey sand with irregular, inverted turves of black-brown sand beneath yellow-brown sand. A soil was developed in slightly clayey sand beneath the fill (Ah and Bv horizons) and above subsoil of grey-yellow sand (C horizon).

Summary of the barrow profiles

Three barrows were built on a substrate of sandy till in the Sjørup Plantation (Sjørup 1a, Sjørup 1b, and Sjørup 2). The other barrows occurred on meltwater sand. The substrate consisted of medium-grained or fine-grained sand. Four barrows (Mølgård 1, Vroue Heath 7, Koldkur 1 and Koldkur 7) were built on sand with a slight clay content.

The fill material consisted of sand with brown or yellow colours. Diffused spots of a darker colour often occurred in the fill. The sand used for building the mounds thus derived from surface layers and from subsoil. Distinctive inverted turves occurred in a few barrows (Mølgård 1, Vroue 7 and Koldkur 7). A soil with blackish and grey horizons had developed within the surface layer of some of the barrows, subsequently covered by a younger barrow.

The soils beneath the barrows were most often differentiated in upper humic horizons (Ah), illuvial horizons (Bv), and unchanged subsoils (C, see Table 1). The humic horizons (Ah) were 1-16 cm deep and were grey-brown-black in colour. The humic content may decrease slightly downwards within the horizon. A light-grey eluvial layer (Ae) occurred at Sjørup 1a, and at Vroue 8. The B-horizons (Bv) were red-brown in colour due to iron or humus, that had precipitated below the A-layer. The B-horizons were 4-44 cm deep. A B-horizon was missing at 3 barrows (AC profile, Vroue 8, Sjørup 2, and Koldkur 10). The subsoils (C horizons) were yellow.

The majority of the soils can be characterized as oligotrophic brown earth (ABC profiles, Andersen 1979). Podzols with strongly leached layers occurred only under the Sjørup 2 and Vroue 8 barrows, both from the Early Neolithic.

POLLEN ANALYSES FROM THE BARROW SECTIONS

Pollen analysis

Pollen diagrams were worked out for soil sections beneath the barrows, and samples from soils enclosed in fill material from the original barrows were analyzed. Fill material from secondary barrows were not analyzed, because these fills may enclose soils, that were contemporary with the older barrow.

The soil samples were treated with KOH, HF (24 hours) and acetolysis mixture. The residues were mounted in silicone oil. About 100-300 pollen grains and fern spores were counted per sample. Frequencies for total tree pollen were calculated in percentage of all pollen grains and spores, excluding ligulate composites and fern spores of *Dryopteris*-type. Tree genera were calculated in percentage of tree pollen, and non-trees as percentages of the non-tree pollen. These percentages reflect the composition of tree vegetation and ground vegetation separately.

Pollen deposition on the soil surface

The pollen deposited on land surfaces covered by trees or in open areas mainly derives from plants growing at the spot and from sources within 20-30 m distance (Raynor 1974; 1975; Bryant *et al.* 1989). These results are confirmed in pollen analyses of surface samples (Andersen 1970; Janssen 1986; Berglund *et al.* 1986). Pollen from more distant sources (extra-local pollen, *sensu* Janssen 1986) may be present in low amounts. Pollen spectra from soils therefore record mainly local vegetation and small scale vegetational change in contrast to pollen spectra from lakes or bogs. Variations in landscape and land use within small distances may also be detected.

Pollen burial in soils

Pollen and ferns spores deposited on a land surface become transported into the soil and mixed with soil mainly by soil fauna (Dimbleby & Evans 1974; Havinga 1974; Andersen 1979; Keatinge 1983). Experiments have shown that spores can be transported down to 5 cm depth in a short span of time (4 years, Dimbleby 1985).

Pollen grains incorporated in calcareous soils vanish within a few years due to biological breakdown (Havinga 1971; Dimbleby 1985) and are well preserved at pH 5 or less (Dimbleby 1957; Andersen 1984a). Biological breakdown of pollen ceased in soils buried under mound structures due to lack of oxygen (Dimbleby 1985). Pollen assemblages may be originally absent in these soils or may cover different spans of time according to variations in pH at the time of soil formation.

Pollen assemblages are moved to increasing depth during burial. The oldest pollen assemblages therefore tend to occur at the deepest levels (Andersen 1979; Dimbleby 1985). The concentration of pollen (numbers of grains per volume of soil) decreases with depth (Aaby 1983). The maximum depth to which pollen grains are present depends on the longevity of the pollen grains and on the intensity and depth of the biological activity. At rapid deterioration, pollen is present only in the topmost soil, whereas long-living pollen assemblages may occur down to 30 cm depth, varying with local conditions (Andersen 1979; Aaby 1983).

Pollen assemblages, that are incorporated in the soil, may become mixed by bioturbation. Walch *et al.* (1970) showed that artificially buried pollen horizons became diffused very rapidly in a soil with high earthworm activity. Discrete pollen assemblages are better preserved in soils with low biological activity (Andersen 1979). Pollen diagrams from soils may therefore reflect changes in vegetation during a short or a longer interval. The pollen curves are, however, more or less strongly smoothed and are best differentiated in the topmost soil (Andersen 1979; Aaby 1983; Keatinge 1983).

Short pollen sequences occurred in soils underneath Early and Middle Neolithic burial mounds from East and North Denmark (Andersen 1992). Longer and better differentiated pollen diagrams were worked out from a passage-grave mound in East Jutland (Andersen in print a) and from soils under Single Grave barrows in central Jutland (Odgaard and Rostholm 1989).

The soils found underneath the barrows in the Vroue area were brown earth of the oligotrophic type. Pollen grains were mainly present in the Ah horizons, and occasionally in the Bv horizons. The pollen assemblages were mixed vertically, and the pollen curves are smoothed. Features of vegetational changes could still be recognized. Pollen assemblages in soil layers found in the fill layers of the barrows reflect vegetation at the time of mound construction (topsoil) or older vegetation stages in that area around the mound, where the material was fetched (Dimbleby 1985; Andersen 1992).

Pollen deterioration

Degradation of pollen grains and fern spores ultimately leads to their removal from the soil. Incipient degradation can be recognized by the presence of pollen grains and spores with etched exines. The etchings may be localized in scars, often called corrosion, or may affect the whole exine, often termed thinning (see Havinga 1971; Aaby 1983; Andersen 1984b). Corroded pollen grains are scarce in mineral soils with pH 5 or less (Andersen 1984a), whereas thinned grains are frequent (Havinga 1971; Aaby 1983).

The numbers of etched grains differs in various pollen taxa, but pollen composition in samples with few and with many etched grains does not differ or differs only slightly (Aaby 1983; Andersen 1984b). Fern spores are more resistant to degradation than pollen grains (Havinga 1971) and may be overrepresented (Andersen 1984b; 1992; Dimbleby 1985).

Corroded pollen grains were scarce in most samples and more frequent (less than 50 %) in others from the present investigation. Thinned pollen grains were frequent. The frequencies for fern spores (adder's tongue, moonwort, polypody, bracken) and *Sphagnum* moss spores increase distinctively with depth in the pollen diagrams from the Early Neolithic barrows, and so do a few heavy-walled pollen types (sandwort, buttercup). These taxa were excluded from the pollen spectra in the Early Neolithic barrows.

Etching of pollen grains hampers identification. Nearly all etched pollen grains could be identified, however. The pollen grains were most often crumbled, as is usual in soil samples. Identification of these grains was often difficult, but not impossible, in most cases.

Pollen representation in soil samples in relation to area coverage

Vegetation structure is expressed in the denseness of trees, and in the area coverage of tree species and of non-tree vegetational components. Pollen percentages, however, do not always reflect area coverage faithfully due to differences in pollen representation.

Experience from surface pollen samples indicates decreasing tree pollen frequencies in percentage of total pollen at increased openness of the tree vegetation. The tree pollen is 80-90 % in deciduous woodland, 50-70 % in glades, around 50 % in farmland and around 20 % in heath areas (Jonassen 1950; Aaby 1994). The high figure for farmland (50 % tree pollen) reflects a very low output of non-tree pollen in modern Danish fields (Jonassen 1950; Aaby 1994).

The percentage representation for various tree species differs substantially from area percentages due to differences in pollen productivity. Percentage frequencies that reflect area percentages were obtained by calibration with correction factors found for modern surface samples (Andersen 1970). The corrections used were 0,25 for oak, birch, hazel, alder and pine, and 2,0 for lime (Andersen 1970, 1980).

The representation of non-tree components in pollen analyses is imperfectly known. Grasses, ribwort plantain and heather were the most important components of the non-tree vegetation in the present investigation. Grasses and plantain seem to be equally well represented. (Berglund *et al.* 1986), and heather pollen obtains very high frequencies in heaths (Jonassen 1950). The grasses, plantain and heather are, therefore, likely to be equally represented in the non-tree pollen spectra. The pollen productivity of the grasses is likely to be reduced in grazed or mowed vegetation (Berglund *et al.* 1986; Groenman-van Wateringe 1986; 1993).

Anthropogenic influence on the vegetation

Lime, oak and hazel were common in the Danish woodlands on dry ground in Atlantic time (Iversen 1960; Andersen 1984b). Birch was also common in West Jutland (Odgaard & Rostholm 1989). Light-demanding trees such as hazel, birch and alder are favoured by human disturbance (early-successional trees, Berglund 1985) and constituted secondary woods or coppice woods in Neolithic time (Andersen 1992).

Cereals and other cultivated plants and weeds are characteristic of fields; grasses and meadow plants characterize pastures and mowed areas, and heather open areas on poor soil. Some weed species are restricted to cultivated fields, other species are connected with a range of land use practices (Behre 1981). Ribwort plantain occurs in fallow land, meadows and pastures (Behre 1981), and Gaillard *et al.* (1992; 1994) found this plantain to be connected with mowed and grazed areas with high pH, and fallow land, but not with fields. Grazing and mowing reduce the pollen production of grasses (Berglund *et al.* 1986; Groenman-van Waateringe 1986; 1993). Sheep are less selective than cattle in grazing preferences and bite the vegetation to a lower level (Buttenschøn 1995). Plantain is resistant to grazing because its growing point is near the ground and because of its ability to form flat leaf rosettes (Broesbøl-Jensen 1995). Unlike the grasses, ribwort plantain therefore is able to produce new flowering spikes at continued grazing.

Andersen (1992) found low pollen percentages for ribwort plantain in cultivated soils from the Early and Middle Neolithic. High percentages for plantain pollen were found in samples, where cereal and weed pollen grains were scarce. Andersen (1992) concluded that the predominance of plantain pollen was due to intensive grazing. Hay-mowing on such a large scale is unlikely to have occurred in the Neolithic (Gaillard *et al.* 1994). The flint sickles from that time had rather been used for reaping cereals (Jensen 1994). Grassland with high frequencies for pollen of ribwort plantain is, accordingly, interpreted as pasture. Heath areas probably provided valuable winter grazing (Odgaard & Rostholm 1989).

Natural heath was promoted by fire in West Jutland in Atlantic time (Odgaard 1992). Heath expanded later due to artificial fires (Odgaard & Rostholm 1989; Odgaard 1994). Grassland is promoted in heath areas on favourable soils by frequent burning and at high grazing pressure (Miles 1985; Clarke *et al.* 1995; Aerts *et al.* 1995).

Deformed pollen. Evidence of burning

Andersen (1988; 1992) found abundant pollen with thickened exines in Early and Middle Neolithic soil samples. Experiments have shown that this type of deformation occurred in pollen grains, that were heated artificially, and in pollen grains present in topsoil after burning of felled trees (Andersen 1992). Tree pollen, in particular, was frequently deformed in the Neolithic soil samples. This was interpreted as an indication that local trees had been felled and burned, when lying on the ground (Andersen 1992). Pollen from herbaceous plants found in the same samples was rarely deformed. It was surmised that the herbaceous plants had invaded the burnt areas, and that the pollen grains from this vegetation had become mixed with deformed tree pollen at burial in the soil (Andersen 1988, 1992).

Deformed tree pollen is frequent in soil samples from the present investigation. Burning of mixed tree populations is indicated by presence of deformed pollen of the tree species present. Deformed birch pollen was more frequent than deformed pollen from other trees. This feature is interpreted as an indication that groups of birch trees were selected for felling and burning.

Deformations were very scarce in the non-tree pollen taxa, including heather. Odgaard and Rostholm (1989) concluded from their investigation of soils under Single Grave barrows that heath had been promoted and maintained by burning, due to an increase in microscopic charred particles that paralleled that of heather pollen. Such heath fires were probably too superficial to affect the topmost soil and the heather pollen buried there.

POLLEN DIAGRAMS FROM BARROWS

The pollen diagrams

Survey pollen diagrams from the soils beneath the barrows are shown in Figs. 4-7. These diagrams show: (1) soil horizons; (2) depth below the soil surface; (3) tree pollen in percentages of pollen and spores; (4) areal frequencies for tree genera, corrected for unequal pollen representation, in percentages of the sum of corrected tree pollen; (5) frequencies for deformed birch pollen in percentage of birch pollen; (6) frequencies for pollen of grasses, ribwort plantain and heather.

Oak, elm, ash and aspen were very scarce, and are not shown on the pollen diagrams. Guelder rose occurred at a few sites with noticeable frequencies (Fig. 5). Other non-tree pollen types and spores were scarce and are not shown.

Fern spores and a few pollen types were excluded in the pollen spectra from the Early Neolithic barrows (see "Pollen deterioration"). The frequencies of these plants are shown ("Spores", Fig. 4). Heather was scarce, at these barrows, and a curve is not shown.

Deformed pollen grains from trees other than birch were frequent at the Early Neolithic barrows (Fig. 4), and were scarce at the other barrows (these frequencies are not shown).

The pollen frequency curves in the diagrams are more or less strongly smoothed, due to vertical mixing during the burial of the grains.

Late Early Neolithic barrows (EN II, Fig. 4)

Sjørup Plantation 1a (1). The frequency of corrosion-resistant pollen and spores is low (1-8%). The tree pollen curve is very high throughout the soil section (81-93%), with a minimum at 10 cm depth (62%), which indicates a short-lasting clearance. Birch was dominant at first (62%). Lime and hazel increased somewhat just after the clearance phase and were then replaced by birch. High frequencies for de-

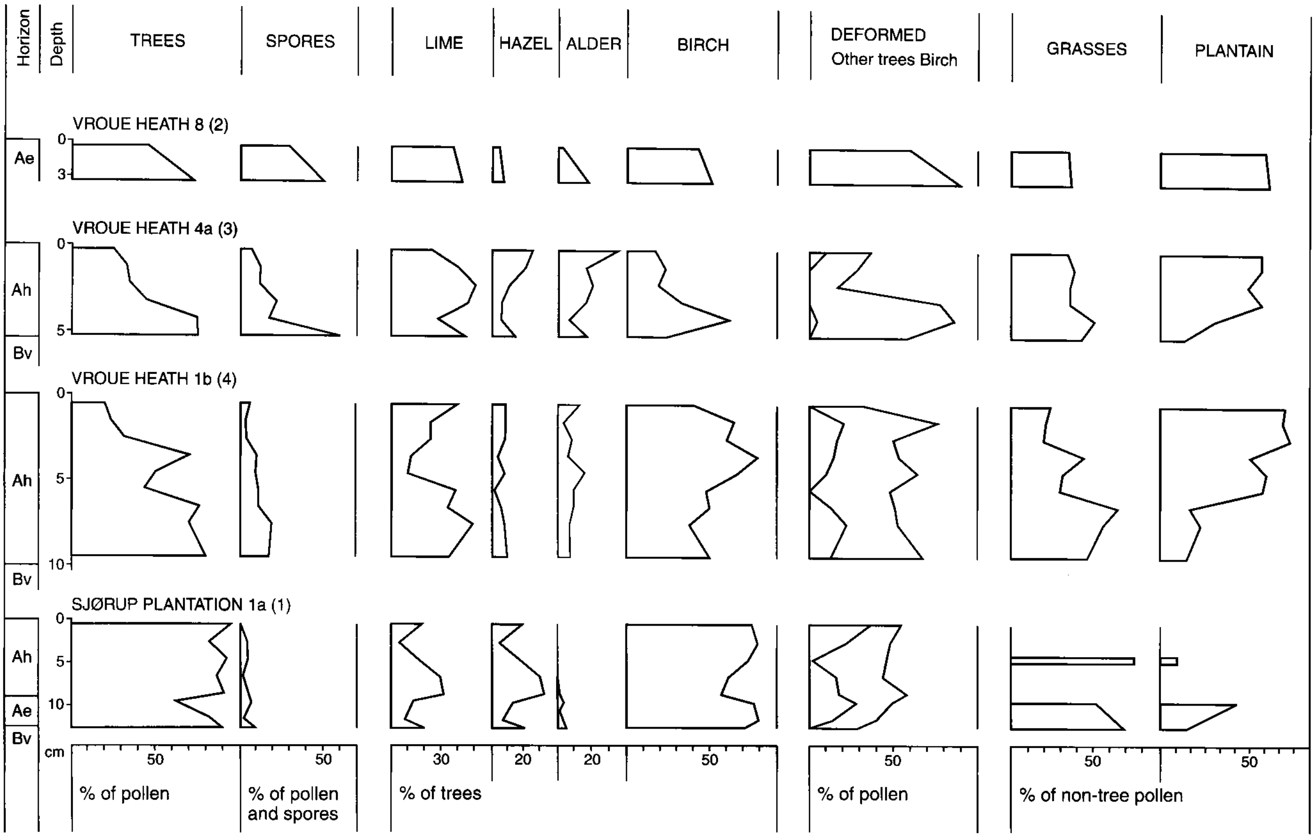

Fig. 4 Pollen diagrams from soils underneath the four late Early Neolithic barrows (EN II). The figures in brackets refer to the map in Fig. 3.

formed pollen indicate that the trees were felled and burned repeatedly. Average frequencies of non-tree plants were calculated for the upper part of the section, due to low pollen numbers. Ribwort plantain pollen is present already in the lowermost sample. A high frequency at 10 cm depth (46%) indicates grazing by husbandry during the clearance phase. Two samples from the fill material had high tree pollen frequencies with dominant birch. These samples correspond to the topmost soil.

Vroue heath 1b (4). Tree pollen is frequent at first (71-81%). A decrease at 5 cm depth (to 44-50%) and an increase at 3 cm (71%) indicate clearance followed by tree regeneration. The trees then decrease in the topmost sample (to 21%) indicating devastation of woodland. Lime was frequent at first (34-47%) and was replaced by birch after the first clearance. Deformed pollen is very high and indicates frequent burning of felled trees. Plantain pollen is present already in the lowermost sample. Plantain increases strongly during the first clearance (from 10 to 63%) and increases again during the second clearance (from 54 to 78%). Hence, strong grazing of the vegetation in the areas cleared for trees is indicated. Two samples from the fill material had low tree pollen (37-56%) and high plantain frequencies (37-56%). They correspond to the topmost soil. One sample from the fill corresponds to the lower part of the Ah horizon.

Vroue Heath 4a (3). The tree pollen decreases from 74 to 23%. Birch was dominant at first (60%) and deformed birch pollen is very frequent. Hence, birch trees were felled and burned and were then replaced by herbaceous vegetation. Plantain increases strongly (from 14 to 60%) indicating grazing of the cleared area. This development is very similar to that seen in the topmost part of the section from Vroue Heath 1b. A sample from the fill corresponds to the lower

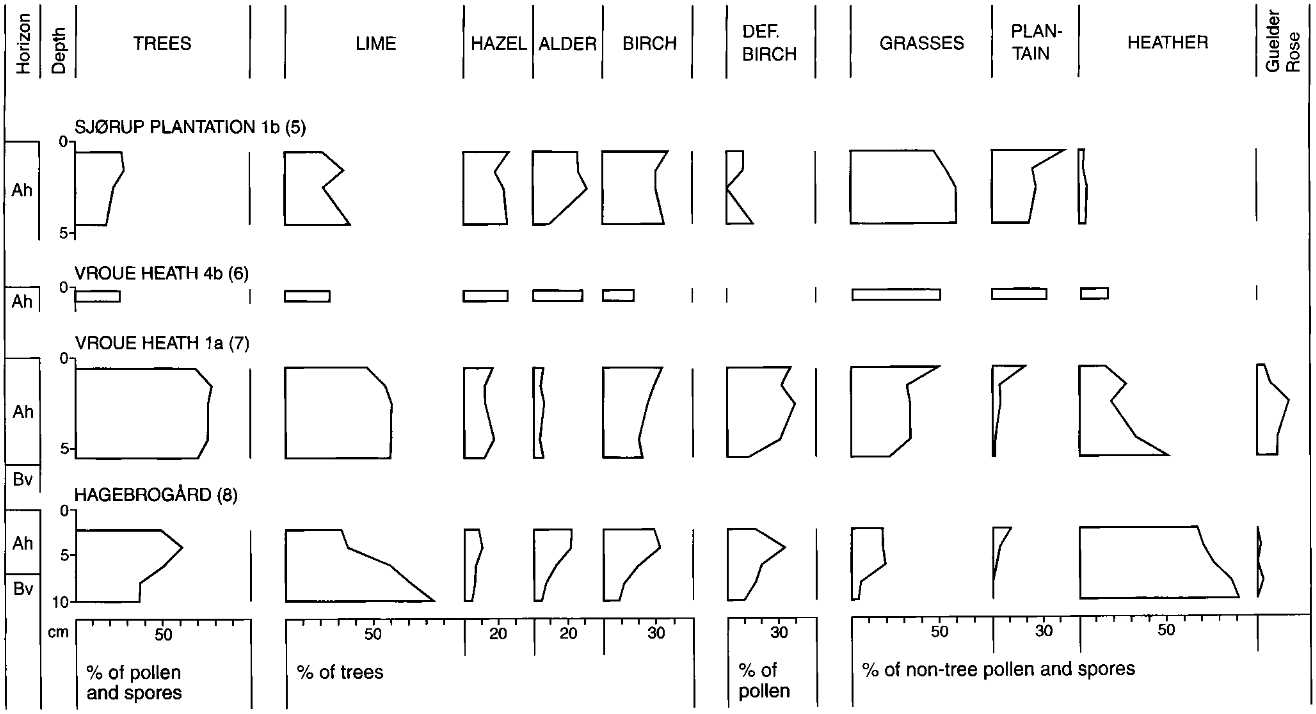

Fig. 5 Pollen diagrams from soils underneath four early Middle Neolithic barrows (MN AI).

part of the Ah horizon, due to high fern spore frequencies.

Vroue Heath 8 (2). Pollen from the soil horizon was badly preserved, and fern spores were very frequent. The two topmost samples indicate decreasing tree pollen (from 71 to 44%), high birch percentage and a high frequency for deformed birch pollen. Birch trees were felled and burned and were replaced by grazed herbaceous vegetation with much plantain (63%), as seen also in the soil sections from Vroue Heath 1b and 4a. Spores were very common in samples from the fill. These samples correspond to the middle part of the soil horizon.

Early Middle Neolithic barrows (MN AI, Fig. 5)

Hagebrogård (8). Tree pollen was 34% at first and then increases to around 60% in the soil horizon. Hence, there was a discontinuous tree cover and open areas of non-tree vegetation. Lime dominated in the tree vegetation at first (85%) and lime woodland undisturbed by humans is indicated. Lime then decreased to 32% at the top of the soil and was replaced by birch and alder. Deformed birch pollen was scarce at first and then increased (to 35%). It appears that the lime trees had been felled in favour of birch and alder. The birch trees were then felled and burned. Heather dominated non-tree vegetation in glades at first (90%) and then decreased (to 66% at the top). Grasses were scarce at first and plantain was absent. The grasses and plantain increased slightly (to 18 and 9% respectively). Grass vegetation was promoted by the felling and burning of birch, and was used for grazing. Guelder rose occurred in the lime woodland. Three samples from the lower part of the fill had low tree pollen and low percentages for plantain (1-3%), and two samples from the upper fill had higher plantain frequencies (11-13%). These samples were derived from the uppermost soil at places around the barrow with increased pasture activity, at increased distance from the barrow site.

Vroue Heath 1a (7). The tree pollen frequencies are rather high (69-78%) indicating fairly dense tree cover. Lime was originally dominant (around 60%), and birch increased near the topmost level. Deformed birch pollen indicates that the birch trees had been felled and burned. Heather was common at

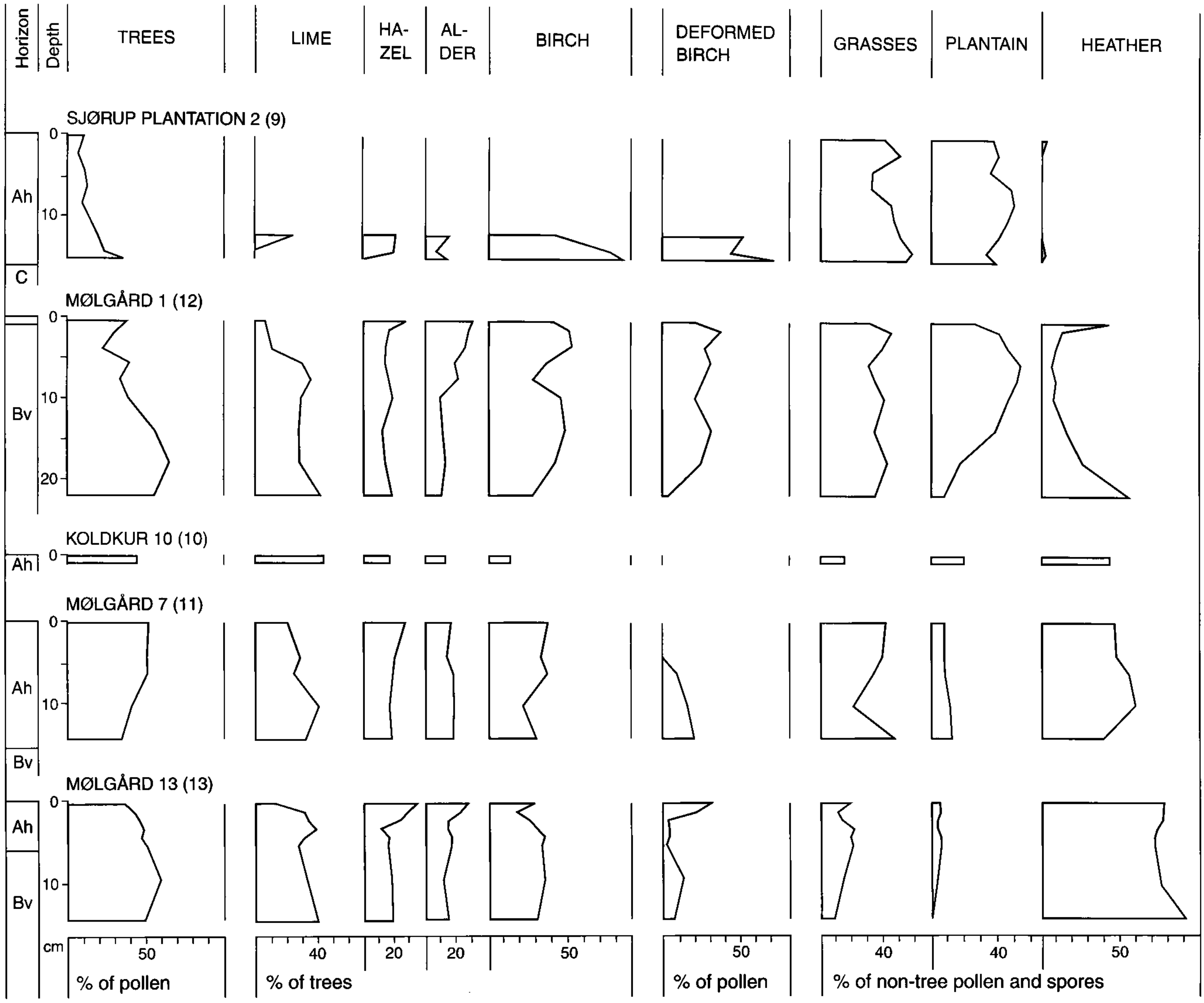

Fig. 6 Pollen diagrams from soils underneath five Single Grave barrows with undergraves (MN BI).

first (51%). The grasses increase (from 22 to 50%). Plantain was scarce (2%) and increases in the topmost samples (to 19%), whereas heather decreases (to 13%). The woodland was at first slightly affected by human activity and there were patches of heath. Birch was favoured and burning of the birch trees promoted expansion of grass vegetation at the cost of heather. The increase in plantain indicates grazing by husbandry. Guelder rose formed a shrub layer within the lime woodland (12-28%). Three samples from the fill material have low tree pollen (25-30%) and high frequencies for hazel and alder (34 and 29 %). The grasses and plantain were frequent (41-52 and 22-46%), and heather is scarce (1-19%). These samples derive from places around the barrow with low cover of mixed tree populations and widespread pasture vegetation, whereas the barrow was built within a wooded area with some pastureland and heath.

Vroue Heath 4b (6). Pollen was absent, except for the topmost soil sample. Tree pollen is scarce (25%). Grasses and plantain are rather high (51 and 21%)

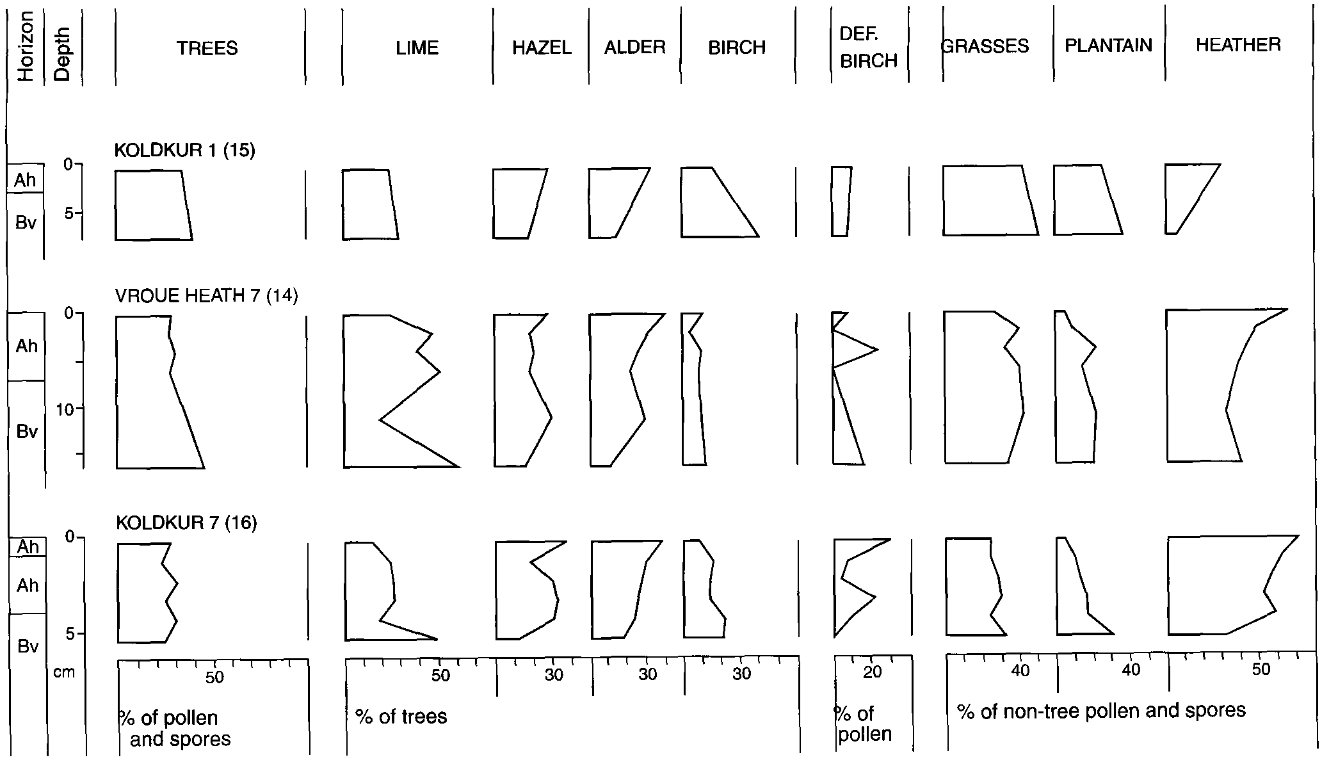

Fig. 7 Pollen diagrams from soils underneath three Single Grave Culture barrows with ground graves (MN B II).

and heather was present (15%). Tree populations were very scarce. Grassy vegetation with pasture was widespread and heath was rather scarce. This non-tree vegetation is very similar to that represented at the topmost level at the Vroue Heath 1a site.

Sjørup Plantation 1b (5). Tree pollen is scarce (17-25%). Lime, hazel, alder and birch are represented. Deformed birch pollen is scarce. Grasses and plantain dominate the non-tree vegetation (60 and 19-23%), and heather is very scarce. Plantain increases somewhat at the top (to 41%). Trees were nearly absent. Grass vegetation with pasture was widespread, and there was no heath.

Single Grave Culture barrows with undergraves (MN BI) (Fig. 6)

Mølgård 13 (13). The tree pollen frequencies vary 35-59%, decreasing somewhat in the upper part of the soil. Hence there were scattered tree populations around the site. Lime, hazel, alder and birch were present. Deformed birch pollen increases near the top indicating burning. Heather dominated the non-tree vegetation (72-89%). The grasses and plantain were scarce at first and increase in the upper part (to 20 and 7%). Hence there are indications that heath was replaced by grassland with grazing in small areas. Pollen spectra from the fill and the surface layer of the primary barrow resemble those from the lower and middle part of the soil under the barrow.

Mølgård 7 (11). The tree pollen is similar to that from Mølgård 13. Deformed birch pollen occurred at the lower part of the section. The grasses and plantain are somewhat more frequent (around 30 and 10%) and heather scarcer (40-60%) than at Mølgård 13. It appears that patches of grassland were used for grazing for some time up to the building of the barrow. Pollen spectra from the fill and the surface layer of the primary barrow resemble those from the lower part of the soil.

Koldkur 10 (10). Pollen spectra from the soil and the fill are similar to the topmost sample from Mølgård 7. Plantain is somewhat more frequent (20 and 15%).

Mølgård 1 (12). Tree pollen decreases from around 60% to around 40%. Clearance of woodland is indicated. Lime is frequent at first (30-40%) and is replaced by birch and alder near the top of the section. Felling of lime is indicated. Birch increases from 28% to around 50%. It appears that birch trees were favoured and were burned repeatedly (deformed pollen 20-30%). Grass pollen is frequent (30-40%). Plantain increases from 8% to around 55% and then decreases to 26% near the top replacing heather, which decreases from 55 to 7% and then increases to 41%. Grassland with increasing grazing pressure replaced heath some time before the building of the mound. Grazing was then abandoned just before the building of the barrow, and heathland returned. This event is marked in the soil section by a thin dark-brown layer. Pollen spectra from thin dark-brown turf layers in the fill material resemble that from the topmost soil layer beneath the barrow.

Sjørup Plantation 2 (9). Tree pollen is scarce at first (37%) and then decreases to very low values (around 10%). It appears that remnants of tree vegetation were cleared away. Birch dominated the tree populations at first (85%). Tree pollen was too scarce for percentage calculations above that level. Deformed birch pollen is very frequent (55-65%). Hence, it is indicated that birch coppices were felled and burned, and then replaced by non-tree vegetation. Grasses and plantain were frequent (30-60 and 30-50%). Hence, grassland was grazed intensively up to the time when the mound was erected. Heath was still absent in this area. The pollen spectra from samples from the fill were similar to the uppermost sample from the soil.

Single Grave Culture barrows with ground graves (MN BII) (Fig. 7)

Koldkur 7 (16). The tree pollen frequencies (23-30%) indicate scattered tree populations. Lime, hazel, alder and birch are represented, and there are indications that birch was felled and burned. Grass pollen is around 23-30%, plantain decreases from 31% at first to 4%, and heather increases from 32% to 70%. Grassland, that was grazed, and patches of heath were present at first. The grazing activity decreased and heath became dominant at the time of construction of the mound. Pollen spectra from inverted turves enclosed in the fill material resemble that from the topmost soil layer. There were, however, higher percentages for plantain (16-17%) and lower heather (41-49%). Hence, continued grazing at sites around the barrow is indicated.

Vroue Heath 7 (14). The tree pollen frequencies decrease from 45% at the lowermost level to 28% at the top of the soil. Scattered tree populations had been reduced. Lime, hazel and alder are represented, and birch was scarce. The birch trees were burned at various times. Grasses (around 40%), plantain (around 20%) and heather (around 40%) were originally present. Plantain decreases (to 5%) and heather increases (to 66%) near the top. It is indicated that grazing of grassland was abandoned and that heath expanded some time before the mound construction, a development, which resembles that observed at the Koldkur 7 site. The tree pollen frequencies found in pollen spectra from inverted turves from the fill are similar to the topmost level of the soil. The percentages of plantain pollen are low (6-7%) in the lowermost turves and higher (15-44%) in turves from the upper part of the fill. The heather percentages decrease, in contrast, from around 60% to 15-51%. It appears that the lowermost turves were collected near the grave site, whereas the turves in the higher part of the fill were fetched at increased distances from the site in areas where grazing was still pursued.

Koldkur 1 (15). The tree pollen percentages at 33-39% indicate scattered tree populations. Lime, hazel, alder and birch are represented, and birch was more frequent than at the other sites (16-40%). Grass and plantain pollen are frequent, and decrease slightly in the top of the soil (from 50 to 42% and from 37 to 26%) contrasting an increase in heather (6-30%). It is indicated that heath was scarce in strongly grazed grassland at first and then expanded just prior to the mound construction. One pollen spectrum from the lower part of the fill material resembled that from the topmost soil. Another sample corresponded to the lower part of the soil (Bv horizon).

CHANGES IN VEGETATION AND LAND-USE INDICATED IN THE SOILS BENEATH THE BARROWS

Early Neolithic II

Birch was common in the woodlands at the Early Neolithic barrows. The pollen diagram from *Vroue Heath 1b* reaches furthest back in time. Lime was originally frequent, mixed with birch, and probably indicates remnants of original woodland. This woodland was cleared and burned and was then replaced by pasture vegetation. Birch coppice wood developed after the pasture phase and was again replaced by pasture after new felling and burning. Hence, there is evidence that the tree vegetation was utilized in swidden rotation, where burnt areas were used for pasture for some time, and the pasture was then renewed after burning of new tree vegetation. Birch propagates easily in abandoned pastures by self-sowing. A similar rotation system was demonstrated in a soil under a Middle Neolithic passage grave in eastern Jutland (Andersen in print a). Shorter sequences were preserved at *Vroue Heath 4a* and *8*. Here, birch coppice was felled and burned and then replaced by pasture vegetation. These phases correspond to the latest development at Vroue Heath 1b.

Birch woodland was dominant at the Sjørup Plantation 1a site. There is evidence of a pasture phase with grasses and plantain followed by regeneration of first lime and hazel, which were then replaced by birch. The woodland was burned intermittently, but new pastures were not established.

The pollen flora was poor in species. Pollen from cereals was not found and weeds from bare soil were very scarce. The ferns adder's tongue and moonwort probably belonged to the pasture vegetation, and polypody and other fern spores (*Dryopteris*-type) were relics from woodland vegetation. Pollen of ligulate composites was frequent. These pollen grains were presumably buried in the soil by burrowing bees (Andersen 1988). Pollen of heather was scarce, below 10 %. Hence, there is no evidence of heath at this time.

Vegetation around the Early Neolithic barrows on Vroue Heath was exploited by burning and grazing at the time of the establishment of the graves. Even the earliest woodland present at Vroue Heath 1b bears evidence of human disturbance. Woodland on sandy till at Sjørup Plantation 1a had been strongly altered by human disturbance and a short pasture phase. Three barrows were built in a late phase of the Early Neolithic (EN II). The dating of the Vroue Heath 8 barrow is somewhat uncertain. The pollen diagram from this site indicates that it was contemporaneous with the other barrows. The evidence from the soils beneath the barrows points to dense human settlement and exploitation already in the Early Neolithic.

Middle Neolithic AI

The pollen diagrams from the *Hagebrogård* and *Vroue Heath 1a* sites indicate at first lime-dominated woodland and patches of heath. The tree populations were altered by felling of lime and spreading of birch. The birch trees were felled and burned, and vegetation of grasses with traces of grazing expanded at the cost of heather. The felling of lime and burning of birch trees thus appear to have been done with the purpose to create areas for pasture. A similar course of events probably took place at the *Vroue Heath 4b* site. Trees were scarce and plantain was frequent.

The passage graves on Vroue Heath were built near Early Neolithic barrows (Vroue 4a and 8, Fig. 3). Nevertheless, these passage graves were built at sites with traces of heath. It appears that the sites with heath vegetation were avoided at the Early Neolithic occupation, and that these sites were then exploited in the Middle Neolithic, just before the passage graves were constructed.

The Middle Neolithic barrow in the *Sjørup Plantation (1b)* was built very near the Early Neolithic barrow (1a). The trees had been removed. The area was used for pasture, and there was no heath.

Areas on the heath plain with lime forest and heath patches were thus occupied and exploited for grazing during the early Middle Neolithic, whereas formerly occupied areas on the Sjørup Moraine were continuously used for pasture.

Guelder rose was frequent in the lime woodland at Hagebrogård and Vroue Heath 1a (Fig. 5). Other non-tree pollen types are scarcely represented.

Site	% pollen	% of trees				% of non-tree pollen		
	Trees	Lime	Hazel	Alder	Birch	Grasses	Plantain	Heather
Hagebrogård	34	85	4	4	7	3	+	90
Vroue Heath 1a	70	59	12	5	23	22	2	51
Mølgård 13	44	39	17	13	31	9	-	89
Vojens	67	43	24	19	6	13	1	78
Harreskov	60	29	17	14	36	25	2	63
Skarrild	77	10	-	42	36	61	-	-

Table 2 Pollen spectra with original vegetation in soils underneath Middle Neolithic A and Middle Neolithic B barrows in West Jutland.

Middle Neolithic BI

Scattered tree vegetation occurred at the barrows on the southern part of Resen Heath (*Mølgård 13, Mølgård 7, Koldkur 10, Mølgård 1*). Trees were cleared away some time before the erection of the barrows at Mølgård 13 and Mølgård 1. The tree populations were originally rich in lime. Birch was favoured at the cost of lime. Heath was widespread at these sites. There are indications that birch trees were burned and that patches of grassland were used for grazing. This procedure is very similar to that used by the early Middle Neolithic people in areas with heath vegetation. The promotion of grazing areas was most successful at the Mølgård 1 site with slightly clayey soil, and least successful at Mølgård 13, where only small patches of grassland appeared. Increased heather percentages near the top of the soils under the barrows at Mølgård 1 and 13 indicate that pasture was reduced or abandoned a short time before the construction of the graves.

The four barrows on Resen Heath derive from the younger Undergrave Period. The conversion of heath to pastureland can, therefore be linked with occupation of areas that were unoccupied at the onset of the Single Grave Period.

The barrow on the Sjørup Moraine (*Sjørup Plantation 2*) dates from the older Undergrave Period, and, therefore, from the first phase of the Single Grave Culture. Trees were nearly absent at the Sjørup Plantation 1b barrow and this area was grazed intensively in the early Middle Neolithic Period. Clearance and burning of birch trees at the Sjørup 2 site may belong to the Funnel Beaker Culture, and it is indicated that the barrow was built in an area that was strongly exploited for pasture.

Non-tree plants other than grasses, plantain and heather are few in number and scarce. Pollen of barley-type and a few bare-soil plants (sheep's sorrel, knotgrass, perennial knawel, and the chenopod family) occurred at the Mølgård 2, Koldkur 10 and Mølgård 1 barrows, indicating weak traces of agriculture. A pollen grain of *Fagopyrum tataricum* L. was found at Mølgård 1. This plant probably was introduced as a weed.

Middle Neolithic BII

Trees were scarce at the sites of the three barrows with ground graves on Resen Heath and Vroue Heath (*Koldkur 1* and *7*, *Vroue Heath 7*). Lime trees still occurred, and birch was very scarce at Koldkur 7 and Vroue Heath 7 and more common at Koldkur 1. Grassland with heath patches at Koldkur 7 and Vroue 7 had been used for pasture, and heath was scarce at Koldkur 1. The commonness of plantain reflects the slightly clayey soils at the three sites. Grazing was abandoned and heath expanded on the barrow sites some time before the barrows were built.

A few finds of pollen of barley-type and bare-soil plants (sheep's sorrel, perennial knawel and chenopods) are week traces of agriculture. One pollen grain of common buckwheat (*Fagopyrum esculentum*) was found at Koldkur 7. This plant was probably introduced as a weed. Other herbaceous plants were scarce and occurred with low pollen frequencies.

Natural vegetation in the Vroue area

Pollen studies from lakes demonstrate that the heath areas of northern West Jutland were covered by open woodland up to the times of land clearance by humans (Odgaard 1994). One of the sites, Kragsø, is situated on the southern part of the Karup heath plain (Fig. 1). The natural woodlands in this region consisted of lime, birch, hazel, oak and alder. Grassland and heath vegetation were widespread. The grasses had the lowest (2,6 %) and heather the highest frequencies (8,6 %) at Kragsø , the site with the poorest soil. Heather was promoted by fires, which Odgaard (1992; 1994) considered most likely to have been natural. A pollen diagram from a soil beneath a barrow from the Ground Grave Period (Harreskov) indicated initially natural woodland of mainly lime, birch and hazel on freely-drained meltwater sand (Odgaard & Rostholm 1987). Grasses and heather were widespread at this site. Another pollen diagram from a site on moist eolian sand (Skarrild) indicated dominant alder and birch with frequent grasses and no heather (Odgaard & Rostholm 1987; Odgaard 1990).

Natural vegetation is scarcely represented in the pollen diagrams from the Early Neolithic barrows on the Sjørup Moraine and on Vroue Heath. There are traces of human disturbance already in the earliest pollen spectra. These areas probably supported woodlands of lime, birch, hazel and alder. A few pollen diagrams from sites occupied in early Middle Neolithic time and by the Single Grave Culture indicate undisturbed vegetation at the lowermost levels. Pollen spectra from these sites are compared with pollen spectra from the Harreskov and Skarrild sites mentioned above (from Odgaard & Rostholm 1987; Odgaard 1990) and a pollen spectrum from a bottom grave near Vojens (from Jørgensen 1965) in Table 2.

The pollen spectra in Table 2 indicate more or less open tree communities with frequent heather and some grasses in the non-tree vegetation. Ribwort plantain was scarce or absent. They support the conclusion of Odgaard and Rostholm (1987) that lime, birch, hazel, alder, heather and grasses characterized undisturbed vegetation on dry ground, in contrast to moist-ground vegetation (Skarrild), that was characterized by alder, birch and grasses. Other trees such as oak, elm, ash and pine were scarce. In view of the conclusions of Odgaard (1992; 1994) about the fire-dependence of heather, the occurrence of heath vegetation on dry ground was probably due to former natural fires.

Anthropogenic vegetational changes

The woodlands found in the Early Neolithic Period on the Sjørup Moraine and on Vroue Heath were changed into secondary coppice woods rich in birch. These coppice woods were exploited for pasture in a swidden rotation system.

Sites with woodland and heath at Hagebrogård and on Vroue Heath were exploited in the early Middle Neolithic by felling of lime trees in favour of birch. The secondary birch populations were then felled and burned to be replaced by pasture vegetation. On the Sjørup Moraine, trees were scarce. The area was used for pasture and the swidden rotation system had been abandoned.

Sites with woodland and heath on Resen heath were occupied in the Undergrave Period of the Single Grave Culture. Birch populations were favoured and were replaced by pasture after felling and burning. It is indicated that grazing was abandoned just before the building of some of the barrows. Grazing had been continuous for some time before the barrow on the Sjørup Moraine was built. This barrow represents the earliest Single Grave Culture and was built in an area, that had been occupied in early Middle Neolithic time.

The barrows from the Ground Grave Period on Resen Heath and Vroue Heath were built on sites where trees were scarce. Heath occurred at one of the barrows on Resen Heath and on Vroue Heath. The sites had been used for pasture for some time, but the grazing was abandoned and heath expanded before the construction of the barrows.

LANDSCAPE AND LAND-USE AT THE TIME OF THE EARLY AND MIDDLE NEOLITHIC AND SINGLE GRAVE BARROWS

The pollen diagrams from the soils beneath the barrows in the Vroue area indicate modifications of the vegetation at the barrow sites prior to the building of the barrows. Vegetation at the barrow sites and in the area around the barrows at the time of construction of the barrows is reflected in the topmost soil pollen spectra and in pollen spectra from soil horizons enclosed in the fill material. Vegetational diversity indicated by these pollen spectra are illustrated in triangular diagrams on Figs. 8-9.

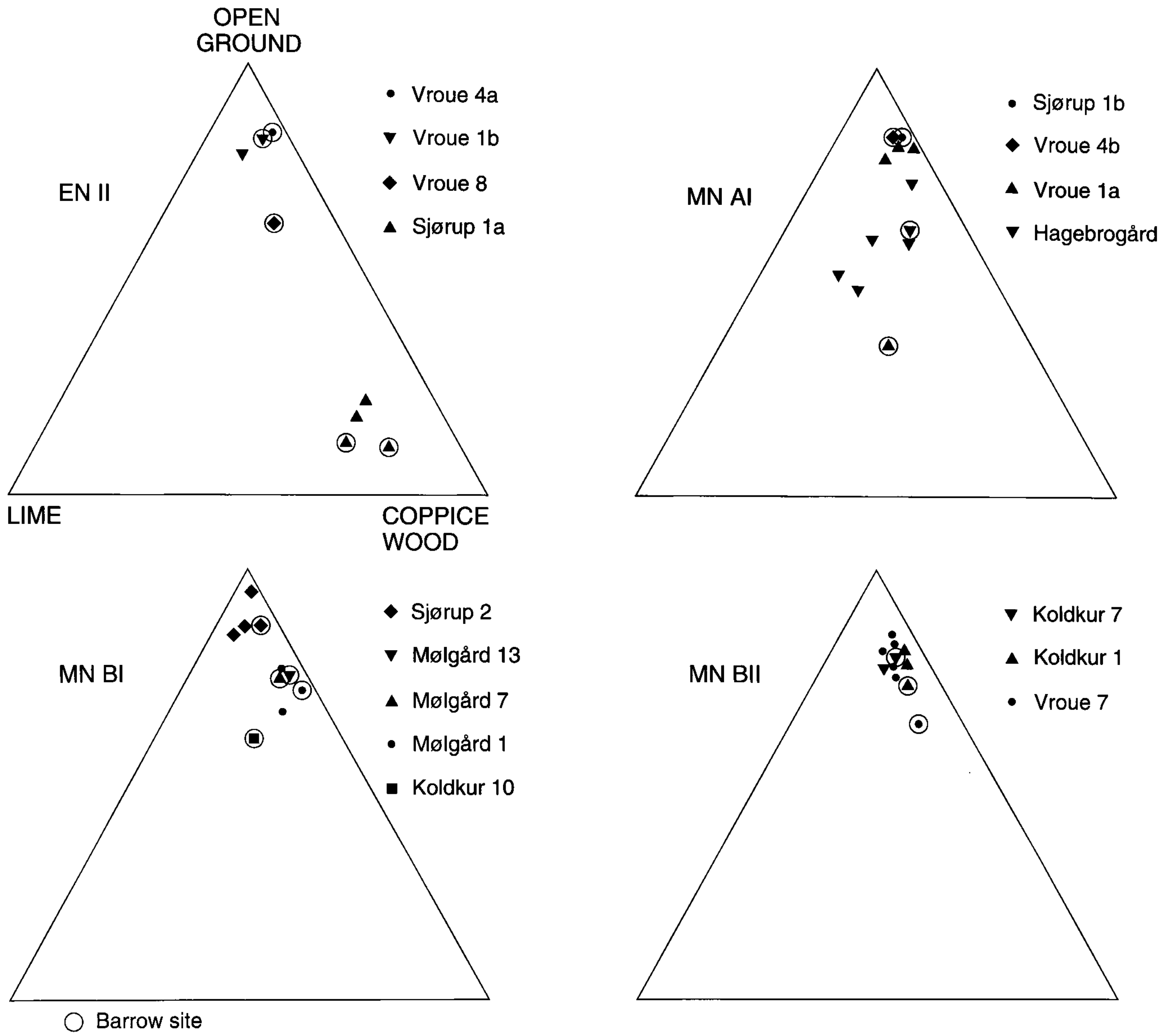

Fig. 8 Landscape diversity illustrated by pollen spectra from the topmost soil at the barrow sites (encircled) and from topsoil enclosed in the fill material, at barrows from the Early Neolithic (EN II), the early Middle Neolithic (MN AI), and from Single Grave barrows with undergraves (MN BI) and with ground graves (MN BII). The dots indicate pollen frequencies for lime trees (100% at the lower left-hand corner), for coppice trees (hazel, birch and alder, 100% at the right-hand corner), and for open ground (non-tree pollen, 100% at the uppermost corner).

Landscape variation

Lime was originally frequent within the woodland vegetation. High frequencies for birch, hazel and alder reflect secondary woodlands or coppice woods, and the frequencies for non-tree pollen reflect the extension of open areas. Landscape variation is therefore illustrated in triangular diagrams, where pollen spectra with high percentages for lime are indicated at the lower left-hand corner, high frequencies for coppice trees at the lower right hand corner, and high

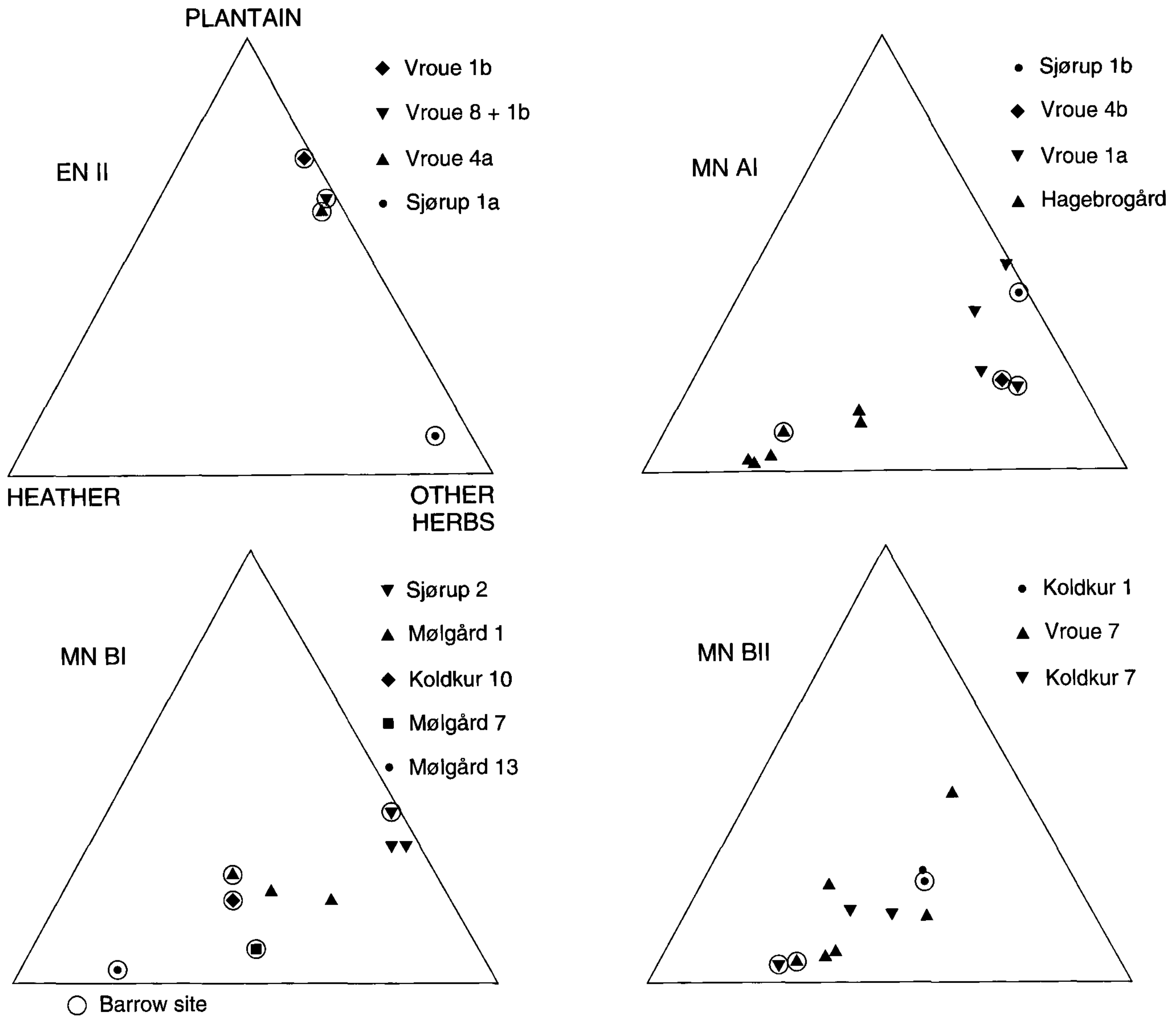

Fig. 9 Land-use illustrated by non-tree pollen spectra from the soil samples (see Fig. 8). The dots indicate pollen frequencies for heather (100% at the lower left-hand corner), for ribwort plantain (100% at the upper corner), and for other herbs (100% at the lower right-hand corner).

frequencies for non-tree plants at the upper corner. (Fig. 8).

The pollen spectra from the Early Neolithic barrows in the Vroue area are distributed along the right-hand side of the triangle. Coppice woods on the Sjørup Moraine are represented at the lower right-hand corner, and predominance of open areas on Vroue Heath is indicated by the dots in the uppermost corner. The tree vegetation had been strongly modified, and landscape exploitation varied widely.

Sites with relic lime-dominated woodlands at Vroue Heath 1a and at Hagebrogård are indicated by dots in the central part of the triangle for the early Middle Neolithic. There were areas poor in trees around these barrows. Trees were very scarce at the Vroue Heath 4b and Sjørup 1b sites. Landscape di-

	Vroue Heath 1a		Hagebrogård		Koldkur 7		Vroue 7	
	Depth cm	Plantain %	Depth cm	Plantain %	Depth cm	Plantain %	Depth cm	Plantain %
Fill			84	12,8			68	15,2
			94	10,9			110	23,2
	81	22,0	100	2,1			136	44,4
	99	46,0	104	3,4	35	17,0	162	7,3
	109	35,5	106	0,9	44	15,9	237	6,2
Soil	125	18,7	108	9,2	50	4,2	273	4,8

Table 3 Percentages frequencies for ribwort plantain in topsoil samples enclosed in fill material and in the topmost samples from the soils underneath the barrows. Increased plantain frequencies in the fill are indicated.

versity was, therefore high at and around the barrows from the early Middle Neolithic.

Tree vegetation was scarce at the time when the barrows with undergraves were built. Scattered populations of coppice trees occurred on Resen Heath. Lime was frequent at Koldkur10. Trees were very scarce on the Sjørup Moraine.

The diversity of the landscape was still more reduced at the time of the ground grave barrows. Vegetation poor in trees predominated on Resen Heath and Vroue Heath in response to increased exploitation. Trees were scarcer around the Vroue 7 barrow than at the barrow-site.

Land-use

The pollen diagrams from the soil sections indicate three main components in the non-tree vegetation, heather, ribwort plantain, and other herbs, mainly grasses. Heather was dominant in heath areas. Grass vegetation was promoted by felling and burning of trees, and plantain increased at the cost of the grasses at grazing. Variations in the composition of the non-tree vegetation at the time of mound building are illustrated in the triangular diagrams in Fig. 9. Pollen spectra with high frequencies for heather occur in the lower left-hand corner, high frequencies for plantain in the upper corner, and high frequencies for other herbs in the lower right-hand corner.

Heath was scarce in the pollen spectra from the late Early Neolithic (EN II). Plantain is low in a sample from birch woodland on the Sjørup Moraine, and is very high (60-75 %) in samples from barrows on Vroue Heath. The birch woodland on the Sjørup Moraine was unexploited, and grassland vegetation on Vroue Heath was grazed intensively.

Heather was dominant at and around the Hagebrogård barrow from the early Middle Neolithic (MN AI). Sites with heath and small areas with pasture occurred around the barrow. Heather was scarcer or absent at the barrows on Vroue Heath and on the Sjørup Moraine, and grazing was prominent. At Vroue 1a, grazing was more intensive around the barrow than at the mound. It is indicated that pasture was promoted with varying success probably dependant on differences in soil quality.

Heath occurred at one of the barrows with undergraves (MN BI) (Mølgård 13). Heath and patches of grazed grassland occurred at the other barrows on Resen Heath, and pasture dominated at the barrow on the Sjørup Moraine.

Two barrows with groundgraves (MN B II) were built in heath (Koldkur 7 and Vroue 7). Heath and patches of grazed grassland occurred in the vicinity of these barrows and at the Koldkur 1 barrow.

The land-use pattern in the Early Neolithic differed substantially from those of the early Middle Neolithic and the Single Grave Period. Sites with heath were avoided in the EN II. The land-use patterns from the MN AI, the MN BI and the MN BII are very similar. Areas with heath were used more or less intensively for grazing, and the best pasture was obtained at sites on the Sjørup Moraine. Hence, there were small-scale variations in the grazing activity.

Interestingly, there are indications that the barrows often were built at sites with less intensive land-use than around them. Trees were more common at the passage graves Hagebrogård and Vroue Heath

1a than in the area where the fill material was fetched. The plantain frequencies are higher around the barrow at Vroue Heath 1a, than at the barrow site, and these frequencies increase upwards in the fill at Hagebrogård, indicating that the uppermost fill was fetched in areas with pasture at increased distances (Table 3). Pasture had been abandoned or was reduced at barrows from the Single Grave Culture (Mølgård 1, Mølgård 13, Koldkur 7, Vroue Heath 7, Koldkur 1), and there are indications of continued grazing at increasing distance from the barrow sites at Koldkur 7 and Vroue 7 (Table 3). Hence, sites where grazing had been abandoned were selected, and the best pastures were avoided.

There are a few traces of arable farming from the Single Grave barrows in the Vroue area. The main agricultural economy was based on pastoral farming and the raising of husbandry. Pastoral farming was favoured by the burning of tree vegetation and at the cost of heath, but areas with heath were probably used for winter grazing. Grassland with grazing was scarce at the two ground grave barrows at Harreskov and Skarrild investigated by Odgaard and Rostholm (1989) and Odgaard (1990). Heath was favoured at these sites by burning of vegetation with the purpose to promote winter grazing. The soils at these sites were probably poorer than most of the soils in the Vroue area.

There are no finds of husbandry-bones from the Neolithic in West Jutland, and it is impossible to decide whether cattle or sheep was reared. Sheep may have been common in the heath areas, as they are less selective in their grazing habits than cattle (Buttenschøn 1995).

SOIL CONDITIONS AT THE TIME OF THE BARROWS IN THE VROUE AREA

The soil profiles have indicated that most of the soils found underneath the barrows in the Vroue area were oligotrophic brown earths (Ah-Bv-C profiles). Soils without a Bv-horizon occurred in a few cases, and podzols were seen at two barrows, both from the Early Neolithic.

Heath areas were present at barrows from the early Middle Neolithic and the Single Grave Period. A raw humus layer (Ao-horizon) had not developed at these sites, and there were no podzols. Hence, there are no traces of pronounced soil degradation. Sarauw (1898) found traces of podzols at 8 barrows from the Single Grave period. These barrows were situated just inside the Weichselian glaciation border or on Saalian tills just west of this limit. Odgaard and Rostholm (1989) also noticed a podzol underneath a Single Grave barrow on Saalian till. Hence, podzols underneath Neolithic barrows have been noticed outside the Vroue area.

REGIONAL VEGETATIONAL CHANGES IN NORTHWEST JUTLAND

Odgaard (1994) published pollen diagrams from three lakes, Kragsø on the southern part of the Karup heath plain 13 km south of the Vroue area, Skaansø on a late Weichselian heath plain 18 km northwest of Vroue, and Solsø on Saalian till 40 km to the southwest (Fig. 1). These pollen diagrams probably reflect vegetation within 5-10 km distance, contrasting the very local pollen spectra from the barrow soils.

The Early Neolithic activities in the Vroue area are reflected by low peaks for birch pollen at Solsø and Skaansø. The grasses increase slightly and ribwort plantain pollen is present with low frequencies at the lakes. Birch woodlands and pastures such as those occurring at Vroue are, therefore, weakly reflected regionally.

Utilization of heathland for pasture at Vroue during the early Middle Neolithic and the Single Grave Period is reflected by slightly increased frequencies for grasses and plantain in the three lake pollen diagrams. The percentages for heather pollen are rather low at Kragsø and Skaansø. The heather curve increases strongly at Solsø during the Single Grave Period. Odgaard and Rostholm (1989) and Odgaard (1994) surmised that heath was promoted and maintained by artificial burning in order to provide winter grazing. There are no indications of heath expansion in the Vroue area. The heath present there at the time of human settlement probably provided sufficient winter grazing.

Agricultural activities as those in the Vroue area can be traced in a wide region but their effect on vegetation was weak probably because of low population density. More widespread agricultural activity is recorded at Solsø during the Single Grave Period.

POLLEN ANALYSES FROM NEOLITHIC BARROWS IN NORTH AND EAST DENMARK, NORTH GERMANY AND THE NETHERLANDS

North and East Denmark

Lime woodlands were present at Early Neolithic barrows inside the Weichselian glaciation limit (Andersen 1992). Open areas were grazed intensively by husbandry, and birch coppice woods have been burned and were used for cereal growing.

The early Middle Neolithic landscape was highly diversified. There were relics of lime woodlands, coppice woods of birch, hazel and alder, and open areas, that were used for cereal growing and grazing in a swidden rotation system (Andersen 1992, in print a). Herbs from woods and coppices were common, and there were few traces of heath (Andersen in print a). A differing strategy was used in the Vroue area, where heaths were utilized for pasture.

Pollen spectra from barrows of the Single-Grave Culture in North and East Jutland were mentioned by Andersen and Rasmussen (1996). The pollen spectra indicate a radical change from the coppice management of the early Middle Neolithic to nearly treeless landscapes in the Single Grave Period. Increasing deforestation during the Single Grave Period is indicated. Pasture vegetation with plantain dominated the treeless areas and heath was scarce in contrast to the Vroue area, where heaths were used for pasture. Neolithic land use was, accordingly, highly adapted to the environment (cp. Casparie & Groenman-van Waateringe 1980).

North Germany

Averdieck (1980) found high frequencies for pastures (grasses and ribwort plantain) in pollen spectra from Neolithic barrows in Schleswig-Holstein. Heather was frequent at barrows outside the limit of the Weichselian glaciation. Mixed woodland and heather were frequent and grasses and ribwort plantain scarce at megalithic barrows on sandy till of Saalian age south of Hamburg (Groenman-van Waateringe 1979). The heathlands thus were utilized more or less intensively for pasture. Averdieck (1980) noticed dominant brown earth soils beneath the barrows, whereas podzols were scarce.

The Netherlands

A comprehensive survey of pollen spectra from soils underneath barrows in the Netherlands was shown by Casparie and Groenman-van Waateringe (1980). This survey includes pollen spectra from megalithic tombs of the Funnel Beaker Culture and barrows from the Single Grave Culture (Protruding Foot Beaker Culture). Heather pollen was common in the pollen spectra from both cultures. Grasses and ribwort plantain were generally low in the megalithic barrows. The grasses tend to be higher in the Single Grave barrows, and plantain varied considerably there. Casparie and Groenman-van Waateringe (1980) assumed that open spaces were used for cereal growing and pasture at the megalithic tombs, and that plantain was favoured by grazing at the Single Grave barrows. Bakker and Groenman-van Waateringe (1988) found lime-dominated woodlands around megalithic tombs on sandy soils. Lime was scarcer on loamy soils with traces of agriculture and grazing and was generally scarce at the time of the Single Grave Culture (Casparie and Groenman-van Waateringe 1980). Relic lime-woodland thus still occurred in the Netherlands during the early Middle Neolithic. The heathlands were utilized intensively for pasture in the Single Grave Period. Podzols were common underneath Neolithic barrows (Waterbolk 1964).

SUMMARY

Neolithic barrows in the investigation area at Vroue are situated on the Sjørup Moraine from the Weichselian glaciation and in the Vroue and Resen Heaths on an upper meltwater terrace of the original Karup valley. One passage grave occurs on a lower terrace.

Sections were excavated in sixteen barrows. Soils found beneath the barrows were oligotrophic brown earth. Pollen diagrams from the soils and pollen spectra from soil enclosed in fill material were worked out for four Early Neolithic barrows, four early Middle Neolithic barrows, five Single Grave barrows with undergraves and three barrows with ground graves.

The pollen diagrams from the soil sections indicate changes in vegetation up to the time when the barrows were constructed. In Early Neolithic time, natural woodland had been converted to birch woods, which were used for pasture in a swidden rotation system. Early Middle Neolithic barrows were built in areas where natural woodlands with heath patches became utilized for pasture or in pasture vegetation on the Sjørup Moraine. The MN BI Single Grave barrows were also built in areas where woodlands with heath patches were used for pasture. One barrow on the Sjørup Moraine, was built in an area that had been occupied in early Middle Neolithic time. Former birch woodland was converted into pasture at this site. MN BII barrows were built at sites, where pastures in heathland had been abandoned and was replaced by heath. There were slight traces of arable farming at the Single Grave barrows.

Landscape diversity was high at the time when the Early Neolithic barrows were built. There were birch coppice woods and open areas with intensive grazing were prominent. In early Middle Neolithic time, trees were scarcer, but relic lime-dominated woodlands still occurred. Pasture vegetation in heathland was more or less widespread. Trees became increasingly scarce during the Single Grave Period and there were areas with pasture vegetation in heathland. Pasture was more widespread around some of the barrows than at the barrow sites. The mounds were often built at sites that were less intensively exploited than areas in the vicinity of the barrows.

The land-use, that was traced at the barrows in the investigation area, is weakly reflected by regional pollen diagrams from lakes in North West Jutland. Coppice woods were much more common in East and North Denmark during the Funnel Beaker Period than in the Vroue area. Trees were scarce and heath was absent at Single Grave barrows in East and North Denmark. Heathland with pasture occurred around Neolithic barrows in North Germany and the Netherlands.

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REFERENCES

Aaby, B. 1983: Forest development, soil genesis and human activity illustrated by pollen and hypha analysis of two neighbouring podzols in Draved Forest, Denmark. *Danmarks Geologiske Undersøgelse* 2. Række Nr. 114.

- 1994: NAP percentages as an expression of cleared areas. In B. Frenzel (ed.): *Evaluation of land surfaces cleared from forests in the Roman Iron Age and the time of migrating German tribes based on regional pollen diagrams. Paläoklimaforschung* vol. 12, pp.13-28.

Aerts, R., A. Hviszoon, J. H. A. Van Oostrum, C. A. D. M. Van De Vijver & J.H. Willems 1995: The potential of heathland restoration on formerly arable land in Drenthe, The Netherlands. *Journal of Applied Ecology* vol. 32, pp. 827-835.

Andersen, S. T. 1970: The relative pollen productivity and pollen representation of North European trees and correction factors for tree pollen spectra. *Danmarks Geologiske Undersøgelse* 2. Række Nr. 96.

- 1979: Brown earth and podzol: soil genesis illuminated by microfossil analysis. *Boreas* vol. 8, pp. 59-73.
- 1980: The relative pollen productivity of the common forest trees in the early Holocene in Denmark. *Danmarks Geologiske Undersøgelse* Årbog 1979, pp. 5-19.
- 1984a: States in soil development reconstructed by evidence from hypha fragments, pollen and humus contents in soil profiles. In E.Y. Haworth & J.W.G. Lund (eds.): *Lake Sediments and Environmental History*. Leicester University Press, Leicester.

- 1984b: Forests at Løvenholm, Djursland, Denmark, at present and in the past. With a contribution by H.J.B. Birks. *Det Kongelige Danske Videnskabernes Selskab, Biologiske Skrifter* 24:1.
- 1988: Pollen spectra from the double passage-grave, Klekkendehøj, on Møn. Evidence of swidden cultivation in the Neolithic of Denmark. *Journal of Danish Archaeology* vol. 7, pp. 77-92.
- 1990: Pollen spectra from the Bronze Age barrow at Egshvile, Thy, Denmark. *Journal of Danish Archaeology* vol. 9, pp. 153-156.
- 1992: Early and Middle-Neolithic agriculture in Denmark: Pollen spectra from soils in burial mounds of the Funnel Beaker Culture. *Journal of European Archaeology* vol. 1, pp. 153-180.
- in print a: The cultural landscape of Megalithic tombs in Denmark, reconstructed by soil pollen analysis. In P.O. Nielsen (ed.): *Megalithic Tombs - their Context and Construction.* Nationalmuseet.
- in print b: Pollen analyses from Early Bronze Age barrows in Thy. *Journal of Danish Archaeology.*

Andersen, S.T. & Rasmussen, P. 1996: Geobotaniske undersøgelser af kulturlandskabets historie. *Danmarks og Grønlands Geologiske Undersøgelse, Rapport* 1996/8.

Averdieck, F.-R. 1980: Zum Stand der palynologischen Untersuchungen an Erdbauten in Schleswig-Holstein. *OFFA* vol. 37, pp. 384-393.

Bakker, J.A. & Groenman-Van Waateringe, W. 1988: Megaliths, soils and vegetation on the Drenthe Plateau. In W. Groenman-Van Waateringe & M. Robinson (eds.): *Man-Made Soils,* pp. 143-182. B.A.R. *International Series* 410. Oxford.

Behre, K.-E. 1981: The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores* vol. 23, pp. 225-245.

Berglund, B.E., Persson, T., Emanuelsson, U., & Persson, S. 1986: Pollen/vegetation relationships in grazed and mowed plant communities of South Sweden. In K.-E. Behre (ed.): *Anthropogenic Indicators in Pollen Diagrams,* pp. 37-51. Balkema, Rotterdam, Boston.

Bryant, R. H., Emberlin, J.C. & Norris-Hill, J. 1989: Vertical variation in pollen abundance in north-central London. *Aerobiologia* vol.5, pp. 123-37.

Broesbøl-Jensen, B. 1995: Fåregræsningens påvirkning af vegetationen på Hjortholm. In. H. H. Hansen & B. Aaby (eds.): *Stavns Fjord - et natur - og kulturhistorisk forskningsområde på Samsø,* pp. 225-240. Carlsbergfondet and Nationalmuseet.

Clarke, J.L., Welsch, D. & Gordon, I.J 1995: The influence of vegetation pattern on the grazing of red deer and sheep II. The impact on heather. *Journal of Applied Ecology* vol. 32, pp. 177-186.

Dimbleby, G.W. 1957: Pollen analysis of terrestrial soils. *New Phytologist* vol. 56, pp. 12-28.
- 1985: *The Palynology of Archaeological Sites.* Academic Press, London.

Dimbleby, G.W. & Evans, J.G. 1974: Pollen and land snail analysis of calcareous soils. *Journal of Archaeological Science* vol. 1, pp. 117-133.

Flora Europaea vol. 1-5. Cambridge University Press, Cambridge.

Fobian, A. 1995: En jordbundsprofil fra Hjortholm under mikroskop. In H.H. Hansen & B. Aaby (eds.): *Stavns Fjord - et natur- og kulturhistorisk forskningsområde på Samsø,* pp 151-164. Carlsbergfondet and Nationalmuseet.

Gaillard, M.-J., Birks, H.J.B., Emanuelsson, U. & Berglund, B.-E. 1992: Modern pollen/land use relationships as an aid in the reconstruction of past land-uses and cultural landscapes: an example from South Sweden. *Vegetation History and Archaeobotany* vol. 1, pp. 3-17.

Gaillard, M.-J., Birks, H.J.B., Emanuelsson, U., Karlsson, S., Lageras, P. & Olausson, D. 1994: Application of modern pollen/land use relationships to the interpretation of pollen diagrams - reconstructions of land-use history in south Sweden. *Review of Palaeobotany and Palynology* vol. 82, pp. 47-73.

Groenman-Van Waateringe, W. 1979: Palynological investigations of five German burial mounds. *Archaeo-Physica* vol. 8, pp. 69-84.
- 1986: Grazing possibilities in the Neolithic of the Netherlands based on palynological data. In K.-E. Behre (ed.): *Anthropogenic Indicators in Pollen Diagrams,* pp. 187-202. Rotterdam, Boston.
- 1993: The effects of grazing on the pollen production of grasss. *Vegetation History and Archaeobotany* vol. 2, pp. 157-162.

Havinga, A.J. 1971: An experimental investigation into the decay of pollen and spores in various soil types. In J. Brooks, P.F. Grant, M.D. Muir, P. Van Gijzel & G. Shaw (eds.): Sporopollenin, pp. 446-79. Academic Press, London and New York.
- 1974: Problems in the interpretation of pollen diagrams of mineral soils. *Geologie en Mijnbouw* vol. 53, pp. 449-53.

Iversen, J. 1960: Problems of the early Post-glacial forest development in Denmark. *Danmarks Geologiske Undersøgelse* 4. Række Nr. 4(3).

Janssen, C. R. 1986: The use of local pollen indicators and of the contrast between regional and local pollen values in the assessment of the human impact on vegetation. In: K.-E. Behre (ed.): *Anthropogenic Indicators in Pollen Diagrams,* pp. 203-208, Balkema, Rotterdam, New York.

Jensen, H.J. 1994: *Flint tools and plant working. Hidden traces of stone age technology. A use wear study of some Danish Mesolithic and TRB implements.* Aarhus University Press. Aarhus.

Jonassen, H. 1950: Recent pollen sedimentation and Jutland heath diagrams. *Dansk Botanisk Arkiv* vol. 13(7), pp. 1-168.

Jørgensen, E. 1973: Magtpolitik i yngre Stenalder. *Skalk* 1973, Nr. 4. pp. 3-10.

- 1977a: Hagebrogård - Vroue - Koldkur. Neolitische Gräberfelder aud Nordwest-Jütland. *Arkæologiske Studier* vol. 4.
- 1977b: Brændende langdysser. *Skalk* 1977, Nr. 5, pp. 7-13.
- 1981: Gravhusenes problem, *Skalk* 1981, Nr. 3, pp. 4-9.
- 1985: Brydningstid. *Skalk* 1985, Nr. 2, pp. 3-8.

Jørgensen, S. 1965: Pollenanalyse fra vegetationslaget (den oprindelige overflade) under højen sb. 8. *Aarbøger for Nordisk Oldkyndighed og Historie* 1964, pp. 26-28.

Keatinge, T.H. 1983: Development of pollen assemblage zones in soil profiles in southeastern England. *Boreas* vol. 12, pp. 1-12.

Miles, J. 1985: The pedogenic effects of different species and vegetation types and the implications of succession. *Journal of Soil Science* vol 36, pp. 571-584.

Milthers, K. 1935: Landskabets udformning mellem Alheden og Limfjorden. *Danmarks Geologiske Undersøgelse* 2. Række Nr. 56.

Molloy, K. 1985: *A Reconstruction of the Vegetation in S.W. Donegal of 5000 B.P. Based on Soils under Megalithic Tombs.* Unpublished Thesis. University of Dublin.

Muller, P.E. 1884: Studier over skovjord II. Om muld og mor i egeskove og på heder. *Tidsskrift for Skovbrug* vol. 7, pp. 1-232.

Odgaard, B.V. 1990: Vestdanske lyngheders oprindelse og fortidige udnyttelse. *Bebyggelsehistorisk Tidskrift Nr. 19,* pp. *117-129.*

- 1992: The fire history of Danish heathland areas as reflected by pollen and charred particles in lake sediments. *The Holocene* vol. 2, pp. 218-226.
- 1994: The Holocene vegetation history of northern West Jutland, Denmark. *Opera Botanica* number 123.

Odgaard, B.V. & H. Rostholm 1988: A single grave barrow at Harreskov, Jutland. *Journal of Danish Archaeology* vol. 6, pp. 87-100.

Raynor, G., J.V. Hayes & E.C. Ogden 1974: Particulate dispersion into and within a forest. *Boundary-Layer Meteorology* vol. 7, pp. 429-456.

- 1975: Particulate dispersion from sources within a forest. *Boundary-Layer Meteorology* vol. 9, pp. 257-277.

Sarauw, G. F. L. 1898: Lyngheden i oldtiden. Iagttagelser fra gravhøje. *Aarbøger for nordisk Oldkyndighed og Historie* 1898, pp. 6-124.

Scheffer, F., P. Schachtschabel, H.-P. Blume, K.H. Hartge & U. Schwertmann 1976: *Lehrbuch der Bodenkunde.* Enke. Stuttgart.

Smith, R.W. 1984: The ecology of Neolithic farming systems as exemplified by the Avebury region of Wiltshire. *Proceedings of the Prehistoric Society* vol 50, pp. 99-120.

Ussing, N.V. 1903: Om Jyllands hedesletter og teorierne for deres dannelse. *Oversigt over Det Kgl. Danske Videnskabernes Selskabs Forhandlinger* 1903 No. 2.

Walch, K.M., J.R. Rowley & N.J. Norton 1970: Displacement of pollen grains by earthworms. *Pollen et Spores* vol. 12, pp. 39-44.

Waterbolk, H.T. 1954: *De praehistorische mens en zijn milieu.* Assen.

- 1958: Pollen spectra from Neolithic grave monuments in the northern Netherlands. *Palaeohistoria* vol. 5, pp. 3-13.
- 1964: Podsolierungserscheinungen bei Grabhügeln. *Palaeohistoria* vol. 10, pp. 89-102.

Zeist, W. Van 1955: *Pollen analytical investigations in the northern Netherlands. With special reference to archaeology.* Amsterdam.

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Danish niello inlays from the Iron Age
A technological investigation

Karen Stemann Petersen

INTRODUCTION

Niello is the collective term applied to silver, copper and/or lead sulphides, which are inlaid as dark embellishments on bright metal objects. Fire gilding is often included as a further decorative element. The word niello comes from medieval Latin nigellum which means dark or black.

In earlier research, considerable attention has been focused on the techniques by which niello inlays were produced, but only the medieval, easily-meltable, lead-containing sulphides, which are described in several primary historical sources, have been fully investigated.

Many of Denmark's niello-inlaid artefacts from the Iron Age are to be found in the collections of the National Museum's Department of Prehistory and Early History and the investigations described here are confined to these.

In the following account, earlier research in the field is reviewed, the technological investigations of this project are described, and the results of these are compared with previously published niello analyses. Finally, the micro-topographical characteristics of niello inlays are described along with the possible reasons for the breakdown of the sulphides.

Finds from the Roman Empire from the 1st century AD bear witness to the use of niello decoration and the technique was spread to the rest of Europe in the course of subsequent centuries. The use of the niello technique is thought to have ceased in Scandinavia at the end of the Viking Age, after which it was largely confined to religious metalwork produced further south in Europe. In Italy in the 15th century, niello was widely used for many different purposes only to be completely replaced in the course of the 16th century by patterns in enamel (La Niece 1983; Oldeberg 1966). Benvenuto Cellini (Ashbee 1967) wrote in 1530 that the niello technique had been forgotten when he became an apprentice goldsmith in Florence in 1515, but elsewhere, for example in Russia, the tradition continued into the 18th and 19th centuries.

PRIMARY SOURCES AND EARLIER RESEARCH

Schweizer (1993) presents the previously published niello analyses of archaeological artefacts chronologically (fig. 1). Byzantine niello, which was of particular interest for his investigations, is shown separately. Pure silver sulphide was termed type I, silver-copper sulphide type II and niello of silver-copper and lead sulphide type III. Also included in the table are niellos of pure copper sulphide which have only been found on some bronze or brass objects from Roman times.

In conjunction with the information from La Niece (1983), Schweizer's table shows that niello of pure silver sulphide (type I) occurs with varying intensity from the 1st century AD, through to around 1000 AD. Silver-copper sulphide (type II), with a significant copper content was most prominent at the end of the 5th century AD and in the 6th century AD, but its use continued up until the 13th century.

According to La Niece (1983), the proportion of copper in the niello of type II was clearly greater in

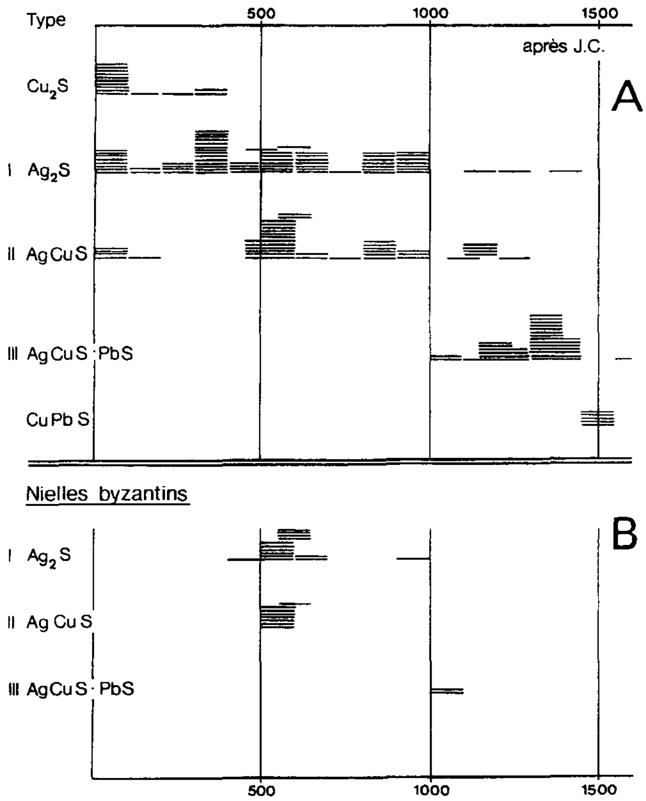

Fig. 1 Published analyses of niello inlays from 0-1500 AD, collected by Schweizer (1993). In diagram B all the Byzantine niello inlays, which were the subject of the article, are separated out. The references are Moss (1953), Schweizer (Lazovic et al. 1977), Dennis & Meyers (1979), Newman et al. (1982), Oddy et al. (1983) and La Niece (1983).

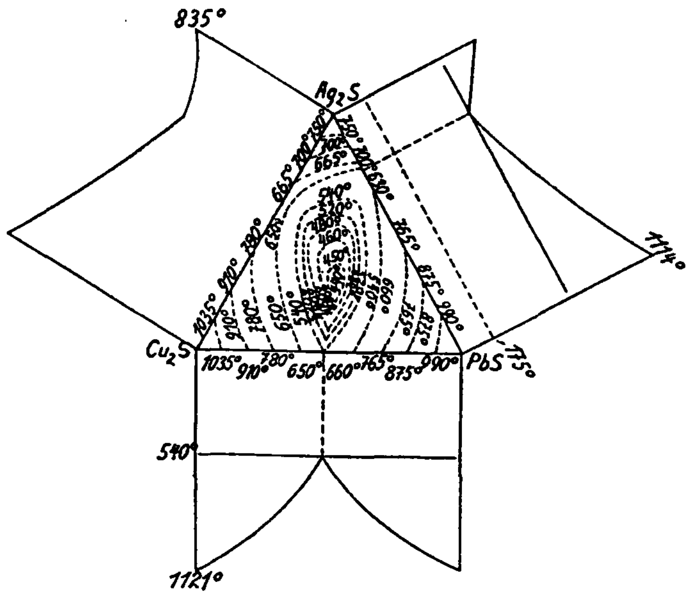

Fig. 2 Phase diagram for the tertiary system Ag_2S-Cu_2S-PbS (Schwarz & Romero 1927), where the melting points are marked with lines like contours on a map. The binary systems are drawn as foldouts.

the northwestern European material she had examined than in the few early examples from Roman times, where the parent material could have been silver of poor quality, rather than that the copper was an intentional addition. From the 11th century onwards, the use of lead-containing niello (type III) became widespread, corresponding to the formulae in medieval technical treatises. In general, the use of sulphides lacking lead was abandoned in the course of a couple of centuries in favour of the less time-consuming easily-meltable leaded niellos.

Pliny (23-79 AD)(Rackham 1968) describes the fusing together of 3 parts silver, 1 part copper plus some sulphur. In the later detailed treatises about lead-containing niello by Theophilus (1110-40 AD) (Hawthorne & Smith 1963), Cellini and others describe how the parent metals are melted together before the sulphur is added. The cast and hot-forged niello is later crushed, mixed with a flux (borax) and melted into the depressions in the artefact just like enamel powder.

Moss (1953) was aware that pure silver sulphide decomposed before it melted. He explains that the fact that silver, copper and lead could be blackened by sulphur must have been known from very early times, but the production of easily-meltable niello was not possible before mixed sulphides were introduced. The reason for this is that single metal sulphides decompose before melting i.e. the sulphur burns off. If, however, they are mixed together in suitable proportions, lower melting points are obtained, just like when metals are alloyed. Mixtures of silver sulphide, copper sulphide and lead sulphide were investigated systematically by Schwarz and Romero (1927), who examined the melting properties of various mixtures and produced a phase diagram (fig. 2). Under laboratory conditions, where the sulphur is prevented from burning off, the melting points for the sulphides of silver (Ag_2S), copper (Cu_2S) and lead (PbS) are 835° C, 1121° C and

1114° C respectively, whereas a mixture of these three sulphides in the ratio of 5:7:8 will melt at about 440° C. The niello formula used by Cellini was difficult to work with in the investigations described by Wilson (1948) and Moss (1953). Cellini was, on his own admission, self-taught in the niello technique. It must be presumed therefore that he added too much lead to the mixture in a direct attempt to achieve the lowest possible melting point.

The Danish artefacts from the Iron Age which have been investigated have no obvious air bubbles in the inlay to suggest that the method of application involved the melting on of sulphide powder. In the exhibition "From Viking to Crusader" (Roesdahl 1992, no. 27f, 304), there were, however, four onion-shaped, oriental pendants from the Swedish Vårby Hoard and a tubular neckring from the Russian Gnezdovo Treasure from the 10th century, which all had conspicuous air bubbles in the niello. These artefacts should be analysed, as they either contain melted-on niello of silver/copper sulphide or are the earliest lead-containing niello yet reported.

Of the niello formulae in eight historical sources (La Niece 1983), only a few are without lead and therefore of relevance to the Danish artefacts which have been investigated. The sources in question are a formula from Pliny (Rackham 1968), one from al-Hamdānī from 942 AD (Toll 1968; Allan 1979) and the formulae in chapters 58, 195 and 196 of "Mappae Clavicula" from the 8th-12th centuries AD (Smith & Hawthorne 1974).

In "Mappae Clavicula" (chapter 58) and al-Hamdānī, only silver and sulphur are thought to have been melted together in the production of the sulphide. Because silver sulphide, as already mentioned, decomposes to give metallic silver and sulphur before it reaches its melting point, it must be assumed that the silver used in the formulae was a silver alloy from the workshop, which contained some copper.

Rosenberg (1924) calculated the relationship between the parent elements for the metal sulphides which will be obtained according to a series of niello recipes in the historical sources and was of the opinion that generally too much sulphur was specified.

He knew of an old description of a Russian test piece, where the task was to cold-hammer a niello-inlaid plate out to double its size. Rosenberg thought that this could only be done because the niello contained some unreacted metal among the sulphides, since malleability is a characteristic of metals and not of mixed sulphides. Theophilus (Hawthorne & Smith 1963) states that cold niello shatters like glass. Moss (1953) addressed this problem and did not think that free metal in the sulphides was desirable as the excess metal would be in the form of lead which would disrupt a silver underlay. Furthermore, the excess of sulphur in the historical formulae proves that the intention was to convert the metals completely to sulphides. In an attempt to copy the Russian test piece, Moss tried to cold-roll inlaid niello so the whole surface became enlarged, but the niello cracked and came away from the silver underlay at the touch of a fingernail. On the basis of the experiments described in the following, it should perhaps be assumed that the use of the expression "cold working" with reference to the Russian test piece is due to a misinterpretation of the craftsmen who perhaps just meant that the silver should not be red hot.

Moss succeeded, to varying degrees, in inlaying pulverised silver sulphide on a heated silver piece by rubbing the powder together using a burnisher. He was therefore aware that silver sulphide becomes plastic at a much lower temperature than its melting point. A corresponding description of an attempt to inlay using sulphide powder is to be found in La Niece (1983).

In the discussion of the nature of niello, Newman et al. (1982) present the phase diagram for CU_2S-Ag_2S (fig. 3), from an investigation by Skinner (1966). The phases of the sulphide mixtures can be drawn as a two element diagram, because sulphur comprises a third of a mole in all the minerals. The melting curve (uppermost in the diagram), with a minimum melting point of 640 ± 3° C, is approximately the same as that given earlier by Schwarz and Romero (1927) (fig. 2). An important point with regard to the niello investigations presented here concerns the polymorphic conversions of the minerals in the system explained by Skinner (1966). At room temperature there are eight different stable crystal phases. There is silver sulphide (acanthite), four copper sulphides (chalcocite, covellite, digenite and djurlite), as well as three tertiary compounds (jalpaite, mckinstryite and stromeyerite). All eight crystal phases appear at specific combinations of the

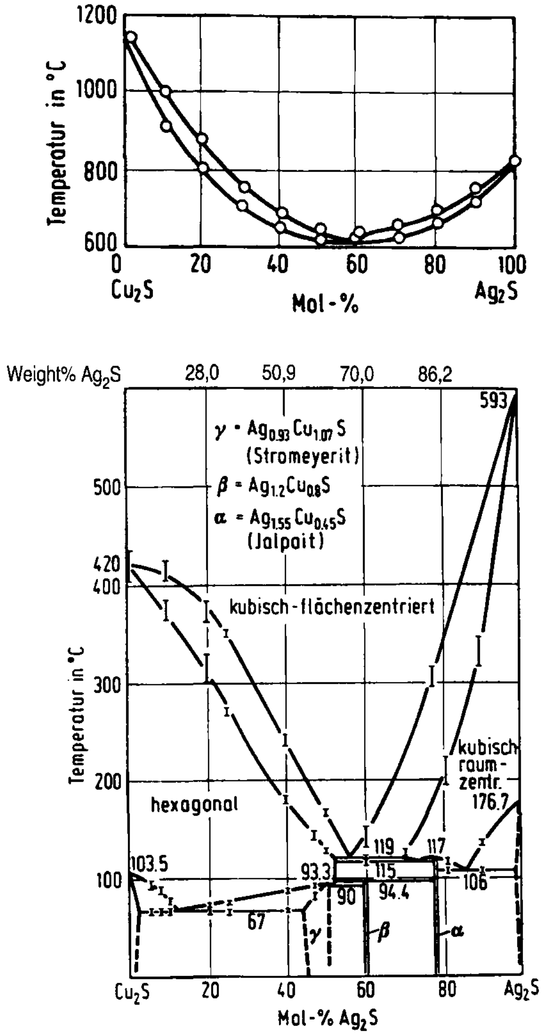

Fig. 3 Phase diagram for Ag_2S-Cu_2S: The upper part shows the melting and setting curves in the system and underneath the phases of the system in a solid state (Gmelins Handbuch 1974). The amount by weight of Ag_2S relative to the molar % has been added to the diagram.

components and the crystal structures which appear are orthorhombic, tetragonal and monoclinic.

In a solid state at higher temperatures, only three minerals occur in the system, with broad variation in composition. They have each their own lattice structure: hexagonal (hcp) at the copper side of the diagram, body-centred cubic (bcc) at the silver side and, in between, face-centred cubic (fcc), which spreads over the whole diagram with increasing temperature. These mineral compounds exist only at elevated temperatures.

In the world of metals, the body-centred cubic structure is quite malleable, while the face-centred cubic is the most malleable.

La Niece (1983) describes a swastika-shaped inlay of silver sulphide on a Roman silver dish from the 3rd century AD, where the ca. 4 mm broad bands of niello resemble cut-off strips. She presumes that this unique occurrence is evidence of an unnecessarily time-consuming application technique.

On the basis of their investigations of artefacts, La Niece (1983) and Schweizer 1993) think that silver-copper sulphide niello, like pure silver sulphide, was not melted in place, because there are no air bubbles in the niello, as there are in the later lead-containing sulphides. La Niece presumes therefore, that an (unspecified) application technique used for pure sulphides in Roman times had been continued despite copper sulphide's somewhat lower melting point.

Moss (1953) examined some bronze Roman belt plates from the 1st century AD, where the niello consisted of copper sulphide. These inlays appear to have been cut into shape before being inlaid, rather than melted into the engraved depressions. He states that "Since the melting point for cuprous sulphate (1112° C) is well above that of bronze, it could only have been inlaid in the bronze in the manner already suggested". As will be apparent from the results of the experiments described later, his interpretation appears to be correct.

Some of Newman et al.'s (1982) niello from Byzantine artefacts contained silver-copper sulphide in the form of jalpaite. When examined at 500-550 times magnification with a scanning electron microscope, the phases acanthite and jalpaite appeared finely distributed among one another. Similar visible phase division could be seen in sulphides on the Danish artefacts and the sulphides produced experimentally as part of this project.

EXPERIMENTS WITH PRODUCTION OF NIELLO AND INLAYING

In order to interpret the niello inlays on the archaeological artefacts, niellos of various compositions were produced. This was done by converting metal

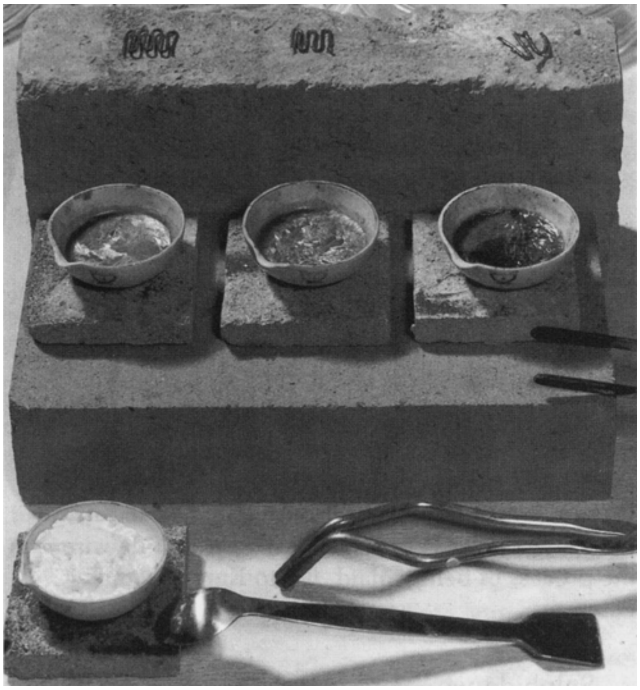

Fig. 4 Crucibles with sulphur used to convert metal wire in an oven. Some of the treated wires can be seen in the background. Photo John Lee.

wire in molten sulphur and, at higher temperatures, by melting together of the components. With sulphides in the form of wire and powder, the various inlaying techniques could then be tried out on furrows cut in sheets of silver, brass, bronze and gold.

Pure silver, pure copper and three silver-copper alloys were the starting point for the experiments. The alloys contained 92.5% (sterling silver), 80% and 70% silver respectively. According to the chemical data (Gmelins Handbuch 1971), silver sulphide can be produced from metallic silver exposed to sulphur vapour or molten sulphur. An accelerated conversion process is achieved above 177.8° C, but above 444° C the conversion of the metal occurs so rapidly that only detached flakes are produced.

Silver and sulphur ions can move freely in silver sulphide covering silver surfaces, so the sulphide does not offer protection against further action by the sulphur (Gmelins Handbuch, 1973). The experiments showed that conversion from silver wire and sterling silver wire to sulphide occurred rapidly, compared to the conversion of metal wire with a higher copper content, where the ions were less mobile in the sulphide coating. In closed bowls containing molten sulphur, 1mm thick pure silver and sterling silver wire was converted to sulphide wire in an hour at an oven temperature of 220° C (fig. 4). Alloy wire containing 80% and 70% silver and pure copper wire, required 350° C for 2 and 4 hours, respectively, for the conversion to be complete. The sulphides arising from the 80% and 70% silver alloy became very soft in the bowls, and the sulphide wires were difficult to detach from the bottom of the bowls and they stuck together in the viscous molten sulphur.

On conversion, the wires increased in volume and at the same time became hollow or developed porosities at the core. The situation is the same as that with metal artefacts which have been totally transformed by corrosion in the soil. The copper sulphide wires produced in the experiment had a hollow core 1mm in diameter, which shows that it was exclusively copper ions which had migrated out of the copper wire in order to react with the sulphur. In the other sulphide wires the hollow or porous core was less marked, which means that the sulphur ions must have moved inwards through the sulphide layer at the same time as metal ions moved out.

Silver-copper sulphide was also produced by fusing together of the components, as among others Moss (1953) has tried using Pliny's formula, at an oven temperature of ca. 1000° C. Casting of the sulphide bars made from sulphur and 70% and 80% silver alloys was done as quickly as possible, but there was, however, a small amount of finely distributed pure metallic silver in the cast sulphide. An excess of sulphur was present in the melting process, but was easily burned off. According to Newman et al. (1982) it is possible, in the laboratory, to fuse together silver sulphide containing only 10-15% copper.

In Skinner's (1966) preliminary work for the construction of the phase diagram, the measurements on silver-copper sulphide were generally uncertain above 450° C, at which point sulphur is released by evaporation and the sulphides begin to decompose. According to the tertiary phase diagram for sulphur, silver and copper at 250° C (fig. 5), pure silver will crystallise out if there is deficiency of sulphur in the mixture. The present experiments showed that the sulphur deficiency can occur during fusion, or if the

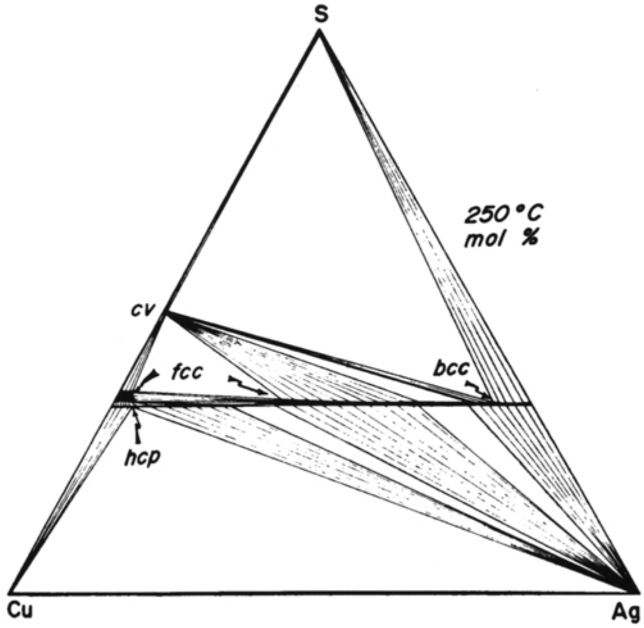

Fig. 5 Phase reactions for Ag-Cu-S at 250° C with the crystal structures marked (Skinner 1966). With a deficit of sulphur (below the horizontal line in the diagram) pure silver dissociates from the sulphide.

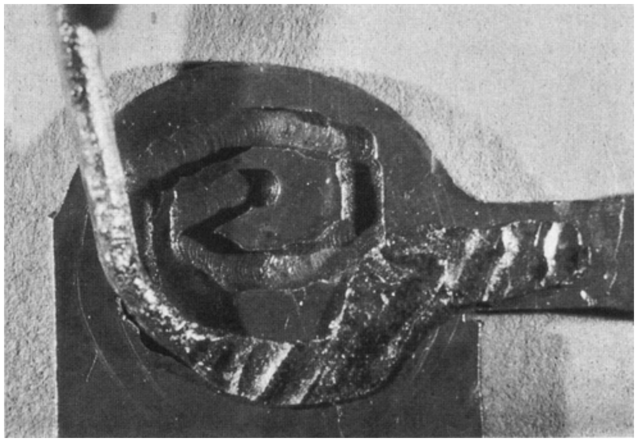

Fig. 6 Close-up photo of a milled spiral 1mm furrow in 14 carat gold sheet, in which a silver sulphide wire is in the process of being inlaid. Photo Karen Stemann Petersen.

sulphur burns off by overheating during forging and inlaying. Overheating experiments in an oven at temperatures of 500° C and 575° C for 5 minutes showed that pure silver sulphide decomposed less readily than niello of silver-copper sulphide. Small crystalline peaks of silver could be seen on the surface of the sulphides.

In order to control the working temperatures precisely during the inlaying experiments, an electric hotplate was used. On the hotplate it was possible to shape the sulphide wires which had been produced and inlay them in furrows milled in sheet metal of sterling silver, and in some cases brass, bronze and gold. This method is illustrated in figure 6 which shows a sulphide wire being inlaid in a 1 mm spiral furrow. For the comparative experiments straight furrows were used. Copper sulphide in the hexagonal (hcp) area of the phase diagram was not malleable (fig. 3), but with further heating it was possible to inlay the sulphide at 450-500°. Copper sulphide is hard and very difficult to inlay such that the furrows easily become mis-shaped. As a consequence, it seems reasonable to conclude that the method was not continued after Roman times.

Sulphide wires produced from pure or sterling silver could be smithed into the furrows when they were in the body-centred cubic area (bcc), but at higher temperatures they became face-centred cubic (fcc) and thus much more flexible. According to the phase diagram, sulphide with 60 molar percent Ag_2S is already face-centred cubic at 119° C, and experiments at 200° C with niello of this composition (from 70% silver) showed it to be a particularly malleable material.

If the converted wires were only slightly deformed during inlaying then porosity still existed along the core of the wire, i.e. the converted wires had to be slightly larger than the furrows for the inlay to be completely compact.

Cast sulphide bars from alloys with 70% and 80% silver could be hot forged to sheets before inlaying. All the inlaying experiments with sulphide wires and strips were convincingly easy to perform.

It is also possible to carry out inlaying by rubbing together the pulverised sulphides, as has been tried in earlier research into the niello technique, but the process is difficult and the results poor. The sulphides were crushed in a mortar. Silver-copper sulphide and pure copper sulphide were brittle, but pure silver sulphide was very tough and unsuited to pulverisation. Attempts were made to fill out the furrows in sheet sterling silver with abundant powdered silver sulphide and silver-copper sulphide

Fig. 7 Detail of a lance point from Svenskens, Endre parish, Gotland (above). Close-up of spiral-like silver lamella from the transverse decoration of the lance point, magnification ca. 70x (left) (Oldeberg, 1966).

respectively. No binding agent was employed to hold the sulphide powder together, as this would have caused inclusions and the addition of a binder in the form of excess sulphur would have resulted in a blackening of the surrounding silver. The sterling silver, with the powder in the furrows, was heated on the hotplate and the powder was rubbed in using a burnisher. It was, however, necessary to fill up the furrows several times as the powder gradually became compressed. Cross sections showed that the powder had not become completely compacted, and that there were small spaces around the conspicuous powder particles.

Experiments with inlaying of furrows with molten silver-copper sulphide, to which borax had been added, only produced a spongy mass, because the sulphide powder did not melt readily. If the borax was replaced with modern flux intended for silver solder (550-750° C), reasonable results were achieved.

In comparison, crushed and powdered silver-copper-lead niello mixed with borax melted readily into the furrows. The product did however contain small air bubbles, just like those seen in 11th century inlays. As melted-on niello does not, as mentioned earlier, occur in the investigated Danish artefacts from the Iron Age, fluxes have not been subjected to further investigation.

Delicate silver inlays, in the form of small tubes etc., within the niello itself are seen in finds from other countries (Maryon 1972; Oddy et al. 1983; Roesdahl 1992, no. 31). Inlays such as these could be easily copied when the niello inlayed piece was heated whilst the silver pieces were beaten in. It was also possible to twist silver sulphide wire together with fine silver wire in a heated state, producing something which could resemble the starting point for the lamella-like inlays (fig. 7) which Oldeberg (1966) tried to explain on the basis of the then available description of the niello technique.

Microscopic investigation of the inlays produced in the experiments showed that the lead-containing sulphide made for comparison reacted and bound with the surrounding sterling silver, such that microscopic wedges formed down into the metal. There seemed to be a slight reaction between the copper in sterling silver and inlays of pure silver sulphide. The silver sulphide appears to bind closer to the furrows than the silver-copper sulphide.

Microscopic examination of inlays in furrows cut in 14 carat gold revealed a reaction between silver sulphide and gold and the good adhesion was already noticeable during inlaying. At 300-400° C, metallic gold in contact with silver sulphide will alloy with the silver according to the following reaction: $xAg_2S + yAu \rightarrow (Ag_{2x}\ Au_y) + xS$ (Gmelins Handbuch 1971).

The experiments showed, furthermore, that it was impossible to inlay niello containing silver sulphide in bronze (with 10% Sn). Even at a temperature of 200° C, the copper of the bronze rapidly reduced the silver sulphide so that the inlay became bright and shiny. The reaction in a heated state proceeds as follows: $Ag_2S + 2Cu \rightarrow Cu_2S + 2Ag$ (Gmelins Handbuch 1971). If, however, the furrow was in brass (with 35% Zn), the silver sulphide in the inlay was less influenced by the copper in the material because of the presence of zinc. La Niece (1983) does not consider there to be any technical difficulties associated with applying silver-containing niello to copper alloys, despite the fact that Moss (1953) was not able to melt silver-copper-lead sulphide on to copper and bronze. He had more success with brass even though the niello did not flow as well as on silver.

Radiographs of the inlaid sulphide samples showed, as one would expect, that the silver-copper sulphides are more easily penetrated by the x-rays than pure silver sulphide and lead-containing sulphides. Radiographs may be able to reveal toolmarks under the niello if the inlaid objects are not too thick.

NIELLO ANALYSES ON ARTEFACTS AT THE NATIONAL MUSEUM

Most of the National Museum's niello-inlaid artefacts from the Iron Age are of silver or silver-plated bronze and the majority are further decorated with fire gilding. There is, in addition, a cast bronze reliquary cross and a pair of gold rings dating from the transition to the Nordic Middle Ages. On the basis of a visual examination of 67 artefacts, a representative group of 21 was chosen for analysis. Two or more very small particles of niello were removed with a scalpel in the same area of each item. The analytical equipment used was a scanning electron microscope linked to an EDAX x-ray detector (Philips SEM 505 with EDAX 9100). After the first round of analyses it was found that improved results were achieved if the surface of the samples was scraped gently with a scalpel to remove foreign material. During preliminary niello analyses in 1991, three objects from Jelling were analysed by placing them directly in the SEM chamber. The analyses were then carried out directly *in situ* on the niello surface.

Where the analyses revealed small amounts of Mg, Cu, Al and Si as impurities, these have not included in the results table (fig. 8). This is because these traces could be due partly to the presence of soil particles, partly to the cellulose adhesive used to hold the small particles during the analysis, and in the case of Al, partly also to the analysis chamber. The sulphur content in the sulphide minerals present can be calculated from the molar weight of the elements (fig. 9). In general, the calculated sulphur content corresponds to that found in the analyses of the artefacts. However, niello can, as mentioned, contain metallic silver and therefore have a lower sulphur content than expected. This is particularly apparent in the analyses carried out on the surfaces of the strap ornaments from Jelling and the Bonderup pendant cross which also had a bright silvery sheen on the niello-inlaid surfaces.

The oldest niello-inlaid artefacts at the National Museum are three very different silver fibulae, all of which have been imported. The silver fibula from a woman's grave from Røgnehøj, Funen, is from the late Roman Iron Age (mus. no. 59/09). Its simple niello pattern of straight lines and arcs is of silver sulphide. The slightly later silver fibula from a woman's grave from the 3rd century AD from Årslev, Funen (mus. no. 8568) also contains silver sulphide, but the niello is inlaid as more variable broad fields with diverging spirals and a narrow punched border (Storgaard 1990). The undulating margins with spirals must have been produced from very broad bands of silver sulphide. A fibula in gilded silver from the 5th century AD, found at Skjerne, Falster(mus. no. C288), contains silver sulphide, in a uniform repeating pattern of lines plus circles enclosed by interlocking arcs.

On the fibula from Skjerne, it is clear that the fire gilding was applied after the niello, as parts of the niello decoration on the side of the arch was never cleared of gold (fig. 10). Where fire gilding and niello are part of the ornamentation, this sequence is usual, as documented by Oddy et al. (1983). The gold amalgam applied to the object was heated to above the boiling point of mercury, 356.9° C, and the areas to which niello had already been applied were then scraped free of gold. Mercury from the gilding can be seen in some of the niello analyses (Oddy & Meeks 1983), as it can spread over the whole object. On the strap ornaments from Jelling there was, for example, a significant mercury content in and on the cast silver, including the now empty niello furrows.

Weapon accessories from the sacrificial bogs at Nydam, Kragehul and Ejsbøl-Syd, dating from around 450 AD, include large numbers of closely-related objects in fire gilded cast silver with Nordic

Analysed objects	"number of analyses"	S	Ag	Fe	Cu	Au	Pb	others
59/09, fibula, Røgnehøj	1	10.2	88.3	0.9	0.7			
8568, fibula, Ørslev	1	13.1	86.9					
C288, fibula, Skjerne	1	14.8	85.3					
NV448, scabbard mount, Nydam	2	15.6	34.3	12.8	37.4			
NV958, button, Nydam	2	18.5	36.1	16.0	29.3			
NV6, belt buckle, Nydam	3	19.9	27.4	24.4	28.3			
NV1, scabbard mount, Nydam	3	12.0	22.3	4.7	61.0			
NV14, clasp, Nydam	3	16.4	27.6	12.9	36.6			6.5 Zn
12524, fibula, Gummersmark	1	11.6	88.4					
C6, fibula, Bornholm	2	14.1	14.0	0.3	65.4			7.1 Hg
10/40, square strap mount, unknown site	3	9.5	50.6		36.6			1.6 Hg
C325, oval brooch, Holbæk county	3	12.7	64.2		23.0			
CCCLXXII, beaker, Jelling, niello on silver	1	11.3	63.0	6.0	19.7			
same, niello on gilding	1	12.0	68.7	8.6	10.6			
Strap ornament A, Jelling	3	8.5	86.6		1.1		0.4	2.3 Hg
Strap ornament B, Jelling	1	2.8	84.2		3.1		0.5	7.7 Hg
J.nr.7375/92, trefoil sword mount, Trabjerg Bakker	1	13.1	86.9					
16370, penannular brooch, Mølleløkken	1	12.0	88.0					
D97-1982, mount, Lundby Krat	2	12.3	87.7					
14190, Bonderup Cross	1	6.6	32.8		60.6			
D12124, Randers Cross	2	13.2	50.0	0.4	35.6			0.9 Zn
MCMXXX, gold ring, Snoghøj	1	12.0	83.0		0.8	4.2		

Fig. 8 Results of the EDAX analyses of niello from 21 artefacts, given as percent by weight. Where there are several analyses from an object a calculated average is given. Small amounts of Mg, Ca, Al and Si have been omitted from the table.

Minerals	S	Ag	Fe	Cu
acanthite, Ag_2S	12.94	87.06		
jalpaite, $Ag_{1,55}Cu_{0,45}S$	14.07	73.38		12.55
mackinstryite, $Ag_{1,2}Cu_{0,8}S$	15.10	60.96		23.95
stromeyerite, $Cu_{1.07}Ag_{0,93}S$	16.01	50.05		33.94
chalcocite, Cu_2S	20.14			79.86

Fig. 9 For the purposes of comparison with the niello analyses in fig. 8 the sulphur content in the corresponding minerals has been calculated.

animal ornamentation, carved relief and with niello inlay. Five items from Nydam, excavated in 1990-1991 (fig. 11) (Rieck 1994; Vang Petersen 1994), were analysed (NV6, 448, 958, 1, 14). The inlays were of silver-copper sulphide with a substantial iron content which will be dealt with later. Like La Niece (1983), I believe that in this period, when the sulphides appear with a significant copper content, it must be an intentional alloying.

The appearance of the niello pattern on the weapon sacrifices is different from that described earlier, in that there are quite narrow inlaid patterns of punched semi-circular marks and opposing triangular depressions (zig-zag pattern). Niello inlay must have been a particularly popular form of ornamentation with the warriors who were defeated and whose weapons were thrown in to the bogs as sacrificial gifts.

It is possible to follow the similar carved reliefs and animal ornamentation with niello inlay in zigzag patterns etc. through the many fibulae from the 6^{th} century, for example mus. no. C6, which is inlaid with silver-copper sulphide. Many fibulae come from graves on Bornholm and areas close to the Baltic Coast, including, in particular, many Swedish finds from Gotland.

Fig. 10 The fibula from Skjerne (mus. No. C288) with niello also on the side of the arch. Under production, partly gold-covered niello has been left after the fire gilding. The length of the fibula is 15 cm. Photo Svend Erik Andersen.

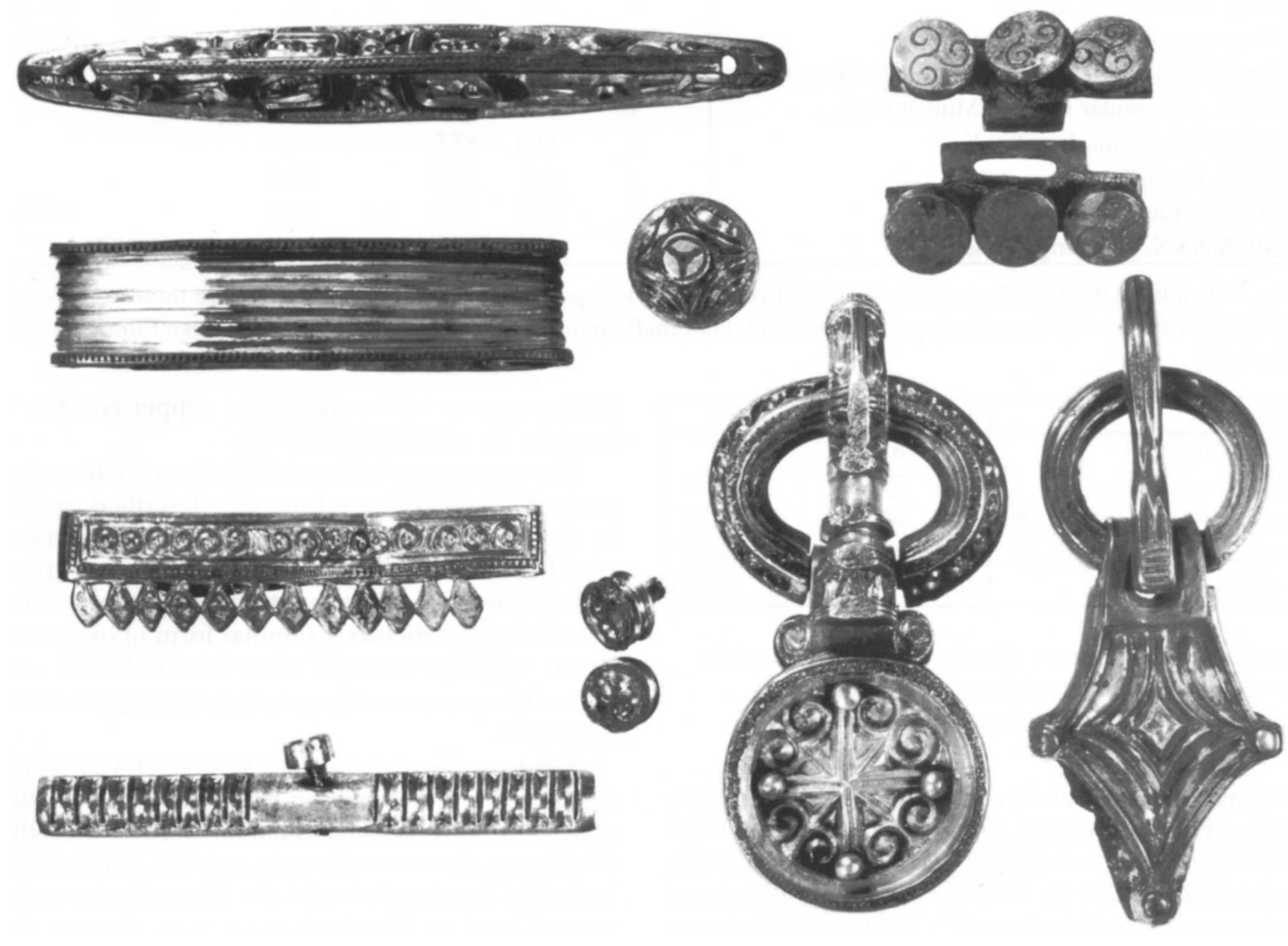

Fig. 11 From a number of different niello-inlaid weapon mounts and ornaments excavated in Nydam Mose in 1990-91, five of the above shown niello inlays have been analysed. Photo Kit Weiss.

Fig. 12 The trefoil sword mount (J.no. 7375/92) from Trabjerg Bakker, Jutland (breadth 5.9 cm). The piece had only been partially cleaned with a scalpel, so the corrosion layer could be investigated before the conservation work was completed. Photo John Lee.

La Niece (1983) found silver-copper sulphide niello on seven out of eight Swedish artefacts from this period, including a scabbard mount and a fibula from Sjörup, as well as three fibulae from Gillberga, Häste and an unknown site. The Swedish artefacts can thus, both in form and niello composition, be compared directly with the Danish finds. An exception to this, where the niello is in the form of pure silver sulphide, is however the fibula from Gummersmark (mus. no. 12524) with some special traces in the inlay which will be discussed later.

From the 7th century, there are some square bronze cross-strap mounts, where a thin covering of sheet silver forms the underlay for niello decorations with zig-zag patterns. The analysed mount (mus. no. 10/40) contains niello of silver-copper sulphide.

The artefact groups from around the 5th to the 7th centuries are related in form and have narrow bands of punched inlays. On the basis of the above mentioned analyses it appears likely that silver-copper sulphide is the most utilised niello type in this period, and the experiments proved this mixed sulphide to be exceptionally pliable and thus suitable for detailed inlays.

Among the Viking Age finds at the National Museum, there are many different silver artefacts inlaid with niello. Analysis of some of these inlays showed, in addition to silver-copper sulphide, also several inlays of pure or almost pure silver sulphide. The artefacts concerned are a trefoil sword mount from Trabjerg Bakker (J.no. 7375/92) (fig. 12), two strap ornaments from Jelling Church, the large 10th century penannular brooch (mus. no. 16370) and the crumpled sheet metal mount from Lundby Krat (mus. no. D97-1982). The silver sulphide inlays on these objects appear in very regular, relatively plain bands.

The Jelling beaker (mus. no. CCCLXXII) has rather less regular engraved lines and the inlay is of silver-copper sulphide. Niello analyses were, as mentioned earlier, carried out directly on the surfaces of the beaker and the strap ornaments in 1991, and the niello analyses from the beaker showed, in addition to silver-copper sulphide, the presence of 6% and 8.7% iron.

The beaker has, in addition to the niello inlays in the silver itself, also niello inlays in shallow depressions on bands of gilding. The smooth delimited lines of sulphide do not appear to be the result

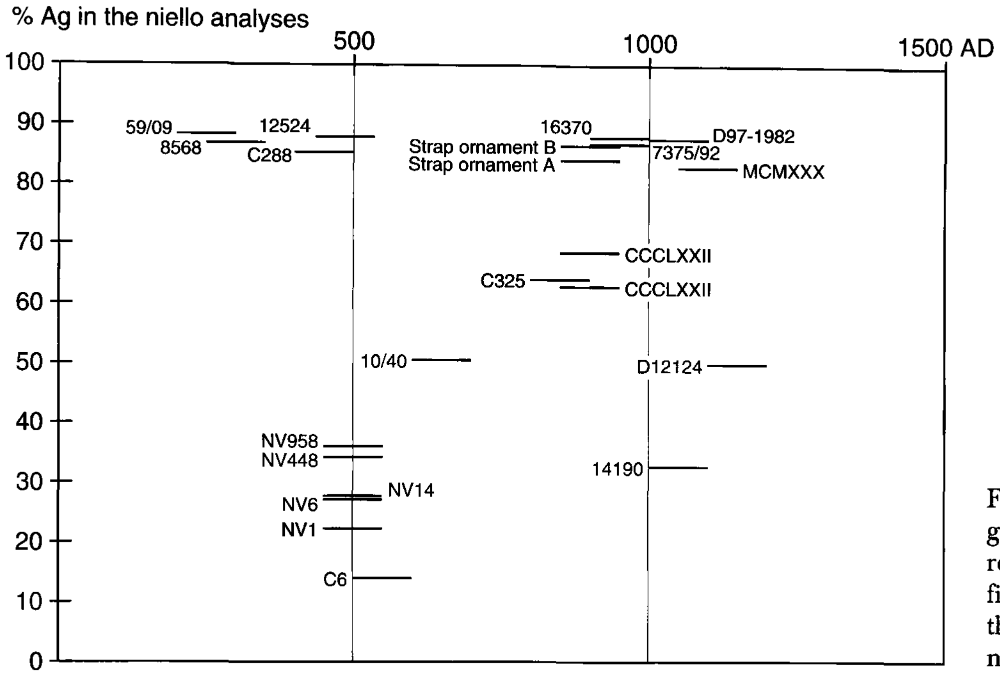

Fig. 13 A chronological graphical presentation of the results of the analyses from fig. 8 arranged according to the silver content in the niello.

of corrosion. The fact that niello can be applied over gilding seems not to have been described previously, but contributes to proving that niello was applied below a temperature, which could cause the already applied gilded areas to dissolve into the underlying silver. The beaker will be deskribed in: Krogh & Leth-Larsen, Vikingekongernes monumenter i Jelling, vol. II.

A very simple pattern of lines in niello on a silver-plated bronze oval brooch (mus. no. C325) consists of silver-copper sulphide. On the silver-plated bronze oval brooches and mounts for harness bows from Mammen (mus. no. C1063) (where the niello has not been analysed), the furrows in the silver are, in several places, cut so deeply that the niello is in direct contact with the underlying bronze.

The niello on the cast silver pendant cross from Bonderup (mus. no. 14190) is engraved with designs in the Ringerike style with the inlay consisting of silver-copper sulphide.

The 12th century Randers Reliquary cross (D12124) is of cast brass, inlaid with silver-copper sulphide niello, just like the Irish St. Cuillean's Bell in iron and brass, dating from the end of the 11th century, which was investigated by Moss (1953) (Roesdahl, 1992 no. 430). The ornamentation of the Randers Cross has been compared with British and Irish artefacts (Lindahl 1990). The choice of brass rather than bronze as an underlay for the sulphides must, as already mentioned, be because the zinc content of the brass prevents a reaction between the silver sulphide and metallic copper.

The National Museum has faceted finger rings in gold, silver and gilded copper, dating from the transition between the Viking Age and the Medieval Period, which bear inscriptions filled out with niello. In the gold ring from Snoghøj (mus. no. MCMXXX), which dates from the end of the 12th century, pure silver sulphide has been inlaid in the engraved letters. A detected gold content in the niello must come from a reaction with the underlay. According to La Niece's (1983) comprehensive list of analyses, gold only appears in niello inlays on gold artefacts, and up until the 13th century, these inlays consist solely of silver sulphide. The ring from Snoghøj is thus consistent with this pattern of events. In "Mappae Clavicula", chapters 195 and 196 (Smith & Hawthorne 1974) a distinction is made between whether the underlay is of gold or of silver. With the former, use of the most silver-rich silver-copper sulphide is recommended.

The graphical presentation of the results of the analyses (fig. 13) has been modified with respect to that of Schweizer (1993) (fig. 1) in that it was possible here to plot the silver content on the y-axis. In this way it is made clear that the group containing pure or almost pure silver sulphides stands apart from the copper-containing sulphides. There is a noteable shift in the sulphides used though time, which is in agreement with earlier analyses.

The niello analysed from Nydam Mose showed a significant iron content within the silver-copper sulphide (fig. 8). In an EDAX analysis technique, revealing the distribution of individual elements, it could be seen that the iron is located in the most copper-rich phase. With the present state of our knowledge of the corrosion of sulphides, it cannot be determined whether the iron could come from the manufacturing process, or from the local concentration of corroded iron in the burial of Nydam Mose. Although, according to the phase diagram, fig. 5, there should be no free copper in the niello inlay with which the iron in the earth could bind.

Arne Jouttijärvi has carried out a niello analysis on an animal-formed brooch from Lindholm Høje on behalf of Aalborg Historiske Museum. The silver-copper sulphide contained 2.9% iron, which with point analysis with EDAX was also found to be bound to the most copper-rich phase of the niello.

Schweizer (1993; Lazovic 1977) has previously demonstrated iron contents of up to 4.7% on the surfaces of Byzantine silver sulphide niello, and Newman et al. (1982), using emission spectrography, found traces of iron on Byzantine niello of both silver sulphide and silver-copper sulphide.

THE MICRO-TOPOGRAPHY OF THE INLAYS

As niello inlays on artefacts found in the soil can be confused with corrosion in the form of sulphides, it is useful to have some diagnostic micro-topographical characters. On bronze artefacts, silver coating is, for example, used as an underlay for the niello decoration, because, as mentioned earlier, it is not possible to apply silver-containing sulphides directly to bronze.

The mount from Lundby Krat (mus. no. D97-1982) is forged and only ca. 1mm thick, in contrast to the majority of objects containing niello, which are cast and are considerably thicker, and thus would have been able to retain heat for some time during application of the sulphide.

As a rule, the inlaid areas occur on raised or flat surfaces, so later smoothing out or scraping of the inlaid material was possible.

Oldeberg (1966) observed niello which occurred above the level of the copper alloy in which it was inlaid and it could be, as he presumes it to be, a result of corrosion of the surrounding metal. Slight differences in level were seen on some Danish artefacts, perhaps because the niello had not been scraped completely flush with the surrounding metal. Smith & Hawthorn (1974) state that in European niello work the decoration lies flush with the rest of the surface, whereas they noticed that in some Sassanian and Byzantine pieces, the niello stood in relatively high relief.

There have been several descriptions of the furrows in the metal underlay. Smith & Hawthorne (1974) saw inlays that were prepared by coarse chisel work to ensure good adhesion in the furrows. La Niece (1983) describes punchmarks which probably correspond to the punched depressions referred to in this investigation. Silicone casts of the tool marks on the strap ornaments from Jelling revealed that a graver with a flat edge had cut the regular notches (Leth-Larsen & Krogh in print). Several other artefacts examined have similar furrows with a rectangular cross-section and notches. Both punched patterns and engraved notches produce uneven surfaces in the furrows, which help, to a certain extent, to anchor the niello. Despite this, there are also niello inlays in furrows with, for example, v-shaped cross-sections cut with a pointed graver and with furrows which are unbroken and quite smooth.

There are several similarities between the encrustation technique and niello inlay. For example, on the silver penannular brooch (mus. no. 16370), three spheres have niello inlay over almost all their surface. These correspond to the closely spaced spiral furrows for inlaying metal wire described by Holmqvist & Arrhenius (1964). According to them, encrustation was a technique commonly-used by Nordic craftsmen from the 5^{th}-12^{th} centuries AD, but apparently with declining popularity in the 6^{th} to 9^{th} centuries. Because of the widespread use of niello in punched patterns around the 6^{th}-7^{th} centuries, it seems likely, that the craftsmen continued using the same inlaying technique, but with niello instead of metal wire. A relationship between the two techniques is also gathered from studying Allan's (1977)

Fig. 14 The fibula (mus. no. 12524) from Gummersmark, Zealand (length 15.5 cm). On the close-up the arrows show that in every inlaid triangular depression there is a cavity in the niello. As the niello is shiny, this appears lighter on the picture. Photo John Lee.

investigation of early Islamic craft traditions. He describes how silversmiths in 11th century had to abandon niello inlay on silver objects, as silver became scarce and expensive, in favour of encrustation work on brass objects.

Experience gained from converting silver wire to sulphide in molten sulphur, suggests that this manufacturing technique could be the reason why on some artefacts there are porous areas running longitudinally in the centre of the inlay. Likewise there is some special repeated flaws on the inlays on the small punched zig-zag patterns on the fibula from Gummersmark (mus. no. 12524). There is a distinctive cavity in the centre of every triangular inlay, fig. 14. In contrast to the other analysed niello inlays with zig-zag patterns of silver-copper sulphide, the niello here consisted of silver sulphide. The repeated cavity might be the result of inlaying a hollow wire, but could certainly not have been produced by rubbing silver sulphide powder into the depressions or by a melting process.

Medieval lead-containing niello appears rather more blue-black than earlier niello of silver sulphide and silver-copper sulphide. This could be the reason that the early types are often found together with fire gilding, so that the colour contrast was accentuated.

BREAKDOWN OF INLAID NIELLO

The sulphides are thought to be stable and are not altered in the soil, but metallic silver, which can occur in the niello matrix will be subject to corrosion in the same way as, for example, the silver object in which the niello is inlaid. The presence of metallic silver on and in the niello on some of the artefacts means that the inlays are not dark. The circumstances regarding niello destruction have been described in several publications.

According to Oddy et al. (1983), care has to be taken in interpreting analyses carried out directly on niello surfaces. The inlay on the large drinking horn from Sutton Hoo consisted solely of silver chloride at the surface, whereas inside it consisted of silver sulphide. Oddy & Meeks (1983) consider it probable that the growth of silver chloride crystals on the surface arises from corrosion of the surrounding silver. In its raw (i.e. uncleaned) state the trefoil sword mount (J.no. 7375/92), fig. 12, had no free silver in the sulphide which appears to be quite intact. The surface covering of silver chloride must therefore stem from the surrounding cast silver.

La Niece lists the reasons why metallic silver occurs in niello as follows: not all the silver has been converted to sulphide during production; silver sulphide is unstable at the elevated temperatures which can arise during inlaying; a possible chemical reduction occurs during certain conservation treatments of the artefacts. With reference to the latter, the strap ornaments from Jelling and the Bonderup Cross (mus. no. 14190), among others, have silver coatings over the niello inlays, which it is hard to imagine were there when the decorations were new. In 1979, the strap ornaments from Jelling were treated by electrolysis in an EDTA solution to remove heavy green corrosion. The metallic silver uppermost in the niello could be a result of this method of cleaning. Half of the niello particle investigated by Jouttijärvi (1995) from the animal- shaped brooch from Lindholm Høje, was of metallic silver, whilst the rest was of silver-copper sulphide with the abovementioned iron content. It must be presumed that it was the uppermost half which was of silver, as previous surface analyses of the inlays have only revealed silver. Most of the niello investigated during this project was however well preserved, including the newly-conserved artefacts from Nydam Mose. The situation regarding corrosion and conservation should be investigated further in connection with new finds.

CONCLUSION

Studies of the common features of the artefacts and the tool marks seen on them, support the theory proposed here with regard to inlaying niello in the Iron Age. Through a discussion of the characteristics of the sulphides and the results of the experiments, it has been demonstrated that Iron Age niello inlaying was in all probability carried out using heated sulphides in strip form. On the raised edge surfaces, for example between carved ornamental reliefs, it would have been impossible to apply sulphides in the form of powder or in a molten state. Furthermore, silver sulphide is quite unsuitable for crushing to powder.

Silver sulphide is easy to produce from silver, which in solid form is exposed to sulphur vapour or molten sulphur. Because silver-copper sulphide is more difficult to make by this method, it apparently was produced by fusion, as described by Pliny (Rackham 1968). This suggests therefore that the changes which the analyses have revealed in niello inlays through time reflect corresponding and significant shifts in production techniques.

The fact that pure silver sulphide decomposes less readily at high temperatures than niello containing copper, perhaps explains why quite pure silver sulphide was the preferred material for early Iron Age inlay, where the work was carried out at high temperatures. From the experiments it appeared that silver sulphide binds closer to the furrows than the silver-copper sulphides. This relationship, as well as the fact that silver sulphide does not decompose so readily at high temperatures and is quite easy to produce, can be the reason why pure silver sulphide was preferred during a substantial part of the Iron Age.

From the middle of the 5th century onwards a significant copper content is found in the niello. The silver-copper sulphide becomes very pliable, and thus suitable for use in detailed inlays, at relatively low temperatures where there is little danger of decomposition.

Whilst bronze is unsuitable as an underlay for silver-containing niello and has to have a silver coating applied before it can be ornamented, brass can be inlayed directly. With the knowledge we have amassed so far regarding the good adhesion of silver sulphides on gold, it would be interesting in the future to conduct a search among Viking Age finds for technical parallels to the Jelling beaker with its niello inlay over gilt silver. It will also require further analyses of Viking Age niello before we are able, in collaboration with archaeologists, to elucidate the parallel use of silver sulphide and silver-copper sulphide during this period.

An explanation for the substantial iron content in the niello from Nydam Mose could possibly be found by carrying out future analyses of the newly found weapon fittings from the bog and other well documented niello finds.

The Iron Age techniques which have been outlined here, can also be of interest to present-day craftsmen, in the light of reservations concerning the health risks associated with the more well-known lead-containing niello.

SUMMARY

In previous research much attention has been focused on the nature of niello and the medieval easily-meltable lead-containing sulphides have been thoroughly investigated. The technological investigations described here were inspired by observations made on archaeological artefacts and by studies of the literature on the chemistry of sulphides. Silver sulphide can be produced by conversion of solid silver in molten sulphur, but this sulphide will decompose in air before it melts. Even though it is possible to produce silver-copper sulphide in the same manner, this form of niello was probably manufactured by fusion of the components. The changes through time which the niello analyses have revealed seem therefore to reflect a corresponding shift in production techniques. With the practical use of the phase diagram Ag_2S - Cu_2S it can be demonstrated that the encrustation technique, which was the technique used in the Iron Age for decorative inlaying of metal wire, could also have been applied to the inlaying of both silver sulphide and silver-copper sulphide in a heated state.

The sulphides bind or react differently with the surfaces of different metals, which explains the choice of materials for niello-inlaid artefacts.

Analyses of Danish niello-inlaid artefacts from the Iron Age revealed unanimously the same changes in sulphide composition through time, as demonstrated in analyses from other countries. The artefacts with niello inlay found at Danish sites dating from the end of the 5th century until the 7th century are related in their Nordic ornamentation and many are thought to be inlaid with silver-copper sulphide. There is a substantial iron content in the sulphides from Nydam Mose, which might be a result of a corrosion phenomenon.

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LITTERATURE

Allan, James W. 1977: Silver: the key to bronze in early islamic Iran. *Kunst des Orients, II.* pp. 5-21.

- 1979: *Persian metal technology 700-1300 AD.* Faculty of Oriental Studies and Ashmolean Museum, University of Oxford. Ithaca Press, Oxford, pp. vi-vii, 19-20.

Ashbee, C.R. 1967: *The treatises of Benvenuto Cellini on goldsmithing and sculpture.* Dover Publications, Inc., New York, pp. 1-9.

Dennis, J.R. 1979: Niello: a technical study. *Papers presented by trainees at the Art Conservation Training Programs Conference.* Center for Conservation and Technical Studies, Fogg Art Museum, Harvard University, pp. 83-95.

Gmelins Handbuch der anorganischen Chemie. 8th ed., 1971: Silber Teil A3. Verlag Chemie, Weinheim/Bergstrasse, pp. 18-21, 51.

Gmelins Handbuch der anorganischen Chemie. 8th ed., 1973: Silber Teil B3. Verlag Chemie, Weinheim/Bergstrasse, pp. 2-5, 18-21 og 51.

Gmelins Handbuch der anorganischen Chemie. 8th ed., 1974: Silber Teil B4. Springer-Verlag, Berlin, Heidelberg, New York, pp. 458-470.

Hawthorne, John G. & Cyril Stanley Smith 1963: *On divers arts, the treatise of Theophilus.* The University of Chicago Press, Chicago, pp. xv-xxv, 104-115.

Holmqvist, Wilhelm & Birgit Arrhenius 1964: *Nordiskt guldsmide.* Historiska Museet, Stockholm, pp. 15-18, 25-27.

Jouttijärvi, Arne 1995: Heimdal Arkæometri, Skovledet 30, DK-2820 Virum, pers. comm.

Krogh, Knud J. 1994: Gåden om Gorms grav. *Vikingekongernes monumenter i Jelling.* Vol. Poul Kristensens Forlag, København, 272 pp.

La Niece, Susan 1983: Niello: An historical and technical survey. *The Antiquaries Journal,* Vol. 63, No. 2. Oxford University Press, London, pp. 279-297.

Lazovic, M., N. Durr, H. Durand, C. Houriet, & F. Schweizer 1977: Objets byzantins de la collection du Musée d'arts et d'histoire. *Genava,* Vol. XXV, nouvelle série, Musée d'art et d'histoire, pp. 5-62.

Leth-Larsen, Bodil & Knud Krogh in press: *Vikingekongernes monumenter i Jelling,* Vol. II.

Lindahl, Fritze 1990: Relikviekors og fingerringe. In Johannsen, Hugo (Ed.): *Synligt og usynligt, studier tilegnet Otto Norn.* Poul Kristensens Forlag, Herning, pp. 1-10.

Maryon, Herbert 1972: Fine metal-work. Singer, Charles et al. (ed.): *A history of technology,* Vol. 2. Clarendon Press, Oxford, (org. 1957), pp. 449-484.

Moss, A.A. 1995: Niello. *Studies in Conservation.* Vol. 1, No. 2, The International Institute for the Conservaton of Museum Objects, London, pp. 49-61.

Newman, R., J.R. Dennis, & E. Farrell 1982: A technical note on niello. *Journal of American Inst. of Conservation.* Vol. 21, No. 2. AIC, pp. 80-85.

Oddy, W.A., M. Bimson & S. La Niece 1983: The composition of niello decoration on gold, silver and bronze in the antique and mediaeval period. *Studies in Conservation,* Vol. 28, No. 1. The International Institute for Conservation of Historical and Artistic Works, London, pp. 29-35.

Oddy, W.A. & N.D. Meeks 1983: Report on the scientific examination of the metal fitments of the drinking-horns. In Bruce-Mitford, R.L.S. (Ed.): *The Sutton Hoo Ship Burial,* Vol. III. British Museum, London, pp. 396-401.

Oldeberg, Andreas 1966: *Metallteknik under vikingetid och medeltid.* Victor Pettersons bokindustri AB., Stockholm, pp. 196-203.

Rackham, H. 1968: *Pliny, natural history.* Vol. IX, Book XXXIII. William Heinemann Ltd., London, pp. 98-99.

Rieck, Flemming 1994: *Jernalderkrigernes skibe. Nye og gamle udgravninger i Nydam Mose.* Vikingeskibshallen i Roskilde, Holbæk, 72 pp.

Roesdahl, Else (Ed.) 1992: *From Viking to Crusader, Scandinavians and Europe 800-1200.* Nordisk Ministreråd, København, 432 pp.

Rosenberg, Marc 1972: *Geschichte der Goldschmiedekunst auf Technischer Grundlage.* Heft 5 & 6. Otto Zeller Verlag, Osnabrück, (org.1924-5). pp. 1-96 & 1-104.

Schwarz, Robert & Alfonso Romero 1927: Zur Kenntnis der Tulalegierung. *Zeitschrift Für Anorganische und Allgemeine Chemie,* CLXII. Leipzig, pp. 149-160.

Schweizer, François 1993: *Nielle byzantin: étude de son évolution.* Musée d'art et d'histoire: *Genava,* Vol. XLI, nouvelle série, pp. 67-82.

Skinner, Brian, J. 1966: The system Cu-Ag-S. I: Bateman, Alan Mara et al. (Ed.), *Economic Geology,* Vol. 61, No. 1, The Economic Geology Publishing Company, New Haven, Connecticut, pp. 1-26.

Smith, Cyril Stanley & John G. Hawthorne 1974: *Mappae Clavicula, a little key to the world of medieval techniques.* The American Philosophical Society, Philadelphia, pp. 36-58.

Storgaard, Birger 1990: Årslevfundet. *Årbøger for nordisk oldkyndighed og historie.* Det Kongelige Nordiske Oldskriftselskab, København, pp. 20-58

Toll, Christopher 1968: *Die Beiden Edelmetalle Gold und Silber, Al-Hamdānī.* Almqvist & Wiksells Boktryckeri AB, Uppsala, Chapter XXXIV.

Vang Petersen, P. 1994: Einige Ergebnisse der neuen Ausgrabungen im Mooropfer von Nydam, Südjütland (Dänemark). *Beitrage zu römischer und barbarischer Bewaffnung in den ersten vier nachchristlichen Jahrhunderten.* Marburger Kolloquium 1994, Lublin/Marburg, pp. 249-259.

Wilson, H. 1948: *Silverwork and jewellery.* Sir Isaac Pitman & Sons, Ltd., London, pp. 315-320.

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Medieval castles and castle mounds on the islands south of Fyn
The situation after 50 years' archaeological investigations

by Jørgen Skaarup

INTRODUCTION

Castles of the Middle Ages occur all over Denmark. About a thousand such structures are recorded, although the original number may well have been significantly higher, with some examples having been demolished at such an early date that agricultural activity in later centuries has erased every surface trace of them.

Despite the facts that excavations have been carried out at some sites – usually only in large and historically famous castle ruins – and that the written sources concerning the history of the castles have been studied minutely, there are still large gaps in our knowledge of the construction of castles and fortified homesteads in Denmark in the period 1000-1500. The variety of structures is also wide, from rather small, anonymous mottes with traces of a simple timber building to the Archbishop's massive Hammershus.

Firm information about individual sites is usually sparse. The written sources provide accounts almost exclusively of the royal or episcopal castles, and leave the other sites undocumented in respect of their date of construction, their appearance, their functioning period, their purpose and their ownership. A number of attempts to date these castle mounds by typological means, with reference to well-dated sites of north-western Europe, have all ended in failure as the types in Denmark have proved to span a very long period. As a result, it is only through a suitably targeted archaeological programme that new information about the date and use of the castles could be won. Such a programme would appropriately concentrate on the ploughed-over moated sites which are threatened with total erasure to begin with, but should also include the areas around the castles where in a number of cases it has been possible to uncover traces of contemporary buildings.

CASTLE STUDIES ON THE ISLANDS SOUTH OF FYN

One of the most substantial attempts at a systematic examination of all the fortified sites and castle mounds within a defined area began on the islands south of Fyn fifty years ago. The work is still far from complete, but it has nevertheless produced so many fascinating results that it is now time to summarize the most important of them.

There are remains of medieval castles on the three largest islands in the archipelago south of Fyn. Ærø has at least six sites and Tåsinge two, perhaps three, while Langeland, where in the late Middle Ages there were 35 noble seats in addition to Tranekær Castle (Lütken 1909:139), produces no less than fourteen such structures, three of which are still built upon (Fig. 1). Archaeological investigations have

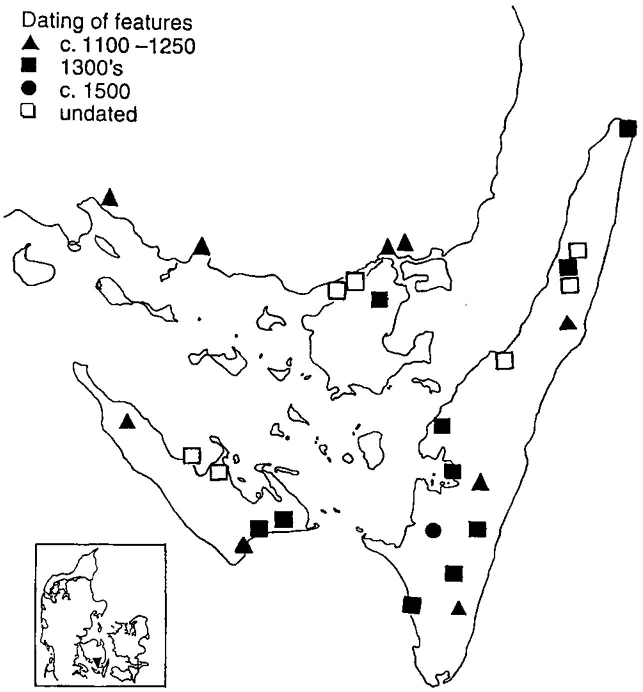

Fig. 1 Medieval castles and castle mounds on the islands south of Fyn.

been undertaken at half of these 23 castles or mottes. There is information about the remains of buildings or finds recovered in a more haphazard manner from five further sites.

FORTIFIED MOUND AND CASTLES OF THE EARLY MIDDLE AGES

From the early Middle Ages, i.e. the period 1050-1250, five castles are known at present, three from Langeland and two from Ærø. The best known of these is the still extant Tranekær Castle in northern Langeland, with substantial building-remains from the thirteenth century. This castle or fort was mentioned as early as the 1230's as Crown property, and was probably founded together with the castles and fortified boroughs at Fåborg, Vordborg and Svendborg in southern Fyn recorded in 1229 (Jansen 1973:43) for the purpose of guarding the royal interests in this part of Denmark.

Tranekær was built on a natural hill 9 metres high which now has an almost rectangular surface as a result of quarrying. The defensive facilities of this hill were reinforced by the construction of a moat at its foot. A dam west of the castle mound was also included in the defensive works as it served to produce a lake which provided water for the moat as well as for the castle mill. This dam also served as a barrier for north-south traffic on the island which could thus easily be controlled from the castle.

Of the brick castle from the time of Valdemar, the main building to the north and a massive outer wall with remains of a guardway to the west still stand. In the Middle Ages, however, there were also walls along the south and east sides of the hill, completely enclosing the castle site. The early fortifications also included a six-storey-high, round brick tower with very thick walls which stood in the northwestern quarter of the castle court until the 1640's (Fig. 2). Architectural studies of the north wing in the 1970's have also shown that this is one of Denmark's best preserved palaces of the early Middle Ages (Stiesdal 1975).

While the later history of the brick castle and its gradual conversion from a fort and royal administrative centre to a noble castle is fairly well understood, it was only as a result of archaeological work in 1965 that it was revealed that a fortified structure had preceded the brick castle on the hill.

In spite of comprehensive later quarrying of the upper surface of the castle mound, it was possible here to uncover traces of a dry, V-shaped, east-west ditch which apparently divided the hilltop in two. At the same time, postholes and remains of floors with no brick fragments in the northern part of the hill testified to the presence of large timber buildings which, on the basis of the potsherds, may date to the first half of the twelfth century. Tranekær could, therefore, very well have been founded as early as the reign of – perhaps by? – King Niels (1104-1134).

The investigation of another, presumably royal, castle, Søby Volde on Ærø, in 1983, corroborated the dating of the first phase at Tranekær. This impressive and very well-preserved moated site is situated on the southernmost part of a long range of hills which stretches northwards out towards the dried up Vitsø cove. This cove was apparently still navigable at the beginning of the eighteenth century and, as the museum's excavations in the innermost part of the cove show, functioned as an un-

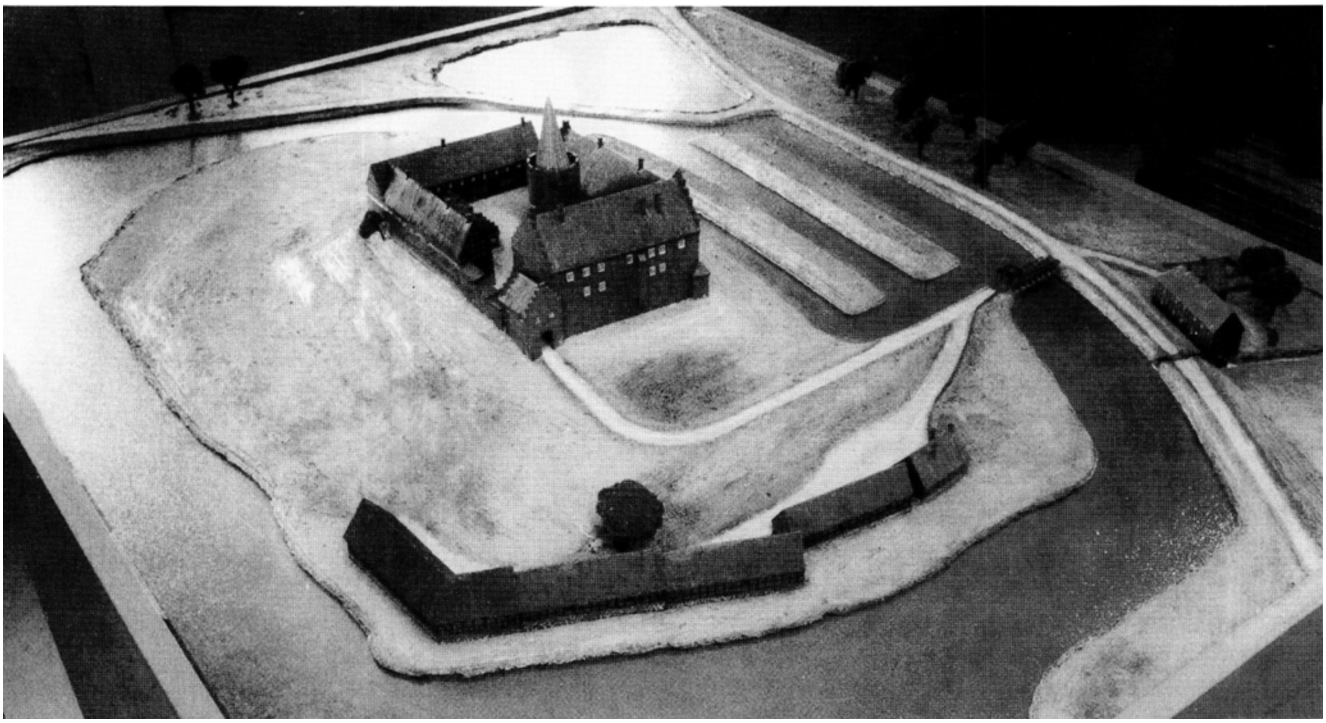

Fig. 2 The appearance of Tranekær around the year 1500. View from the north-east. After a model constructed by conservator B. Felsted in collaboration with the author.

Fig. 3 Søby Volde from the air, with the dried-up Vitsø cove upper right. Photo: H. Stiesdal 1959.

loading site and harbour for sea-traffic over the western Baltic as far back as the Iron Age (Skaarup 1979; 1981).

Søby Volde consists of three main units (la Cour 1972:205). Furthest south is an almost trapezoid castle mound with sheer sides which rises about 10 metres above the surrounding terrain. The top of this mound is enclosed by a strong ring bank, the fill of which appears to have been held in place on both sides by a substantial plank revetment. A row of deep postholes placed at intervals of a couple of metres along the inner side of the bank may have supported an internal walkway which would have enabled the defenders to move their forces around more easily under the cover of the rampart when under attack.

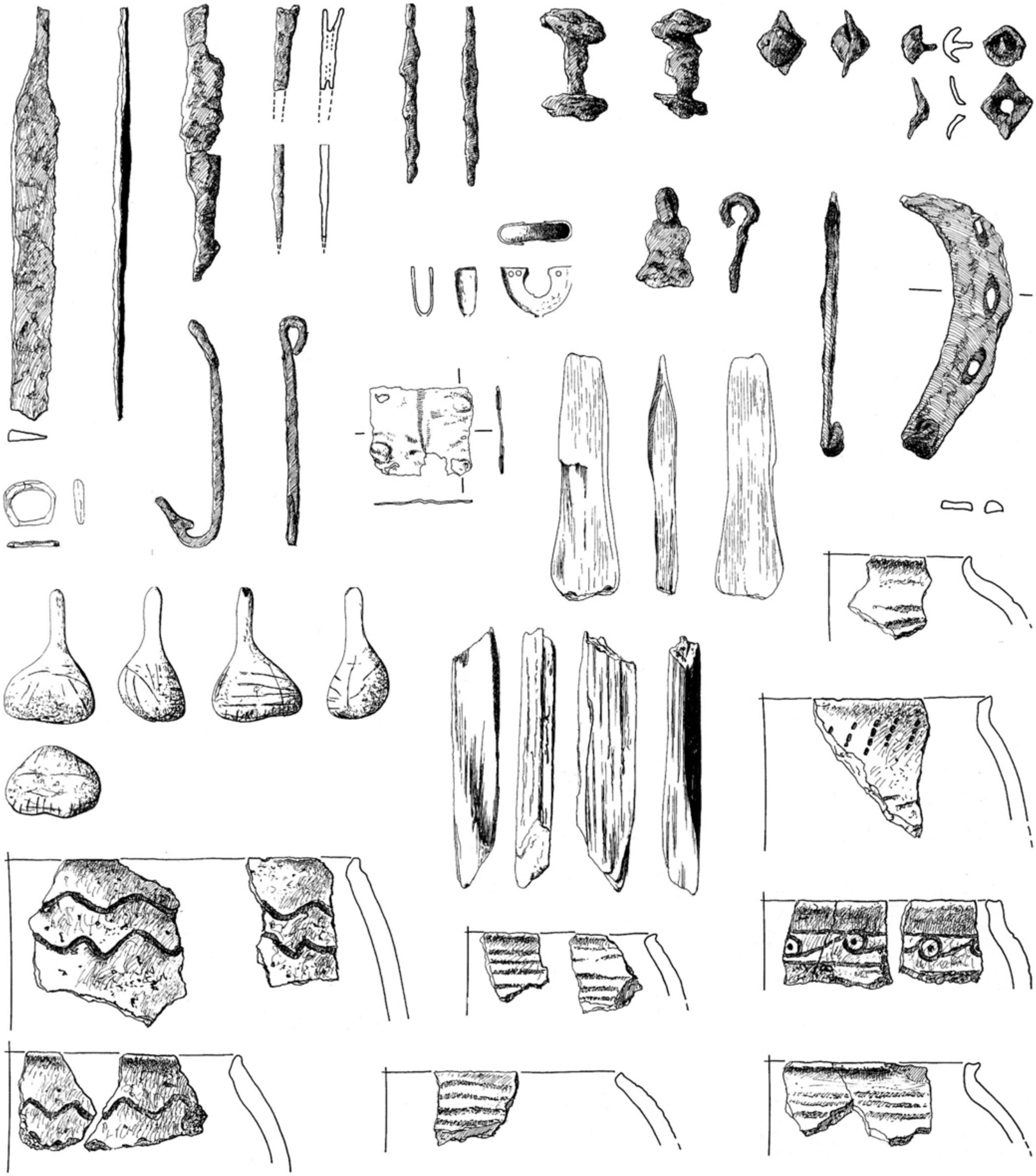

Fig. 4 Søby Volde. Knives, arrowheads, rivets, horseshoe, fish-hook, mount, buckle, chape, whetstone, decorated flint nodule and pottery. 2:5.

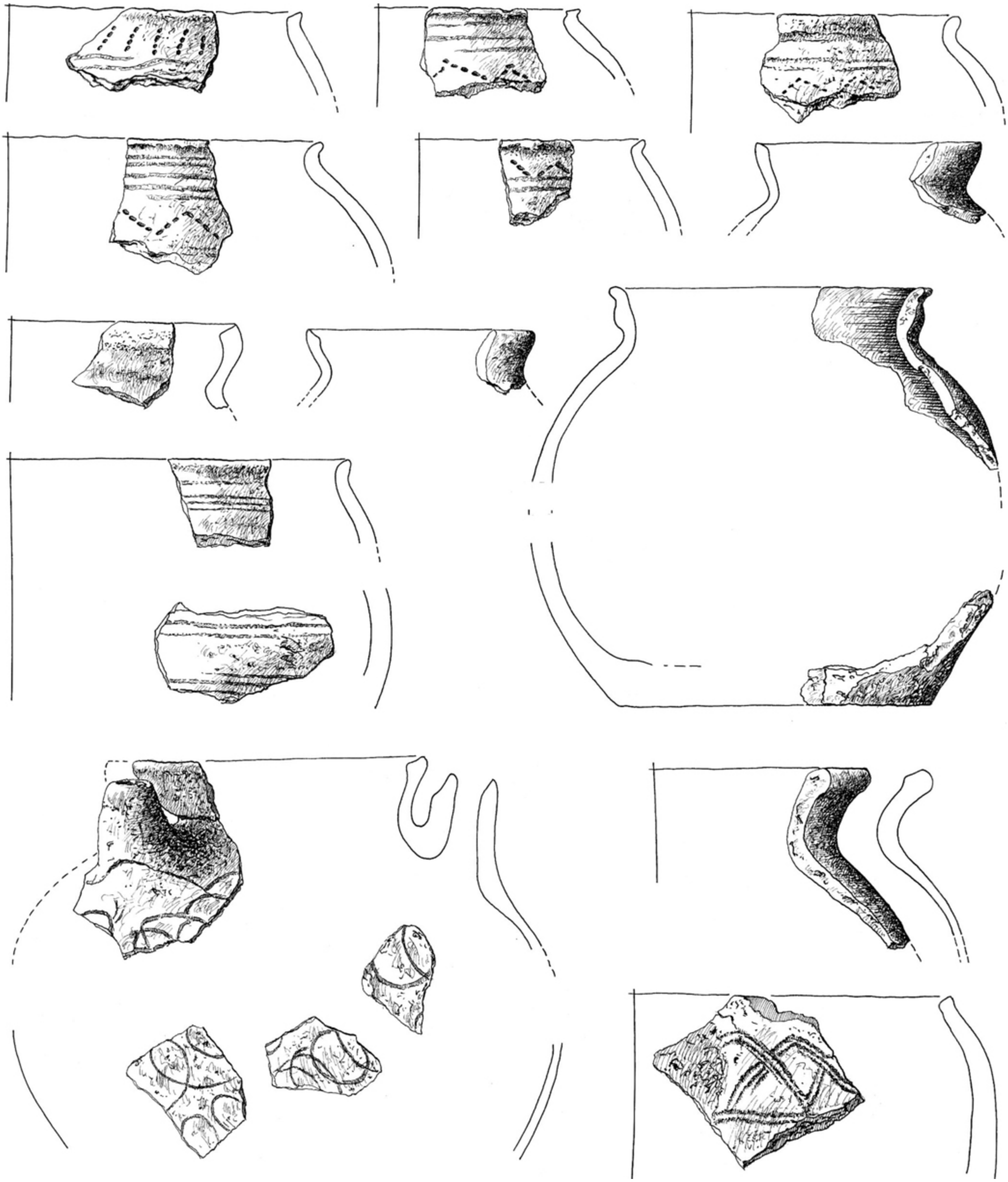

Fig. 5 Søby Volde. Pottery. 2:5.

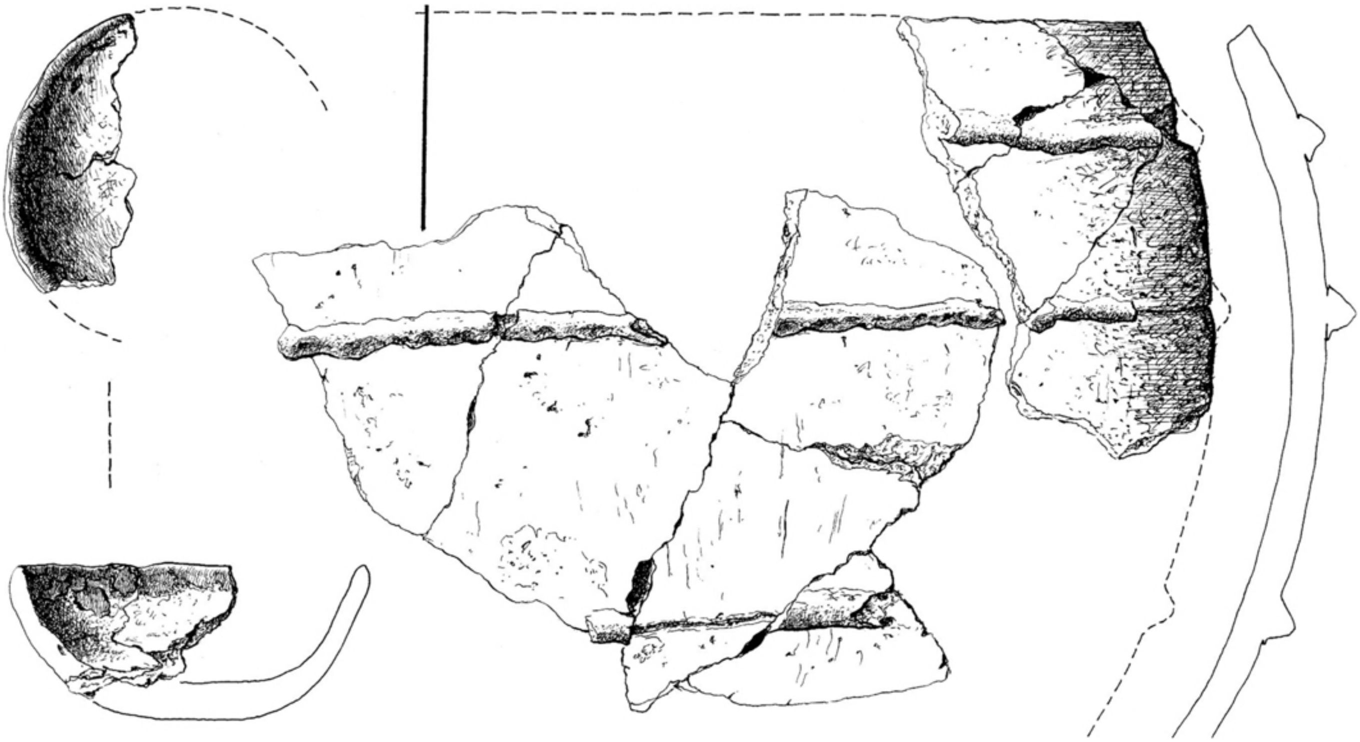

Fig. 6 Søby Volde. Large strip-decorated pot and small cup. 2:5.

Access to the castle was from the north by way of drawbridges which lay across a deep, double moat with an intermediary bank. Before an attacker reached this point it would have been necessary to force an outer castle which was defened by a north-facing, semicircular rampart. A section along the foot of the main castle has also shown that the moat continued around the foot of the mound as a dry ditch, 2 metres deep and 6 metres wide at the top. A couple of metres outside of this traces of yet another defensive structure were discovered in the form of a palisade.

The very small trial trenches into the surface of the main castle produced a significant quantity of finds including sherds from at least 75 vessels together with weaponry and various tools of bone, stone and metal (Figs. 4-6). Besides these there were some building traces, all of them timber, amongst which the foundations of just one building were fully uncovered. This was the plot of a small log building of almost rectangular outline (Fig. 7). This building lay close beside the rampart to the south and had its entrance facing the middle of the castle. A collapsed furnace and various pieces of smithing slag outside the building, together with the large quantities of animal and fish bone in the floor layer, show that the building served the castle's domestic economy. Up against the rampart to the north there were scattered traces of another building, apparently the remains of the gatehouse of the castle. A feature more than 2 metres deep on the inside of the rampart to the west seems, meanwhile, to have served as the castle cess-pit initially, before it was filled up and a building could be placed on the site.

Particularly puzzling is the discovery of a row of large postholes which seem to cut diagonally across the eastern part of the castle plateau. These can hardly be part of a hall structure, however reasonably such a structure could be postulated in this place. The observations rather suggest that the row of posts was placed there in order to divide the inner surface of the castle up.

Both the pottery, which consists almost exclusively of the Slavic-influenced Baltic Ware (Liebgott

Fig. 7 Søby Volde. View from the surrounding bank to the south with the western part of the small log building in the foreground and remains of the long crossing row of posts in the background. Photo: J. Skaarup 1983.

1977:132; 1989:296), and the other finds imply a very short functioning period for this large castle. Of importance in this respect are three silver coins struck under King Niels, Valdemar Sejr and Erik Plovpenning respectively, i.e. within the period of 1104-1250. The coin of Niels was found deep in the floor layer beneath the small log building. It has no signs of wear and thus cannot have been in circulation long. There is thus good reason to infer that King Niels was the founder of the castle. The few sherds from just three or four glazed jugs apparently show that Søby Volde was redundant as early as the second half of the thirteenth century and had ceased to exist as a castle.

The construction of large castles such as Tranekær and Søby Volde in the twelfth century ought probably to be seen primarily as an expression of the king's desire to defend his kingdom against foreign attack. German expansion in the Baltic area and repeated Wendish assaults on the population of the Danish islands at this time necessitated the raising of a series of fixed strongpoints along the coasts. What is new is that it appears possible to assign the castles to a date as early as the reign of Niels. This particular king's long reign created ideal circumstances for strengthening the defence of the realm.

The royal power did not, however, stand alone in attempting to stem the Wendish raids, which appear only to have been brought to an end with the Danish naval victory over Bugislav of Pomerania in 1184. The hard-pressed rural population on the islands appear, in these circumstances, to have themselves attempted to defend their lives and property by constructing refuges in which they could shelter at times of war. These could be of substantial dimensions, such as Gammelborg on Bornholm and Virket on Falster, which are mentioned by Saxo in connexion with a major Wendish attack in 1158. Very much smaller structures are also known, however, which must have been linked to neighbouring major farms or have been constructed as a common shelter for the occupants of a single village (Engberg 1992; Andersen 1992). Borrebjerg in the now dried-out Magleby cove in southern Langeland is apparently a good example of one of these minor, local defensive works of the early twelfth century. So too is Guldborg in central Langeland, a 38 metre-high hill with sheer sides and a surface of a good 3,000 sq m, where cultivation has produced, amongst other things, a silver chain with coins of the late eleventh century (Skovmand 1942:152). A now destroyed structure at Gundesgård, northern Langeland, probably also belonged to this group, to which in 1996 a hitherto unknown fortified site at Vejsnæs on Ærø could be added.

The Borrebjerg structure, which was excavated in 1946-47, consists of a semicircular rampart about 120 metres long, raised along the eastern foot of a natural hill, 10 metres high, which at the time of construction was an island in the innermost part of Magleby cove. The area of some 1,100 sq m inside the bank contained no structural remains and only negligible waste layers, which must indicate that the castle was never permanently occupied (Skaarup 1982).

Fig. 8 Alfvini's pendant from Borrebjerg. Photo: National Museum. 2:1.

A section through the barely 3 metres high, now severely plough-eroded bank, revealed that it was constructed in two phases. The building material was grass turf which was stabilized by a row of strong, deeply driven oak stakes in the core of the rampart. In the first phase there may have been a gateway towards the south-west. No moat was considered necessary. The waters of Magleby cove appeared to the defenders of the castle to offer a reasonable substitute for any such thing.

As a refuge Borrebjerg was a failure. The site fell twice in the first half of the twelfth century, with the defenders either being cut down or taken prisoner. The bodies of the defenders during the first assault were left on the site, and remained there until after a certain interval sufficient means were available to rebuild the castle. At this time the semicircular rampart was substantially reinforced. On the inside there seems to have been a certain amount of clearing up, as the now completely disarticulated remains of the defenders of the refuge, together with various fragments of their possessions, were gathered together and redeposited beneath the fill of the now higher rampart. Altogether, the remains of one small child, three women, three men and four unsexable individuals, one of whom was very old, were found here. Several more bodies may of course remain in the unexcavated parts of the rampart. But not even the higher rampart was strong enough to keep the enemy out. Another attack sometime around 1140 put an end to the existence of this little fortification. This time too the slaughtered defenders were left on the site, where their skeletal remains were found scattered behind the rampart. Old traditions record the ploughing up here of 'many skeletons lying side-by-side' and a 'terribly long iron sword'.

The finds from this small refuge comprise Baltic-ware pottery, weapons, riding equipment, various mounts and locks, and a range of personal items and tools such a knives, scissors and jewellery. Of especial interest in respect of dating is a small gilt silver pendant with the inscription +ALFVINI MEFECIT – 'Alfwine made me' (Fig. 8). Alfvini or Alvvin is the same as Erik Emune's English moneyer who was active in Lund in the 1130's. This piece is unworn and, according to its find circumstances, must have been lost during the final conquest of the castle.

Excavations at the Guldborg motte in 1993-95 revealed a situation which is reminiscent of that at Borrebjerg in several ways. Scattered along the uppermost part of the sides of the mound and around the edge of the its top were various weapons, including javelin-, lance- and arrowheads, which bear witness to a violent battle at the site (Skaarup 1995; 1998). In this case too, the castle eventually fell. Skeletal material containing the remains of the dead defenders, men, women and children, and their possessions, was found in a large heap besides the remains of the castle entrance close to the southern edge of the plateau and scattered inside the burnt palisade to the south and east. The distribution of the bones indicates that the very casual clearing up of the site did not take place before the bodies had been completely defleshed.

Two complete bodies, those of a man and of a 12-year-old child, buried in a line in front of the gate section, seem to have been sacrificed by the victors, who hung a flayed horse's head with its skull and lower jaw still *in situ* above the bodies. This votive ritual, together with finds of Slavic types of arrowhead and sheath-mounts, indicates that the conquerers were Wends from the areas south of the Baltic.

With the aid of several finds of jewellery, the weaponry, and a few silver coins, the latest of which was struck under Erik Emune (1134-1137), it is possible to date the dramatic fall of Guldborg to the around the middle of the twelfth century: the same date as the final conquest of Borrebjerg.

In 1996 Langelands Museum learnt of another fortified site that had been used in the early Middle Ages. During the excavation of the site of a fourteenth-century church dedicated to St. Albert at Vejsnæs, it transpired that the church was built inside an almost completely obscured earlier fortification consisting of a V-shaped ditch about 6 metres wide and 3 metres deep with an internal bank of about the same dimensions (Skaarup 1997:54f.). This fortification was based upon the steep coastal bank to the east and enclosed a nearly trapezoid area of about 2,500 m^2. On the basis of radiocarbon datings of animal bone found at the base of the ditch the construction of the fortification can be dated to the eighth century. There is, however, clear evidence that it was kept maintained both in the Viking Period and in the early Middle Ages. At the beginning of the thirteenth century the structure appears to have been equipped with a tower-like brick building with a ground area of 10 m x 10. Several crossbow bolts from this date have been found, the chape of dagger sheath, pottery and more. This old fortification was superseded only by the construction of St. Albert's church alongside the brick building around 1300, when the castle site was converted into a churchyard.

CASTLE MOUNDS OF THE HIGH MIDDLE AGES

While the castle-building of the twelfth century and the first half of the thirteenth seems to have been very limited in extent, and predominantly the result of initiatives taken by the royal government and the uppermost ranks of society, the turbulence following the end of the Valdemar period and the increasing dissolution of the kingdom led to a veritable avalanche of castle-building in Denmark. This development, which apparently meant that every landowner with sufficient means fortified his home, naturally left its mark on the islands south of Fyn too, where various new castles were built in the period. Of the 'old' castles on the islands, only Tranekær remained in use at the end of the thirteenth century. The new fortified sites show a wide range of variation in respect of form and size, which must reflect, *inter alia*, the economic resources of the builders. A general feature, however, is that the castles or – as in many cases they ought rather to be called – fortified homesteads, were constructed as water fortresses: in other words exploiting small islands, headlands or islets in lakes, coastal areas and marshlands. These natural defensive facilities were sometimes supplemented by the construction of moats or palisaded banks, but generally the structures seem better designed to provide shelter against wandering armed bands than to resist a regular military seige.

The structures on Langeland

At least two of Langeland's still extant manor sites can be traced back to the fourteenth century. These are Fårevejle by the innermost part of Henninge cove and Skovsgård by the Langeland channel. Fårevejle is first mentioned in written sources around 1350 and it appears even then to have been a significant place. This is also implied by the presence of a now demolished, foundation-trenched late-medieval main building of several storeys, and traces of old ditches and ramparts.

In the case of Skovgård, the earliest documentary reference is from 1457. The main building of this farmstead lies within a ditched, four-sided, fortified site, where a four-winged timber-frame seventeenth-century building stood until 1887. When this was demolished the remains of a large medieval brick building were discovered. A round, now severely plough-eroded bank surrounded by a ditch in the field slightly south-west of the present main building indicates where the first Skovsgård is to be sought.

This inference was confirmed by a small excavation in 1993, when, with the aid of sherds found, it was possible to date the structure to around 1300. Ploughing had removed nearly all of the structural evidence from the surface of this natural hill about 6 metres high and measuring about 100 m x 110, but at its foot traces of a ditch-system could be identified, doubled in the east, and exploiting a narrow

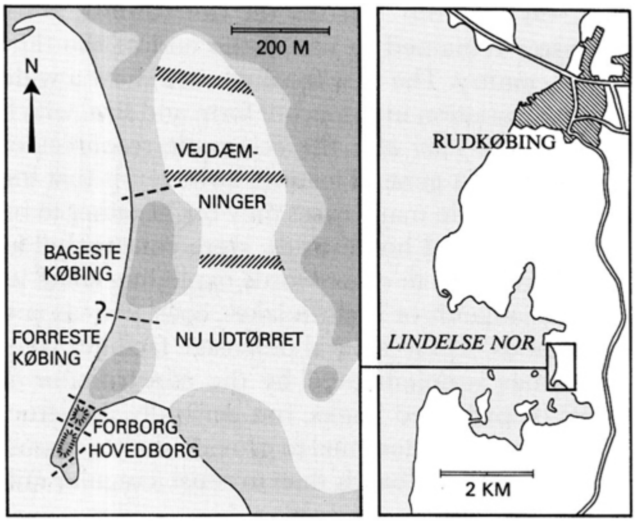

Fig. 9 The castle at Købingshoved and the two Købings. The stipled lines mark the crossing ditches. (After SKALK 1986:3).

Fig. 10 Købingshoved. Part of pilgrim badge for the Dutch saint Servatius, venerated in the town of Maastricht. End of the 13th century.

swampy band of water and bog around the hill. Inside the ditch there appears to have been a now collapsed rampart along the foot of the hill, material for which was obtained by quarrying the hill.

In addition to Skovsgård, the construction of five more castle mounds on Langeland has been dated to the end of the thirteenth or first half of the fourteenth century as a result of archaeological work. The most interesting of these is the legendary site of Købingshoved which is situated on a long, narrow headland stretching northwards into Lindelse cove. According to a persistent old tradition, there is supposed to have been a castle or pirate stronghold at this site, together with an urban community in the nearby field of Købing that was older than the island's market town of Rudkøbing. When the inhabitants wished to build a church here they were unable to complete it, and as at the same time the water in the cove became so shallow that ships could not sail in to the town, the settlement could not thrive. The decision was taken to pull down the unfinished church and to move both it and the whole town to the place where Rudkøbing church and town now stand. Thus the legend. The excavations of 1947-48 told a different story, at least in respect of dating. The moated site itself had been fairly extensively dug away, and the top surface, where wall remains had been found on several occasions in previous centuries, was, in consequence, not included in these excavations.

The moated site occupied the highest part of the originally about 800 metre-long and up to 150 metre-wide headland (Fig. 9). Cutting across this point three ditches about 5 metres wide at the base were dug. The northern ditch cuts the moated site off from the mainland to the north. South of this there is a small, almost square bailey which is about 4 metres higher than the ditch. South of this bailey is the middle ditch, and south of that the main castle, the surface of which lies about 7 metres above Lindelse cove. The main castle measures about 70 m x 30 and is divided from the lower part of the headland in the extreme south by yet another transverse ditch. Along the foot of both the bailey and the main castle there is a row of deeply driven heavy oak stakes which were presumably placed there to reduce the natural erosion of the castle mounds at high water.

Access to the castle was across two bridges from the north. The heavy supporting posts of the south-

Fig. 11 Kalveborg from the air viewed from the south. Photo: H. Stiesdal 1966.

ern bridge were found *in situ* and are preserved in the fill layers of the rampart. The layers in both ditches were rich in finds: food remains, sherds from broken pots, various wood and bone artefacts including one complete yew-wood bow, various shoes and leather fragments, and a number of coins. Amongst the more unusual finds are a small silver stylus and a Dutch lead pilgrim's badge (Fig. 10). On the strength of the finds the functioning period of the castle can be identified as the first decades of the fourteenth century.

North of the bailey the headland becomes somewhat wider, and forms two low hills, called the Town Site, or Back and Front Købing. These are separated from the northernmost part of the headland, Svinglen, by means of a now partially refilled transverse ditch. Traces of another ditch may be discernable between Back and Front Købing. The remains of three old road dykes lead from the Klæsø peninsula across the inner, low section of the dammed-up cove east of Købingshoved out to Svinglen and the castle.

In earlier times, large quantities of stone and waste have been dug out and carted away from the Town Site, and there are many reports of the finding of sherds, medieval brick and iron slag associated with quadrangular and rectangular stone pavements. In the excavation of 1948 the destruction of the old settlement area proved to have been so extensive that only a few coherent structural remains could be recorded in the form of rubbish pits, a well, postholes, and individual damaged pavements which must represent floors and paved slipways. The finds of pottery and common utensils have since been added to by a large quantity of metal-detector finds, including a number of coins, whose dating from the end of the thirteenth century to the middle of the fourteenth locates the settlement within the same date-range as the castle.

Fig. 12 Kalveborg. The refilled ditch with pieces of timber in the foreground. In the background the drawing of a section through the northern part of the semicircular rampart. Photo: J. Bech 1983.

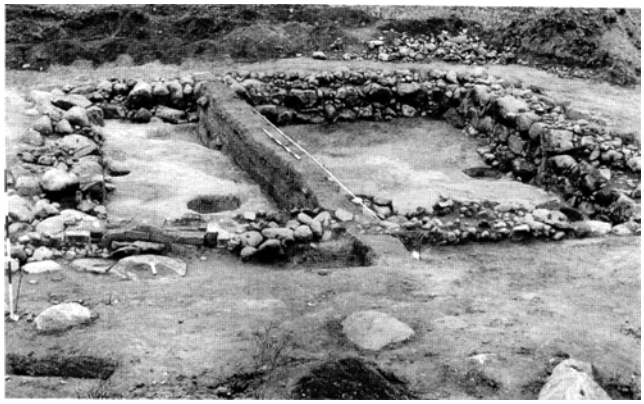

Fig. 13 Lykkesholm. The surviving foundations of the largest of the brick buildings on the castle mound. Left, the bottom layers of the walled entrance staircase in the southern wall. Photo: J. Skaarup 1988.

The background to the construction of the castle and the small defended settlement on the headland north of it is perhaps to be sought in the political circumstances that arose in 1326 when the influential seneschal Laurids Jonsøn Panter, through the alliance between Duke Valdemar and Count Gert against Christoffer, was granted Tranekær (and Langeland) together with Ærø as his fief. It must have been of particular importance for Laurids Jonsøn to maintain a secure connexion between his two possessions. On Langeland, the natural harbour in Lindelse cove provided the best embarkation point for navigation to Ærø. It is therefore reasonable to postulate that Laurids Jonsøn was responsible for the fortification of the Købing area, and that part of the island's trade, as long as the site was active, was drawn to this site.

Kalveborg, by the south coast of Langeland, is a small, very much ruined castle mound, the dating of which was first established by a study carried out in 1983. The mound stands right above the Baltic and consists of a natural oblong hill about 6 metres high which has been transformed into a small motte-like fortification by quarrying. The hill was a virtual island at the edge of a shallow lagoon (Fig. 11). Its north-eastern part was separated from the rest by a wide, trough-shaped cross-ditch and was used for the construction of a rampart about 10 metres wide and still 1.5 metres high which forms a small, irregular circle east of the castle mound and about 12-15 metres from its foot. The bank was built of grass turf and morainic soil (Fig. 12). The area between the rampart and the castle mound served as a broad, flat-bottomed moat only 80 cm deep.

There are no finds from the castle mound, the small, now nearly completely eroded surface of which could scarcely have afforded space for anything more than a simple timber defensive tower. It was probably remains of this, or of a wooden bridge across the ditch, which were found during trial excavations in the moat in 1983. Since the other finds, a few animal bones and a couple of undiagnostic body sherds, provided no basis for close dating, the museum had to refer the question to Skalk's dendrochronological laboratory. Here it was possible to establish that the wood for the construction was felled after – but not long after – 1326. The small castle structure, which seems only to have been meant to serve as a temporary refuge in times of trouble, can thus, as many other castles all over Denmark, be associated with the state of civil war that followed the death of Christoffer II in 1332 and the efforts of his successor, Valdemar Atterdag, to unite the divided kingdom by armed force.

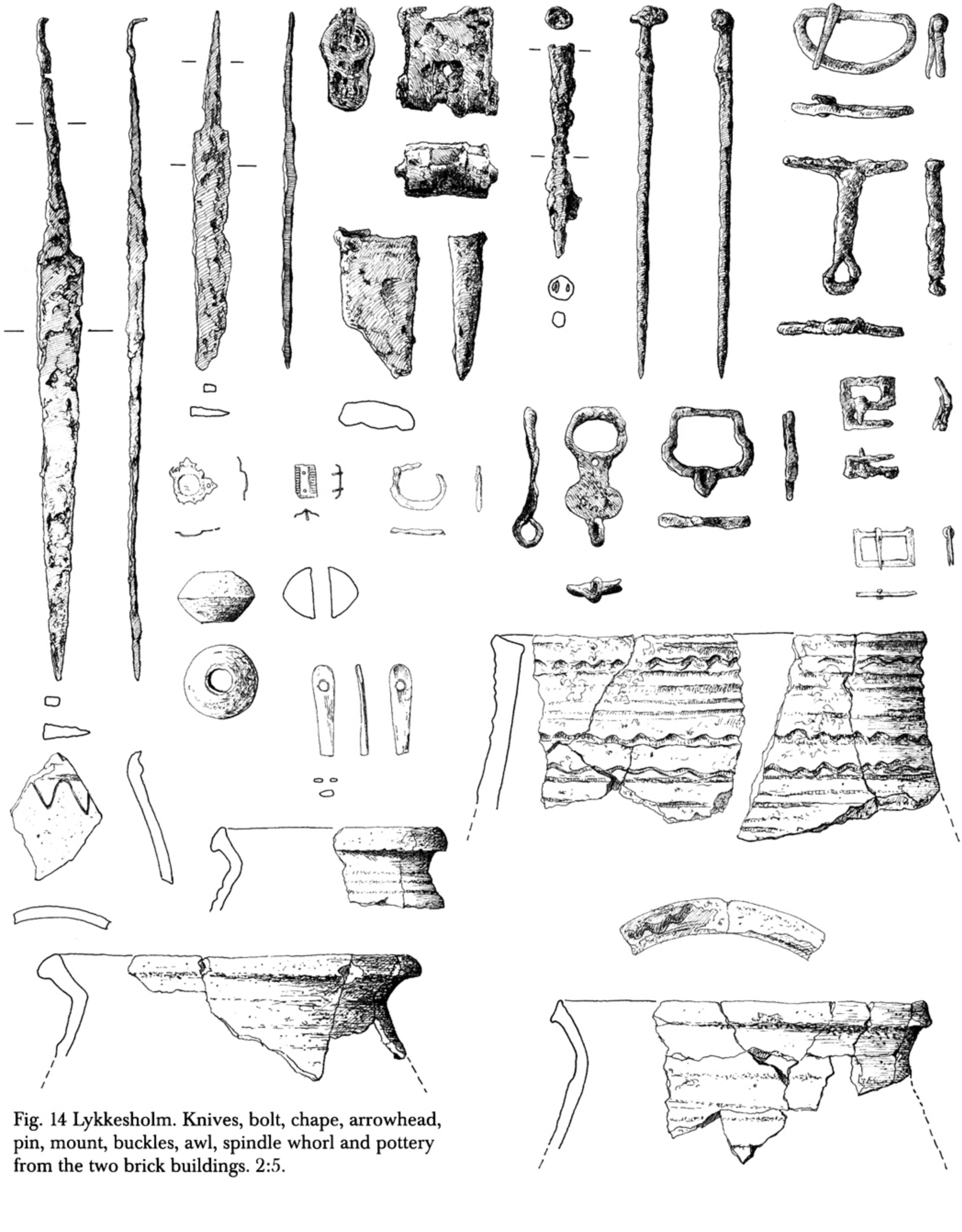

Fig. 14 Lykkesholm. Knives, bolt, chape, arrowhead, pin, mount, buckles, awl, spindle whorl and pottery from the two brick buildings. 2:5.

Fig. 15 Lykkesholm. Unglazed oxidized jug from the burnt brick building. Photo: S. Botfeldt. 1:2.

Fig. 16 The brick building at Heigned during excavation. Photo: T. Bech 1990.

In 1987, the mound of the medieval manor of Lykkesholm was identified in southern Langeland, a site first mentioned in surviving sources in 1459 (Trap 1957:971). The site was formed of a natural, now cultivated, hill of a rounded and slightly ovoid outline. A small spit of land links the south-east of the hill with the surrounding land. Ploughed-up remains of a stone-paved roadway on the spit and to its south evidently represent the original access to the homestead, which must here have been guarded by a palisade.

On the northern part of the mound the remains of three buildings were uncovered, together with various pits and wells. Two of the buildings are thirteenth- or fourteenth-century while the third, and the most poorly preserved, is from the Late Middle Ages. At the top of the hill lay the well-preserved rock-built cellar of a brick building measuring about 8 m x 8 with a square ground plan. The remains of a walled entrance staircase were preserved in the southern wall (Fig. 13). On the basis of coin finds, the construction of this building could be dated to the second half of the thirteenth century. In the middle of the fifteenth century a fierce fire had brought this phase of use to an end. The brick building appears to have served as the owner's residence throughout its functioning life, while he also, naturally, had at his disposal other buildings of less durable material. Rich finds in the house site, of pottery, food remains, various metal tools, jewellery, and some weapons and coins, clearly illustrate this point (Figs. 14-15).

About 18 metres east of the burnt building, the foundation of another thirteenth-century brick building measuring 6 m x 6 was discovered. This site contained large quantities of pottery, faunal remains, and a number of metal, bone and antler artefacts. These finds, which also include several coins, date the functioning period of the building to the thirteenth and fourteenth centuries. These two buildings seem to have been totally superseded by a Late-medieval timber-framed building which may have remained standing right up until the abandonment of Lykkesholm as a major court by Kaas family in 1689.

In 1990, only 800 m east of the hall of Egeløkke in northern Langeland, Langeland Museum excavated a large part of the newly discovered castle mound left by the manor of Heigned, abandoned after a fire around 1715 (Trap 1957:948). The ploughed, slightly ovoid castle mound was surround-

Fig. 17 Heigned. Knives, harpoon point, lamp stand, key, scissors, fragments of metal cauldron, decorated ceramic lids and pottery. The lids and cauldron fragments are unstratified finds from the castle mound; the other objects were found in the brick building. 2:5.

Fig. 18 14th-century seal found outside the entrance to the small brick building at Heigned. 2:1.

ed by natural ditch-like hollows which were supplemented to the west by a low boundary ditch. The fortified site proved to contain the remains of various buildings, most of them, however, late and severely plough-damaged. Best preserved was the cellar of a High-medieval brick building on the eastern side of the hill. This small, almost tower-like building had a square ground plan measuring 6 m x 6 externally. The lime-covered boulder wall of the cellar was intact to a height of 1.5 m. In the northern wall a walled entrance-way was found with the frame to an internal door and a medieval brick floor in the entrance opening that was only 1 m deep and 1.1 m wide (Fig. 16). North of this an access pit with a simple stone stairway and traces of a timber-framed side building was uncovered. The date of construction of the brick building can be dated to the first half of the fourteenth century on the basis of various coins and domestic implements (Fig. 17). The building appears to have been pulled down at the end of the Middle Ages. Amongst the more unusual finds from the building is a well-preserved seal of the fourteenth century (Fig. 18). The seal bears a previously unknown coat of arms in the form of a stylized oak tree and the inscription * S'OLAF (?) EAM(?) ALVINCNC. Herr Olaf may very well have been the builder of the house.

Although unambiguous evidence in the form of datable finds from excavation is still lacking, there is no doubt that the majority of the other, so far undiscussed castle mounds of Langeland will, through future investigation, prove to have been constructed in the late thirteenth and fourteenth centuries. Hovgård at Bøstrup and the now almost completely levelled Hoborg near the northern point of the island both belong to this group.

Hoborg, like Kalveborg and Købingshoved, is situated on a coastal hill. The very prominent castle mound was still about 6 metres high in the middle of the last century and had four-sided outline and steep sides. It was enclosed by a double ditch on the land side. Rows of heavy driven stakes guarded the sea side against erosion. Fragments of brick and broken walling have been found on the hill. According to local tradition the site is supposed to have been very much haunted at night time, with the sound of wagons and flaming torches! A small excavation in May 1998 confirmed the construction of the site with a double ditch and gave finds from the fourteenth century.

Hovgård, further south, which is recorded under the name of Fæbækgård as early as 1416, was also surrounded by a moat. On the much quarried main mound of Hovgård there was reportedly a stone or medieval brick building with foundation trenches. Hovgård was also owned, at the beginning of the sixteenth century, by Christian II's famous governor Søren Stampe (Trap 1957:948).

Castle mounds on Ærø

On Ærø, in addition to the earlier medieval Søby Volde and the newly discovered fortified site at St. Albert's churchyard, Vejsnæs, there are four known High-medieval castle mounds, one of which, Borrevold or Stylteborg at Borgnæs, collapsed into the sea leaving no trace behind. None of the sites on Ærø is referred to in contemporary documents.

The site of Absalon's Fort on the eastern side of the wide Gråsten cove was investigated by Langelands Museum in 1995. The now totally levelled castle structure was described in 1781 as 'a four-sided fort with a double ditch and bank within which there anciently stood a four-cornered tower which is believed to have been constructed on the direction of Bishop Absalon in order to keep watch for pirates'. The investigation demonstrated that the central part of the structure consisted of a small, almost rectangular, castle mound, measuring about 18 m x 35, upon which were found traces of a very solidly built, tiled central tower of timber. The tower had a ground area of 6.5 m x 7. South of the tower a plank-built well and a set of heavy, deep-planted oakwood posts which probably represent a (draw)-bridge were discovered. The southern foot of the hill was marked and reinforced by a row of slender driven beechwood stakes. The castle mound proved to have been surrounded by a double ditch, triple in the west, with banks in between the ditches, now completely levelled. The inner ditch was 10 metres wide and round-bottomed, the outer ditch 5-8 metres wide. The large and diverse assemblage of finds, including about 125 coins, appears to assign the structure to a brief but intensive period of use in the first half of the fourteenth century.

By the western shore of Gråsten cove and directly above the Baltic lies the castle mound of Gråsten Fort, consisting of two, small, four-sided mounds connected by a dyke (Olsen & Bang 1992:143). This structure has a low position, surrounded by a marshy coastal meadow in which, as at Absalon's Fort, the remains of double and triple ditch-systems with intermediary banks can be seen. Apart from a section trench through the dyke no investigations of this castle have been made, and there are no known finds by which it can be dated. In 1983, a storm revealed a triple row of heavy, deep-driven oakwood stakes which were manifestly intended to protect the exposed sea side of the castle against marine erosion, as at Hoborg and Købingshoved. A dendrochronological analysis of the stakes carried out by the National Museum's department of Scientific Investigations in 1996 dated them to the middle of the fourteenth century. On the basis of its close relationship to the neighbouring Absalon's Fort the date of construction of Gråsten Fort should, however, be put at the beginning of the fourteenth century.

The last of the castle mounds on Ærø, Borret, or Kongens Bakker (the King's Hills), is situated west of Ærøskøbing on a small headland in Stokkeby cove. The heavily quarried and eroded castle mound consists of a hill measuring 70 m x 70 with the remains of a low bank around the edge and surrounded by ditch behind a rampart. The form of the castle mound, and the occurrence of brick fragments, indicate a date in the fourteenth century.

Castle mounds on Tåsinge

The most important castle on Tåsinge throughout the Middle Ages was the strongly fortified site of Kærstrup (Olsen & Bang 1992:86), the mound of which is in the north-eastern area of the island. Kærstrup had a four-sided main castle mound surrounded by deep moats, with a substantial but extensively plough-eroded bailey with a storeyard to the north, originally also enclosed by ditches. The castle is first mentioned in 1387, when it was in the possession of the Crown. Eight years later Queen Margrethe granted it to the diocese of Fyn, which kept the castle up to the Reformation when it returned to the Crown. In the 1620's Christian IV had the old castle pulled down.

Another medieval castle was sited in Horseskov by the north coast of Tåsinge. This structure, which has now been completely levelled, was guarded by a ditch and bank on the land side. In the 1820's substantial cellar walls from a small, foundation-trenched building could still be seen on the castle mound. The remains of the storeyard of the castle and a demolished watermill are reported to have been discovered near the castle mound. No finds are known from the castle, which is believed to derive from the fourteenth century.

There may have been yet another fortified site on the north coast of Tåsinge, as a small tongue of land which projects into Svendborgsund has been separated from the land by a cross-cutting ditch. The site is called Saksenborg (Saxon Castle). It has not been excavated and is undated (Olsen & Bang 1992:89).

CASTLE MOUNDS OF THE LATE MIDDLE AGES

On the back of Valdemar Atterdag's long and persistent campaign to capture all of Denmark, by fighting, as it were, from castle to castle, it was finally possible, in the 1360's, to bring the dissolution of the state to an end and to re-establish strong central authority. His daughter Margrethe (I) shrewdly continued his policy of consolidation. She did not simply fight over the castles but rather organized things so that they came into her possession by inheritance or purchase, and then had them demolished. By 1396, Margrethe had things so thoroughly under control that she could issue her famous decree forbidding all private castle-building (Olsen 1986:88). This ban seems to have been enforced, and even though it was lifted in King Hans's coronation charter of 1483 the new aristocratic residences which were constructed on the islands south of Fyn in the fifteenth and sixteenth centuries clearly show that the islands' noble families were then expecting more peaceful times. Egeløkke and Nedergård on Langeland, for example, both of which are mentioned as noble seats for the first time in the fifteenth century, were apparently never fortified. In those cases where newly built noble houses were surrounded by moats, as at Skovsgård on Langeland or Duke Hans the Younger's Søbygård in a vale below Søby Volde on Ærø, the function of the moat was evidently to impress and to demonstrate the owner's stature rather than to provide defence.

The nobleman's home in the Late Middle Ages was often constructed as a timber-framed building of three or four lengths (Olsen 1981). An example of a late, unfortified building of this kind has been studied at Navnegården, southern Langeland. On a small headland which stretches out into Humble Ålemose the foundations of a substantial four-length timber-framed homestead from about 1500 were excavated in 1985-86. The southern wing contained the well-preserved remains of a rock-built cellar measuring 7 m x 4 with a stone-tiled floor and a walled entrance facing north. This farmstead has not been definitely identified in the written sources. It may be the same site as a squire's homestead which is referred to in Helsned as early as the fifteenth century (Trap 1957:968). It is remembered locally as 'a pirates' castle' occupied by a family called Erlandsen. According to the tale, two maids from the house are supposed to have been murdered early one morning on their way to the service in Humble church (Lütken 1910:39).

SUMMARY

The reference to this minor aristocratic residence at Navnegård in folk tradition is in many ways typical of the important and persistent role the castle mounds play in the popular imagination. Similar legends and stories about fierce pirates, proud women and cruel barons are linked to these grass-clad or ploughed-over castle mounds virtually all over Denmark, where now, on the whole, only place names ending in *-slot* or *-borg* (*fort* and *castle*) bear witness to buildings long gone.

With the results to date of the investigations of castle mounds south of Fyn an important step has been taken, in this area at least, towards retrieving the castle mounds from the realm of legend. On several points it has been possible to supplement or improve our knowledge of medieval castle-building. Here one thinks especially of the early datings of the presumably royal structures at Søby Volde and Tranekær, and the refuges at Borrebjerg and Guldborg, although also of the evidence for thirteenth- and fourteenth-century brick buildings on the small private castles at Lykkesholm and Heigned, and the small urban community in the lee of the castles at Købingshoved and Søby Volde.

The investigations have also emphasized the need to see the project through to the end. Several of the castle mounds are threatened with complete destruction through cultivation or coastal erosion, and in these cases surveying, sectioning and trial trenching needs to be undertaken without delay (cf. also Ericsson 1993:272; Andersen 1992:30). Such well-thought out and necessary work is in no way 'premature archaeological intervention' but simply reflects the reality of the situation, in contrast to the recent complacent assertion that 'the Danish castles are lying secure and well guarded by the Protection Act' (Liebgott 1993:24). To put it mildly, this is a reckless approach to the truth, and in the case of the archipelago has no basis in reality. Here, therefore, efforts are still being invested in limited investigations of all of the medieval castle mounds of the area. Only when this work has been completed will it be possible to produce a comprehensive overview of the architectural history of the castles, their relations with one another, and their function in medieval society. The significance of this will also extend far beyond the islands of the archipelago south of Fyn.

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REFERENCES

Andersen, H. 1992: De glemte borge. *Skalk* 1992:1, 19-30.

la Cour, Vilh. 1972: Danske borganlæg til midten af det trettende århundrede. 1.

Engberg, N. 1992: Danske privatborge før 1250? Et bidrag til det omdiskuterede spørgsmål. *Hikuin* 19, 15-30.

Ericsson, I. 1993: Wehrbauten des Mittelalters in Skandinavien und dem Gebiet südlich der Ostsee. *The Study of Medieval Archaeology*. Lund Studies in Medieval Archaeology 13, 219-291.

Jansen, H.M. 1973: På sporet af vikingetidens Svendborg. *Fynske Minder* 1972, pp. 43-46.

Liebgott, N-K. 1979: Keramikfundene fra voldstedet Pedersborg ved Sorø. *Aarbøger for Nordisk Oldkyndighed og Historie* 1977, 118-171.

- 1989: *Dansk Middelalderarkæologi.* København.

- 1993: Middelalder og nyere tid. In S.Hvass & B. Storgaard (eds.): *25 Years of Danish Archaeology*, 238-241. Copenhagen/Aarhus.

Lütken, Vilh. 1909: *Bidrag til Langelands Historie.* Rudkøbing.

Olsen, R.A. 1981: Danish manor-houses of the late Middle-Ages. *Festskrift til J.G.N. Renaud.* (Zutphen 1981).

- 1986: *Borge i Danmark.*

Olsen, R.A. & Bang, V. 1992: *Voldsteder i Danmark. En vejviser. Fyn og omliggende øer.*

Skaarup, J. 1979: En middelalderlig ladeplads ved Vitsø Nor på Ærø. *Antikvariske studier* 3, 69-86.

- 1981: Wysby på Erre. *Skalk* 1981:4, 7-12.

- 1982: Borrebjerg - et 1100-tals borganlæg på Langeland. *Hikuin* 8, 7-28.

- 1986: Øhavets borge. *Skalk* 1986:3, 7-13.

- 1995: Venderplagen. *Skalk* 1995:2, 5-10.

- 1997: Ærøs Sankt Alberts - kirke og fæstning. *Meddelelser fra Langelands Museum.*

- 1998: Guldborg - a Danish hillfort of the 1100's attacked and conquered by the Wends. *Castella Maris Baltici III.* Malbork.

Skovmand, R. 1942: De danske skattefund fra vikingetiden og den ældste middelalder indtil omkring 1150. *Aarbøger for Nordisk Oldkyndighed og Historie* 1942.

Stiesdal, H. 1975: The medieval palatium in Danmark. Some recent discoveries at Tranekaer castle. *Château-Gaillard VII.* Caen., 201-207.

Trap, J.P. 1957: *Danmark. Svendborg amt.* Bd. V, 2. Femte udgave.

Varming, J. Chr. 1979: Søbygaard. *Antikvariske studier* 3, 145-152.

Tårnby – a farm of the period 1100-1800
An analysis of the medieval farm

by Mette Svart Kristiansen

INTRODUCTION

The development of both the structure of the medieval village and that of the plan of the farm in Denmark are practically unknown. Studies of the village in the High and Late Middle Ages have not been a high priority. This is partly because research effort has been directed by preference towards the new types of site appearing in the Middle Ages – market towns, castles, churches and monasteries – and partly because of the unfavourable conditions for the survival of relevant evidence from this period. At the beginning of the High Middle Ages buildings whose constructional elements rested on the ground were introduced in place of the older building practices using earth-fast posts. There was, however, no comprehensive replacement of the older building style, and the use of earth-fast posts continues to a certain extent right through the Middle Ages. Sites at which the new way of building was used are archaeologically intractable. Where the farms were moved out into the fields after the agricultural reforms of the eighteenth century, the medieval village site was exposed to cultivation, resulting in the plough erosion of building remains and severe damage to the sites. Thick culture layers remain well preserved beneath those villages which retained the old village structure, but excavations here are financially as demanding as in towns, which unfortunately often limits the scope of investigation.

In 1993 and 1994, in advance of the construction of the motorway spur to the Fixed Link to Sweden, the Copenhagen County Museum Council undertook comprehensive work in the middle of the medieval village of Tårnby on the island of Amager.[1] This is the first major study of a farm of the High and Late Middle Ages since Steensberg's extensive investigations of the 1940's and 50's. Concurrently it has been possible, for the first time in Denmark, to trace a complete farm unit from its foundation in the earlier Middle Ages to its abandonment in favour of another building pattern in the mid-nineteenth century, thanks to a lucky combination of the size of the excavated area and the good state of preservation of the cultural deposits. Best preserved is the medieval farm plot, which has probably been uncovered to its full extent. In this article, selected results of the excavation will be presented, with particular emphasis on a discussion of the farm unit at Tårnby and special attention to the Middle Ages.

TÅRNBY VILLAGE IN THE MIDDLE AGES

Topography

The village of Tårnby now lies in the middle of the island of Amager. The present extent of the island

1 The excavation known as 'Tårnby Torv' has J.nr. SØL 457. The excavations were finaced by Øresundsforbindelsen A/S. The site director was district archaeologist Dr. D. L. D. Mahler. The supervisors in 1993 were mag. art. P. S. Schiellerup and stud. mag. M. S. Kristiansen; in 1994 cand. phil. T. Roland and M. S. Kristiansen. Field assistants in 1994 were stud. mag. H. Rensbro, stud. mag. U. Johansen and cand. mag. L. Trabjerg. The excavation team was one of 8-9 in 1993 and up to 18 in 1994.

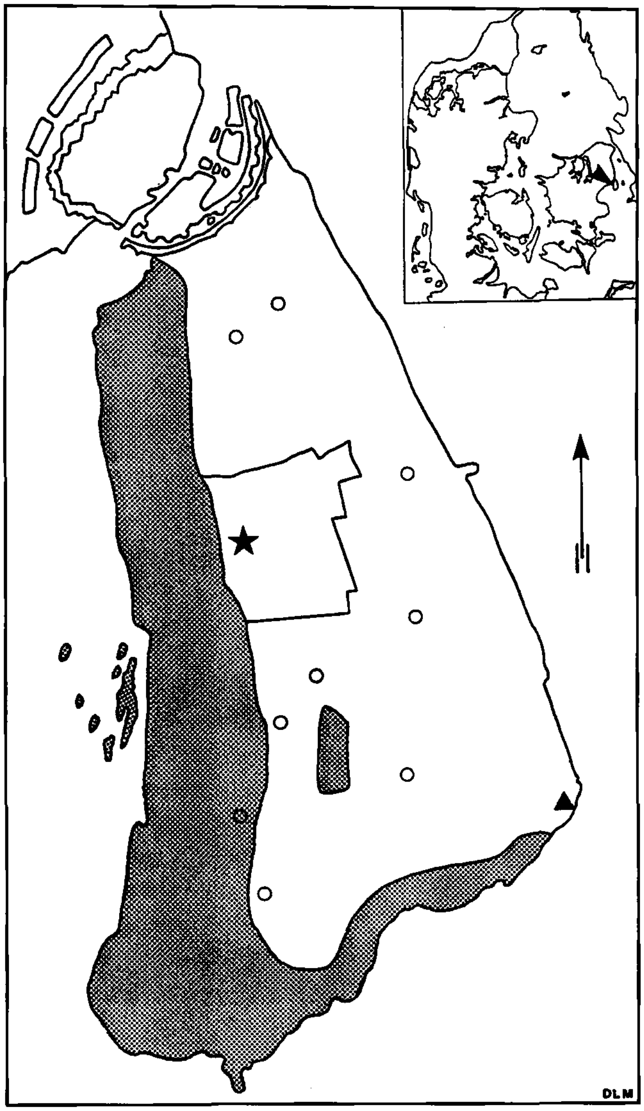

Fig. 1 Map of Amager in the eighteenth century. Tårnby village (star) lies on the boundary between the moraine and the coastal meadow (stippled). To the north lies Copenhagen and to the south Dragør (triangle). Other villages and settlements are marked with circles (after Kristiansen *et al.* 1994).

is, however, very much the product of a major dyke programme undertaken during the Second World War on the western side of the island, which created Amager Common in its present form. In the Middle Ages, Tårnby, located on the moraine area immediately adjacent to the old shore line of the Littorina Sea, would have lain in a quite differently attractive and central position for the exploitation of various resources, with the extensive, low-lying common and coastal meadow areas to the west and the fertile morainic zone to the east some 3-5 m above sea level (Fig. 1). Before the modern dyking, the sea shore lay about 1.5 km west of Tårnby. The character of the coastal zone presumably varied with the seasonal water level.[2]

This coastal position was probably not without its problems. Storms would have driven water from the Baltic up through the Øresund and the shallow Kalveboderne (the channel between Zeeland and Amager), possibly causing flooding. In what would then have been the coastal zone, now within the enclosed area, one can still see the dykes which protected the lands behind them. The dating of these dykes needs to be determined by archaeological means. In addition to protecting the village itself, the dykes should also perhaps be regarded as a means of enclosing additional meadowland.

The village of Tårnby in the Viking Period and the Middle Ages

The suffix *-by* indicates a Viking-period origin for the village, and in the former medieval fields immediately east of the village, along the line of the motorway, traces of a Viking-period settlement of the ninth and tenth centuries were discovered. The character of this settlement is not known. It may have been no more than a single farmstead, or perhaps have consisted of dispersed farmsteads (Fonnesbech-Sandberg, in Kristiansen *et al.* 1994:29ff.). A copper-alloy pendant in the Borre Style was found in 1939 in the area north of the present Tårnby Torv, possibly indicating the site of a cemetery.

Tårnby village (Fig. 2) is first recorded in 1135, when King Erik Emune granted the church in Lund a landholding in *Thornby* (Weibull 1963: DD, I, 2, no.63). This must imply that the king held some of Tårnby if not the whole village. Whether Tårnby were in the possession of the Hvide family, or were

2 The area was trial trenched with a view to localizing coastal settlement and the old shoreline. No settlement traces were found. However the coastline was discovered over a distance of about 100 metres: trial excavation report SØL 412.

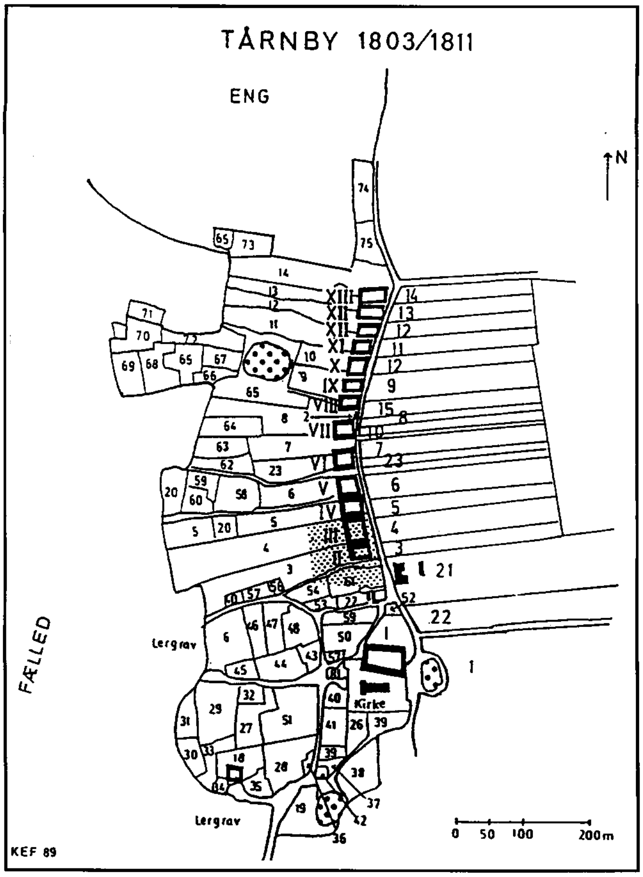

Fig. 2 Composite map from the survey of 1803 and an extract from the official survey map of 1811. The buildings are marked as on the 1803 map, and the farm numbers (corresponding to the survey numbers of the Land Survey of 1688) are marked with roman numerals. New survey numbers are marked with arabic numerals. East of the village can be seen the toft fields of the farms. The three original village ponds are dotted in. Excavation SØL 457 is stippled (after Kristiansen *et al.* 1994).

part of Valdemar the Great's comprehensive grant to bishop Absalon, is unknown, but we do know from repeated evidence in the papal confirmations of Absalon's own grant to the bishopric of Roskilde in 1186 and 1193, that Absalon owned both 'the manor of Borgby with its appurtenances' (Nielsen 1872: KD, I, no.1) and 'the church on Amager' (Nielsen 1872: KD, I, no.3). Neither the manor nor the church are directly associated with Tårnby in the sources, but both are unquestionably to be assigned to the village.

In the Land Book of the See of Roskilde, we find information that the village of Tårnby consisted of four land holdings – a piece of information which is reflected, indirectly, in the Land Survey of 1688. Unfortunately, Tårnby is referred to only in the unspecified lists of the Land Book, and the size of the individual farms is not given, nor the number of units (Christensen 1956:134, 154). In 1518 '12 farmers' are recorded, a figure which must represent the number of farms. In the 1688 census there is information about the number of farms and their size. At this date Tårnby again comprised twelve farms (cameral units), referred to as whole, three-quarter and half farms (Frandsen 1983:49ff.).

Use of resources

Tårnby lay centrally placed for a balanced and productive economy. The flat land between the coast and the morainic clay with its rich grazing was a precious resource to the farmers. There was also access to extensive shallow water areas offering rich scope for net fishing and trapping. The fish bone from the excavations reveals the great importance of coastal fishing (Enghoff, in Kristiansen *et al.* 1994:106ff.).

The medieval fields lay east of the village on the even morainic land surface. The agricultural area belonging to Tårnby village (Frandsen 1983:49ff.) was assessed in the Land Survey of 1688 as 314 *tønder* of land (1 *tønde* = 1363 acres), including 55 *tønder* belonging to the priest, so the cultivated land belonging to the village was not particularly large. The twelve farms enjoyed, however, particularly high yields per unit land. The morainic soil is of exceptionally good quality, and with access to grazing outside the fields it would have been possible to cultivate the fields using a permanently cultivated infield system (*alsædebrug*). In the Land Survey of 1688 cabbage gardens of striking size are noted. How far back in time such extensive garden cultivation might go we do not know. In more recent times the animal stock was of great importance to the village economy, as was undoubtedly the case in the Middle Ages.

Tårnby was ideally situated to trade agricultural produce, 5.5 km from Copenhagen and 6 km from Dragør. The former, as one of the most important harbours of Zeeland and later the meeting place of the national government, and the latter, as one of the poles of the Baltic herring markets, must have been exceptionally good markets.

THE FEATURES EXCAVATED

The excavations

The excavations revealed a wide variety of features in the subsoil as well as large quantities of settlement detritus in the culture layers. The strategy of excavation was governed by the standing buildings in the area which were only gradually vacated and demolished. The area of a total of 7,491 sq m was therefore divided into two main areas, of which the first 1,371 sq m were excavated in 1993 at the northern end of the site. Here, the northernmost part of the medieval farm site was revealed. The remaining 6,120 sq m were excavated in 1994, including the remainder of the farm site. The method of the trial excavation, in trenches with baulks, proved not to be ideal for the very complex sequences of layers encountered. In 1994 the method was therefore changed to one of areal excavation without systems of baulks, with the preliminary trial excavation revealing only the extent of the latest culture layers. In 1994 the investigation of building grounds from more recent times was also given a more significant place in the objectives of the excavation, while the medieval remains had been given priority in 1993.

The area where the buildings were concentrated was excavated stratigraphically. The culture layers consisted of, amongst other things, sequences of buildings 40 to 70 cm thick. Typical of the site to the west and south of this was a homogeneous layer of soil 1.5 m thick and the remains of more recent activities. After trial excavation and on the basis of the experience of 1993, these areas were excavated down to the subsoil in 1994. An extra network of trenches was laid out south of the building plots, and excavation down to the subsoil was not undertaken before the clearance of modern soil, as the map evidence of 1803 suggested the possibility of eighteenth-century remains on the ground here. With a few, fragmentary exceptions, these only survived in the subsoil.

Account of the features

In the subsoil about 1,280 features of various character were found (post-holes, trenches and pits). From the post-holes several stretches of fencing and two (perhaps four?) post-built buildings can be identified. These buildings are probably to be dated to the twelfth century. The most conspicuous aspect of these features is the large number of trenches, especially in the centre and the south-eastern area of the site. These trenches are of varying character and it appears possible to distinguish different types. The groups of trenches seemingly derive from the twelfth/thirteenth and sixteenth/seventeenth centuries.

The foundations of 29 completely or partially preserved buildings from the thirteenth to eighteenth centuries were recorded in the culture layers. With just a few exceptions, the buildings are divided between a northern group on the farm site and a southern one. There were in addition fragments of what are thought to be patches of floor- and rubbish-layer sequences, and part rows of sill stones, predominantly of more recent times, possible earth cellars, 14 dated and 6 undated wells, etc. The majority of the features are interpreted as the central part of a farmyard which remained in the same place within the toft.

The small finds are quite limited and include 75 kg of pottery, 140 kg of faunal remains, small personal items, various iron and wooden objects including tools and a unique piece of a hook ard, and wood from re-used ships' timbers and buildings.

THE MEDIEVAL FARM UNIT

Comparative material

The geographical location of medieval farms, their resource-governed economy, and the social status of the inhabitants, must have affected the layout of individual buildings in one way or the other, of the

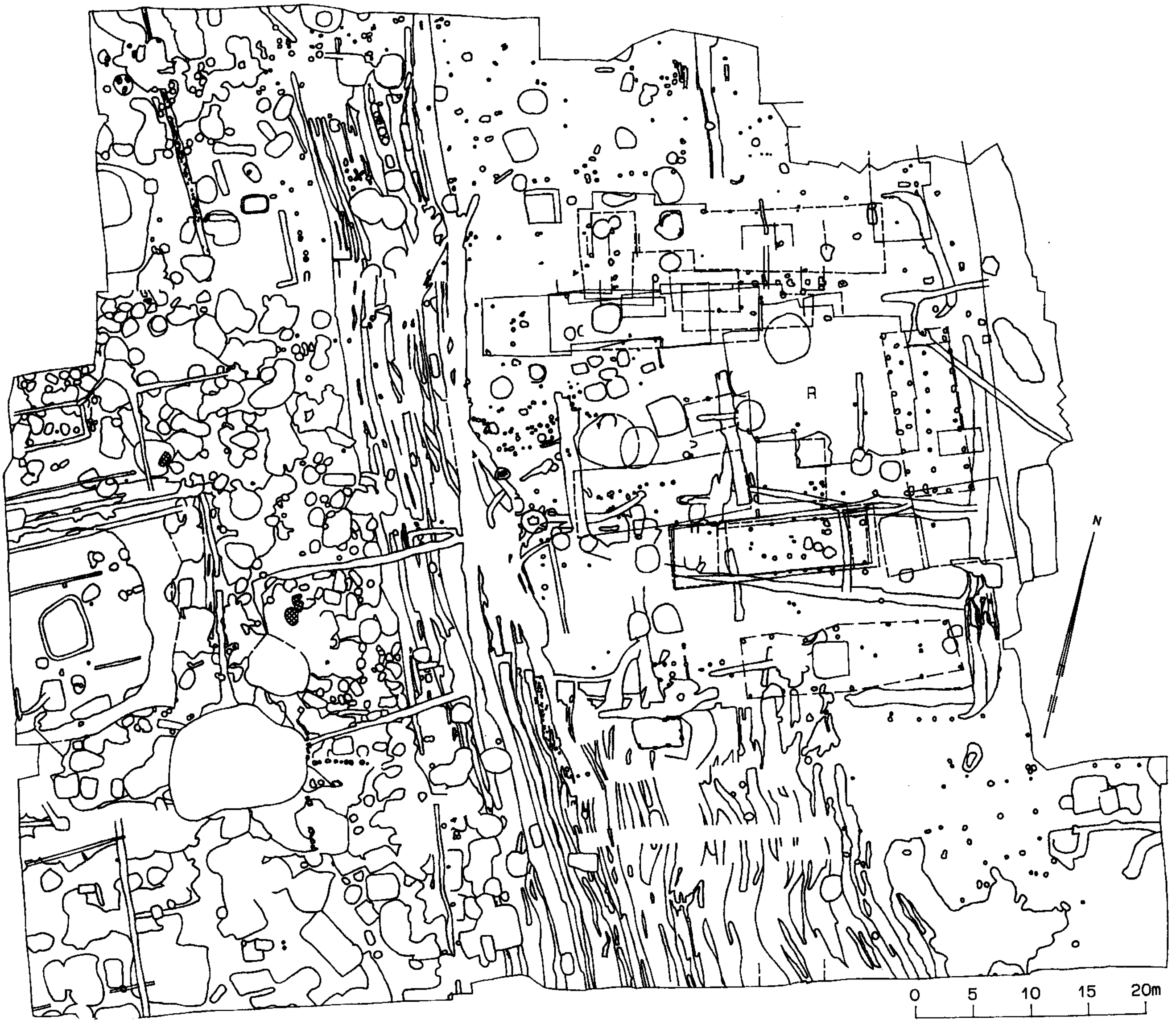

Fig. 3 Plan of all the features in the subsoil and selected features in the culture layers. R: recent cellar. Immediately to the east of the excavated area lies Englandsvej, the old village street. Drawn by TR/MSK/JP 1995/96.

number of buildings and of their position in relation to each other both close by and at a distance from the main farmstead. At the moment the evidence from Denmark is neither quantitively nor qualitatively sufficient to shed light on this issue. The few excavations that have hitherto uncovered significant parts of a farm unit of the High or Late Middle Ages have been of limited extent, either because they were rescue excavations or because of the excavator's particular goals; or the remains of the settlement have been severely truncated by subsequent ploughing. In no case, in consequence, has it definitely been possible to expose a complete farm site or farm toft[3].

The excavation at Tårnby apparently shows us a complete farmstead (the built area of the farm toft). The main parts of the toft have been uncovered too. The western limit of the toft is not known but its southern limit is defined by several physical features and its eastern limit by the village street, now Englandsvej. Less certain, however, is its northern extent. In the following, the terms *toft* and *toft-boundary* refer to the farmyard toft and not the toft field (the 'croft').

The delimitation of the Tårnby farm

On the whole, the buildings can be described as well preserved, although there have been disturbances. A large modern cellar in the centre of the farm area has removed culture layers down to the subsoil in an area measuring 150 sq m. West of this cellar the later culture layers of the seventeenth and eighteenth centuries have been dug away. These interventions evidently did not affect the medieval culture layers as these follow a slight dip in the terrain.

The building grounds reveal a high degree of continuity of location (Fig. 3) represented by up to five consecutive buildings. With a few exceptions from more recent times, the building plots are concentrated within an area measuring 1,350 sq m. Archaeologically, continuity of building is revealed by two mounds in the northern and southern parts of the farm area produced by sequences of floors, an impression which is further enhanced by a slight dip in the subsoil between these two areas. There is no matching growth of layers over a substantial area around the buildings, probably because of the consistent use of waste from the farm to manure the small but efficiently cultivated land of the village. Because of the lack of clearly defined external layers it has not been possible to link the northern and southern settlement clusters by stratigraphic means, although a phasing yields some idea of contemporaneity between the buildings.

Most of the remains of the buildings lie together in the middle of the eastern half of the excavated area while the wells and cellars are spread out over a slightly larger area, albeit still in the eastern half of the site. All of the features are thus, with the exception of a few later wells situated on the clay moraine right out to a slight fall in ground level running north-south. This is particularly evident at the northern end of the site. This drop in level reveals the gradual change from the moraine to the slightly lower-lying coastal meadowlands. The boundary between these two resource areas was also reinforced by dense systems of trenches running north-south, possibly remains of a dyke guarding the higher, settled area of the toft (see below). With the dykes on the common in mind, it seems probable that the farm buildings were placed close to and respected the fall in ground level. The recorded western edge of the building plots thus probably corresponds to the original extent of the central farm buildings of one farm unit. The slightly lower land west of the farm buildings was where the cabbage patches and *abild* yards were situated in more recent times, and this was undoubtedly also the case in the Middle Ages. The soil in this area of the excavation was primarily an unstructured layer of earth 1.5 m thick with a number of modern features. Intensive garden cultivation in later years, for which Amager has become famous, may have destroyed any earlier settlement traces lying immediately west of the drop in terrain, but this would be a remarkable coincidence. A more pertinent question is rather whether the cluster of buildings discovered represents an entire north-south transect of the medieval farm unit.

The south-eastern corner of the excavation was characterized by a thick and homogeneous soil layer. Settlement was represented in the form of a cellar (B2) and the northernmost part of a building (B1) in the south-facing section of the excavation beneath Hallinggården, a parsonage from around 1787. Both buildings belong to the seventeenth and eighteenth century. Further building was identified only in the form of two small, highly fragmentary patches of paving, a few sill stones and a small clay surface. These may be remains of Hallinggården's predecessor, 'the old parish clerk's house', before Hallinggården was constructed as a new parsonage immediately south of here. Some may also be the remains of a later building recorded in the fire assessment of 1854 (Frandsen 1989:50ff.). Since the two buildings recorded in written sources are effectively unrecog-

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3 Sites of the High and Late Middle Ages where large areas of a farm site have been uncovered are: Hejninge (Steensberg 1952; 1986); Pebringegården (Steenberg 1952); Store Valby (Steenberg & Christensen 1974); Tangen (Sterum 1976); Åstrup (Jeppesen 1982; 1983); Poghøj (Mejdahl 1987); Klemmenstrup (Rasmussen 1990); Jens Kusks Vej, Tjæreborg (Siemen 1991); Todderup (Hoff & Jeppesen 1994); Østerbyvej, Tjæreborg (Siemen 1991).

nizable archaeologically, one must assume that more recent interventions and disturbances have removed all building traces in the culture layers, and possible medieval deposits with them. It is, however, remarkable that in the southern area of the site there are no medieval features in the natural subsoil; only the aforementioned cellar (B2) and wells of the seventeenth to eighteenth century. The trenches may have removed medieval features, but one would still expect, *inter alia*, a continuing density of wells, as it is seen in the middle of the site, to be visible in between the trenches. The area, which may have belonged to the parsonage even in the Middle Ages, thus appears to have been undeveloped until the building of "the old parish clerk's house".

North of the cluster of buildings there is nothing earlier to be seen than sequences of layers from about 1400 continuing into modern times. Two earth cellars are the only medieval structures in the area.

Finally there is the boundary of the farmyard to the east, against the village street, now Englandsvej, where the lines of fencing and trenches apparently represent the eastern limit of the toft.

It would be reasonable to conclude that the excavation has uncovered a medieval farmstead from which the great majority of the building foundations in the area around the farm itself have been recorded. Some may have been removed by, *inter alia*, the modern cellar, while there may also be unrecorded functional buildings at the far west of the site at some distance from the central farmstead. Such doubts about the completeness of the farm unit are raised primarily by the lack of stalling.

The picture of 'the old parish clerk's house' and farms II and III from the Land Survey of 1688 is much more patchy because of disturbance and modern garden cultivation. Farm III could not be identified when the soil was stripped in 1993, although several buildings which cannot be clearly assigned to farms II or III were partially removed by a trial trench. Farm II, above the medieval farm area, is represented most clearly by a very well-preserved farmhouse of several phases[4].

Economic buildings

A general problem for earlier investigations of the High- and Late-medieval farm with well-preserved culture layers has been the recognition of economic buildings, as, for example, at Store Valby (Steensberg & Christensen 1974) and Hejninge (Steensberg 1986). Farmhouses have been recorded, but rarely functional buildings. The absence of economic buildings at these sites can be explained through the excavations having been concentrated around the farmhouse, through the economic buildings being harder to recognize, or through the excavations rarely having been of extensive, areal character. With the excavation at Tårnby it is now possible to reveal a composite farm structure with a changing number of economic buildings throughout the Middle Ages. If one assumes that the absence of a hearth indicates a functional building, around 75 per cent of the excavated medieval buildings in the culture layers at Tårnby can provisionally be identified as such[5]. In addition to this, the majority of the area of two of the buildings (A20 and A21) apparently primarily accommodated economic functions. None of the economic buildings differs architecturally from the houses. It is, however, striking that these buildings comprise only outhouses, storage buildings and sheds. No certain cattle stalls have been identified. The lack of stalling at Tårnby is remarkable and, in spite of the high proportion of economic buildings, sharpens the question about the fullness of our view of the farm. Were there economic buildings towards the back of the toft, in the machine-stripped soil layers behind the trenches protecting the farmyard? Were the stalls excavated, but not recognized as such – for instance building C19 (Fig. 8)? Were the stalls constructed of some perishable material such as turf, in order for it to be carried out to the fields as an efficient form of manuring together with the cattle dung, as, perhaps, the remains of C20 (Fig. 10)? Does the absence of stalls reflect the real situation with a special, climatically conditioned ecosystem and cat-

4 A comparison of the location of farm II on the survey map of 1811 and several of the buildings revealed by excavation reveals close correspondence in extent.

5 The hearth, however, is not an unambiguous indicator of function. Fire is used in association with certain forms of craft, and there was undoubtedly some seasonally governed functional change amongst the rooms. People presumably lived in the heated room in the winter and moved to unheated rooms in the summer.

tle remaining outdoors? Pig sties in the fields are known from written sources (Kroman 1942:77), but cattle were of much greater value, and one cannot imagine cattle stalls out on the coastal meadows. Another possibility is that the farm simply had no cattle stalls but that in the Middle Ages the cattle were concentrated on the main farm of Borgby.

DATING THE FEATURES

The two separate clusters with building-sequences and other features in the culture layers to the north and south of the farm plot, and a similarly stratigraphically isolated building to the east of the area, pose problems for the determination of the contemporaneity of individual buildings within particular dating brackets. Because of the paucity of datable finds the establishment of probable contemporaneity between individual buildings is of vital importance to the phasing of such features. The crucial structures in the subsoil can be related to one another stratigraphically. Similary the medieval building plots, with just one exception (U5), can be related to one another within their own clusters. On the basis of the stratigraphical evidence and datable artefacts it has been possible to divide the development of the toft and farmstead into seven phases running from the twelfth century to the eighteenth. The relatively sparse datable material means that there is uncertainty over the assignment of several buildings and wells to one out of two or more phases. Likewise most features in the subsoil can only be dated earlier than the overlying culture layers.

The dating of individual buildings and phases is based predominantly on the pottery. The earliest phase of settlement was findless, and is dated by building typology. No local pottery chronology has been worked out for the Copenhagen area,[6] so no local chronological variation can be built into the ordinary date-ranges of the pottery types. In addition, only 2,734 sherds were collected in the excavation, of which at most 2,250 are medieval.[7] The oxidized, externally glazed pottery of the thirteenth and fourteenth centuries can be followed through from the earliest settlement represented in the culture layers. The presence of stoneware is central to the separation of the thirteenth-century phase from the fourteenth and fifteenth centuries. Stoneware, however, constitutes only 5 per cent of the total quantity of sherds, and the absence of stoneware thus cannot be used as a secure basis for dating pre-1300.

Coins were also used for dating, including a number of civil-war issues with special significance for the dating of the High-medieval phases.[8] These datings are corroborated by a number of other dated objects such as, for example, double combs, or the presence of tiles. But a detailed and secure phase-division is not possible as the majority of the datable artifacts and pottery are chronologically insignificant, with broad date-brackets within the High and Late Middle Ages. The datings of the buildings in the northern cluster are particularly uncertain.

THE BUILDINGS

By means of excavation the sites of 31 buildings were recorded, 18 of which can be dated between 1100 and 1500 and the remainder to the sixteenth to eighteenth centuries. Sixteen of the buildings, dated 1200-1500, lay within the culture layers and thus greatly increase the evidence for buildings of the High and Late Middle Ages in the present area of Denmark, where only 44 High- and Late-medieval buildings from 21 sites have hitherto been published. It is evident that, because of the still limited amount of evidence, no discussion about possible developments in constructional techniques or the relationship between region, date and economic circumstances is possible.

6 The only published evidence from the area is from Stakhaven, Dragør, which, when more recent pottery is removed, consists of about 2,000 Late-medieval sherds (Liebgott 1979).

7 The material includes local reduced and oxidized wares together with a small admixture of jugs from Bruges and Flanders and stoneware from Siegburg, Langewehe, Niedersachsen and Raeren. The provenance of the stoneware was determined by cand. mag. J. L. Larsen.

8 A total of 45 coins were collected, two of which are uncertain and nine unidentifiable. Twenty-three coins can be dated to High and Late Middle Ages. The coins were identified by mus. insp. A. Kromann and mus. insp. J. S. Jensen of the Royal Collection of Coins and Medals, the National Museum.

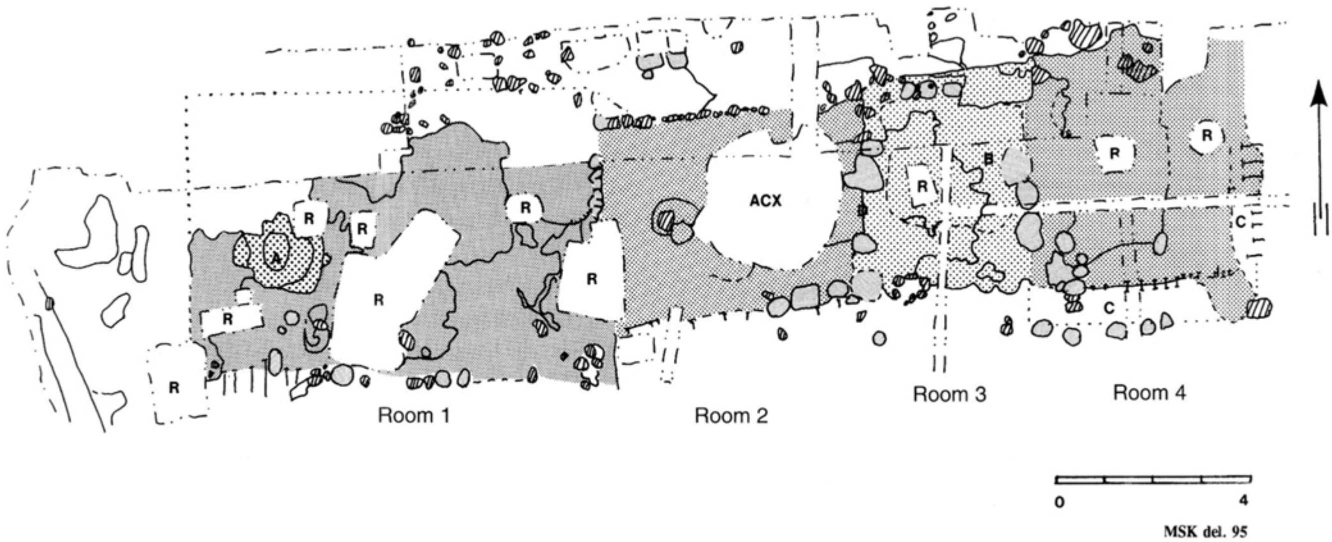

Fig. 4 Building A21 is a 19.5 metre-long feature aligned east-west and comprising four rooms. Its width varies from 3.4 to 5.2 m. It had a floor area of 84 sq m. The dwelling area was in the western room, and the other rooms apparently all accommodated economic activities. A: hearth in two phases; B: compact layer of fish bones; C: bench in the south-eastern corner of the room; D: doorway; R: recent; ACX: 17th-century well. The northern part of the building was excavated in 1993, the southern in 1994. MSK 1995.

Building practice

No clear image of either consistency or change in building practice immediately presents itself in the building remains from Tårnby, nor could anything of the kind be expected from material which is too small to be of statistical significance and which might at best just indicate some developmental tendency. The 18 medieval buildings are not only spread over four centuries in date; regional differences and minute differences from farm to farm, particular functions, the changing availability of building materials, regulatory restrictions, social needs, and not least mere tradition, can all determine the form of construction of any individual building. The buildings at Tårnby do, however, support the view of a development from buildings with earth-fast posts to sill- or wall plate-founded walls upon the ground around 1200 (Fig. 4). The High- and Late-medieval building remains typically show a mixture of different building techniques including post-bearing stones combined with sill timbers on the ground, individual post-holes, and scattered and irregular rows of sill stones comprising small stones measuring only 10 to 30 cm, though stronger, well-laid sill-stone rows with granite boulders measuring from 40 to 60 cm appear in the fourteenth and fifteenth centuries. The use of large boulders continues into more recent times when the constructional technique becomes more uniform.

The Tårnby buildings of the Middle Ages are predominantly one-aisled with roof-bearing walls, although a possible five buildings were of central-post construction. The wall material was presumably mostly daub. In one single case a turf building of the fourteenth to fifteenth century is recorded (building C20). Unfortunately only the gable end survived because of disturbance by the modern cellar. In three of the medieval buildings remains of turf-built part lofts were found above lath and plaster. Part lofts have previously been identified at Hejninge by Steensberg (1986:47ff.). With a few exceptions, the buildings are aligned E-W with only minor deviations. The buildings are of widely differing sizes and can be divided into three size-groups. Building A1/A2/A3 stand alone at 27 metres long. It is followed by two approximately equally large groups of buildings of 10-20 metres and up to 10 metres respectively. The plans of the buildings are fairly well preserved and in several cases it has been possible to identify room-divisions and changes therein. Hearths were recorded in five of the medieval buildings but no furnaces.

The function of the buildings

Determining the function of the individual buildings depends upon the presence or absence of a hearth. In an attempt to identify different activity zones at the farm a functional analysis of the separate buildings and rooms on the basis of the distribution of finds was attempted. However the relatively small quantity of finds regrettably meant that this analysis was inconclusive.[9] Domestic waste and manure had been methodically removed from the farmyard, which means that the range of finds was severely reduced both at the microlevel of the individual buildings and at the macrolevel of the toft. At the time of writing only pilot studies of the faunal and geobotanical remains have been undertaken, and no comprehensive analysis of the complete material.

TRENCHES AND FENCES

In the subsoil of the site was a complicated system of trenches, especially in the central and eastern part of the site. Several stretches of fencing can also be reconstructed (Roland, in Kristiansen *et al.* 1994: 4ff.)[10]. The trenches are laid out in roughly two ways. One of these is a variety of single trenches, the other two trench-systems running north-south, the 'western trench group' west of the farm site and the 'southern trench group' to the south of it. Of these, the western group at least consists of two phases. The fences are, as far as one can tell, mostly to be assigned to the earliest phases of building.

The group of various *single trenches* is probably to be interpreted as a set of toft-boundaries, folds, pens and the like. Where the stratigraphy can be read, the single trenches are later than the earliest phase of the western trench group. These trenches lie beneath building plots dated to the thirteenth century.

The *western trench group* of long, regular trenches runs in the boundary zones between the moraine and the lower coastal meadows to the west (Figs. 5-6). This trench group appears to define the limits of the farmyard. It consists of 10 to 15 trenches[11] which are evidently not all contemporary but fall into a sequence moving from the west to the east. The last trench, however, of the sixteenth/seventeenth century, after a break of several centuries, was placed back in line with the earliest trench to the west. Stakes and posts were found associated with several of the trenches which can be interpreted as the traces of wicker- or lathwork fences or hurdles. In some places breaks in the trenches can be identified as entrances. The group can be divided into two phases, respectively earlier and later than the dividing ditch FCZ running east-west. The later group to the east is covered by a layer which probably belongs to or is contemporary with the earliest building in the northern building group, A21, dated to the thirteenth century (Fig. 7). A number of trenches to the west cut a layer which is dated post-1500/1600. The functioning period of the trenches was thus an extended one. The majority of the trenches, however, can be assigned to the twelfth and thirteenth centuries.

The *southern trench group*, consisting of 15 to 20 trenches, lies south of the building plots (Fig. 11). Here too a sequence of construction running from west to east can be identified. The trenches here follow a more wavy line. It cannot be determined whether the difference between the long, continuous trenches in the western trench group and the interrupted, curved courses of the southern group is a functional matter. These trenches are cut into a layer of fill above a hollow in the subsoil. This fill

9 Plotting of all finds and subsequent analysis of their distribution has been successfully used to reveal functional divisions and/or social structuration, e.g. in Czech excavations (Felgenhauen-Schmiedt 1993:132). The minute three-dimensional plotting of all finds has only been attempted on Steenberg's excavations in Denmark, although in this case, unfortunately, the large quantities of finds are not always given individual analysis.

10 Work on the structures in the subsoil was undertaken by cand. phil. T. Roland. The stratigraphical relationships between the fences and trench groups are based upon his work, and the various features have been assigned to the phases of the farm in collaboration with him.

11 The trenches vary in width from 0.4 to 1.7 metres, with most between 0.6 and 0.7 metres. Where the original top is preserved they are found to be 2 metres wide and 0.8 metres deep.

may be identical with the layer of fill referred to above dated to post-1500/1600, in which case the southern group must be dated to more recent times. The group lies below building B1 and cellar B2 which are dated to the seventeenth and eighteenth centuries. The sharply defined northern end of the trench group indirectly indicates a toft-boundary or some internal division within the toft. This boundary coincides with the southern extent of the group of single trenches. As the single trenches and the southern trench group are not contemporary, this situation must reflect the maintenance of a boundary line throughout the Middle Ages into more recent times.

In addition to the trenches there are a number of lines of *fencing* running both east-west and north-south. Most fences were observed in the subsoil. The fences are mostly visible only in fragments and the remains might often be interpreted differently. In many respects, however, they agree with the arrangement of the western trench group. It is likely that several of the remaining post-holes in the vicinity of the trench group originally belonged to similar lines which have, however, been so fragmented by later disturbances that they could not be identified as lines of fencing. Where the lines in the subsoil can be related to the building grounds in the culture layers (A20, A21, C18 and C19) the fences are earlier. Some fence lines are, however, also recorded within the culture layers.

The large number of sequentially dug trenches is thought-provoking, and in the case of the western trench group at least it is possible that they marked the boundary of the occupied area of the farmyard. A discussion of the meaning of the trench groups (Roland, in Kristiansen *et al.* 1994:47), indicates the critical conditions for the identification of toft-boundaries. To begin with, it is easier to clear an existing trench out than to dig a new one. Interpretation as drainage ditches is unconvincing as the trenches nearly all run the wrong way in relation to the natural slope of the land, while they also contain next to no water-deposited layers. Nor does an interpretation as field or bed boundaries appear probable. For one thing the trenches were originally of considerable depth, while also only a few such divisions would have been found at the same time. A fourth possibility is that they represent dykes consisting of ditches and banks, constructed to prevent the flooding of the settled area to the east. The constant improvement of the bank could explain the eastwards shift of the trenches, as it is conceivable that the bank formed of the upcast could collapse into the trench behind it. In rebuilding the dyke one would take material from the back, thus producing the parallel trench lines. But none of the numerous sections through the trenches have shown that the fill entered them to any especial degree from the western side, and this hypothesis does not explain why some trenches fall outside the general pattern of construction running from west to east by being placed in the middle of the system. Nor can the small number of entrance ways crossing the trenches be explained in the context of a dyke.

Since this is a common structure, running right across several farm tofts, perhaps the entire village, the idea of a dyke structure seems plausible in spite of everything. Its west-east line both before and after the toft regulation of phase 2 with trench FCZ does not allow the trench group to be interpreted as a western toft-boundary.

The function of the southern trench group appears to have been truly strange. Its location leaves no space for building, and the function (whatever it may have been with these irregular and undulating courses) must have been abandoned at the latest with the construction of Hallinggården's predecessors, building B1 and cellar B2, which cut across the line of trenches. There can be no question of it being a toft-boundary as the distance from here to the village street immediately east of the area of excavation, the present Englandsvej, is simply too small, irrespective of variation in the medieval street line; and there is no basis for assuming that in the High and Late Middle Ages the street line was radically different. If the trench systems are to be interpreted as dykes we cannot explain why it was found necessary to continue improvements for three or four centuries on the southern toft after they had ceased on the toft to the north.

THE TOFT AND THE DEVELOPMENT OF THE FARM SITE

In Denmark, the structure of the farm in the Viking Period and the earlier Middle Ages is generally characterized by buildings dispersed over the whole farm

Fig. 5 Phase 1, with the earlier toft layout and the earliest phase of the western trench group. The smaller number of trenches to the south of the group was caused by the deeper clearance of the overburden of layers of fill which looked like the subsoil. TR/MSK/JP 1996

toft, while in the eighteenth century a compact farm complex right beside the village street was typical. When the change took place we do not know (Porsmose 1991:194). The excavation at Tårnby shows it to be probable that this farmstead lay alongside the village street as early as the twelfth century.

Because of the absence of continuous culture layers over the surface, it is difficult to explicate the development of the farm plan or the chronological relationship between the groups of buildings. The following phasing of the farm area and toft is based upon a number of stratigraphical observations combined with probable associations where mutual relationships are otherwise lacking.

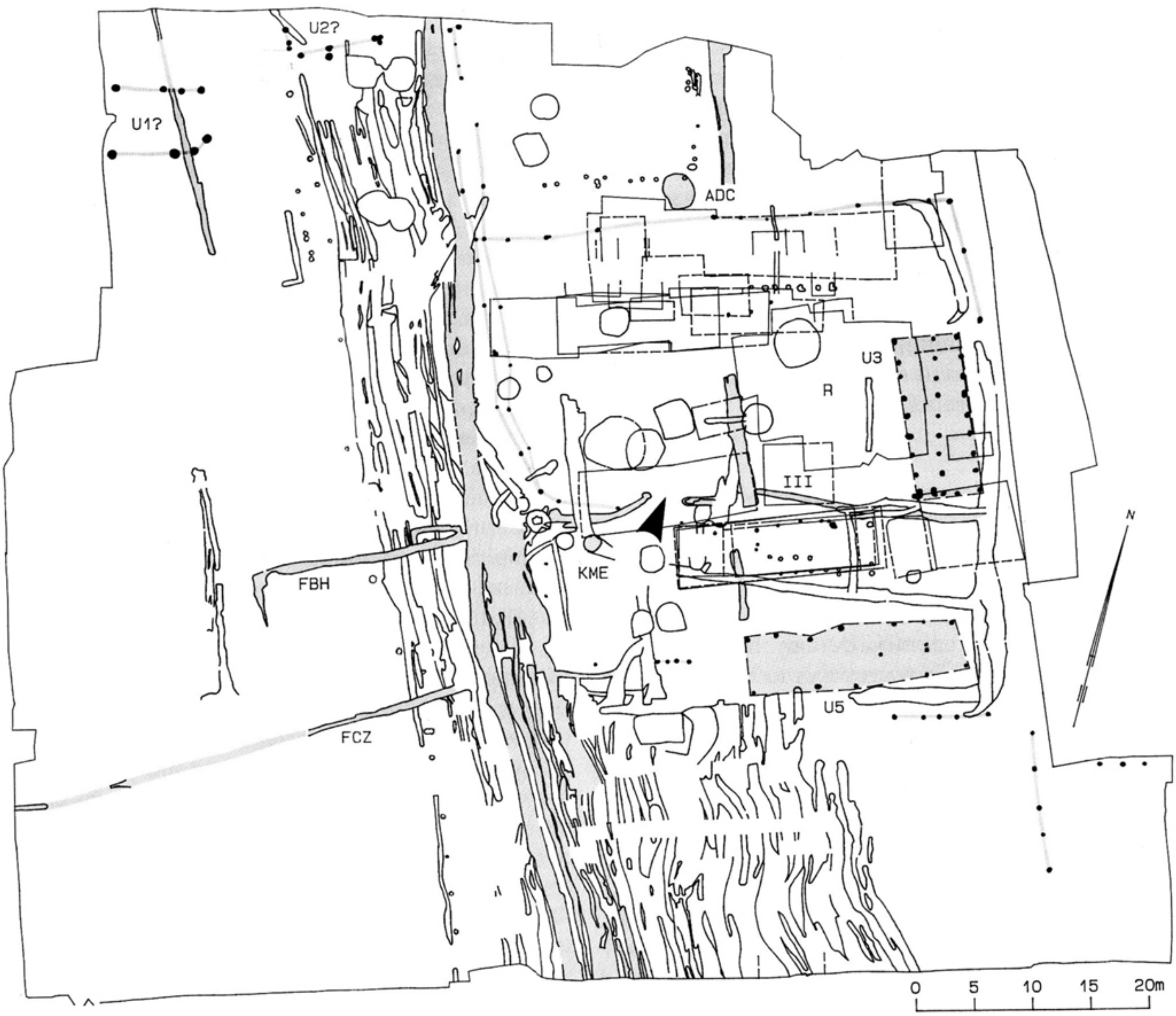

Fig. 6 Phase 2, with the regulation presumably effected in the twelfth century and the latest phase of the western trench group. The buildings may belong to both phases 1 and 2 but are probably to be assigned to phase 2. The farmstead is divided into a cattleyard and a stackyard. Arrow: entrance; R: modern cellar. TR/MSK/JP 1996.

Phase 1. 1000-12th century(?) Trench lines from an earlier toft division

This phase (Fig. 5) may show part of a larger toft whose limits were not revealed by excavation and which is divided into western and eastern parts by a system of trenches running north-south (the earliest phase of the western trench group). There may be a case for the northern toft pertaining to an earlier village structure with four large tofts situated around a green (see below). Approximately in the middle of the area of excavation can be seen a real break in several of the trench lines, while the trenches end or are interrupted at the northern limit of the excavated area. These breaks must represent entrances. It cannot be determined, however, whether the end of the trenches to the north is likewise due to an entrance way or is the real limit of the trenches. The function of the trenches is not obvious. Interpretation as the remains of dykes is speculatively proposed but they served in any event as an internal boundary line for the slightly higher eastern area of the farmyard. The earliest phase of the trench group may be contemporary with the buildings and several trenches marked on phase 2 (Fig. 6) but this cannot be verified stratigraphically. Both structures U1 and U2, also shown on phase 2, can be interpreted as the remains of buildings but are more likely to have been fence lines or droveways associated with one or both of the trench phases.

Phase 2. Toft regulation in the twelfth century

In this phase (Fig. 6) a regulation of the large toft was effected by means of the later, isolated east-west trench FCZ. The parcel division is probably to be dated to the twelfth century, though the thirteenth is possible. Trench FCZ is probably to be identified as the boundary between the new farm toft and the parsonage land to the south. In different physical forms this boundary can be traced as a fixed division right through the Middle Ages and more recent times (trench FCZ in the twelfth century [phase 2]; the angled terminal of trench GMC in the thirteenth and fourteenth centuries or later [phases 3-5]; and the abrupt northern end of the southern trench group in the sixteenth and seventeenth centuries [phase 7]: see below). Interior trenches and fences contemporary with the settlement also belong to phase 2.

The western trench group of phase 1 continues to shift eastwards in its later phase, cutting across FCZ and FBH. Functionally, this trench group must now relate to several tofts, delimiting the area immediately up to the farmsteads. In the latest phase of the western trench group the entrances of its earliest phase were closed. East of the trench group and parallel to it can be seen a line of fencing. This fence can only be followed in the northern part but that may be due to the digging of the southern trench group in phase 7. The fence could have been just one of many, as is hinted at by scattered post-holes and small fence lines preserved in between the closely spaced trenches.

The east-west line of fencing in the north can only be dated to before phase 6 but was probably established in phase 2 or phase 3. Its contemporaneity with phase 3 seems to be established by the angled northern end of trench IKV which respects the fence line (Fig. 7). Its position may mark a toft-boundary, although it apparently did not continue west of the western trench group like trench FCZ. This, however, could be just a matter of preservation. The stratigraphical relationships between the northern fence, the later phase of the western trench group, and the inner lines of fencing parallel to this, are unknown. The interpretation and dating of the fence to the north is essential to the understanding of the subsequent development of the toft as it could either be a fence within the toft or a toft-boundary. If it were simply a subdivision of the toft, the extent of the latter is not known. If, on the other hand, it were a genuine toft-boundary, three tofts can be seen in the area excavated. In the middle of the area is a toft 40 metres wide. This toft is bounded to the south by a trench and to the north by a fence. North of this can be seen the southern part of another toft, perhaps including well ADC. This well, however, can only be dated as earlier than building A1/A2/A3 (phase 6). South of the central toft can be seen the northern part of a toft with no medieval building remains. The western boundary of the tofts is not known. Minor stretches of fencing running north-south towards the east may be parts of a longer fence that was partially removed by the later trench systems of phase 3. This fence could be a toft-boundary against the village street.

The earliest buildings in the area (and of these only U3 and the well KME) can only be dated as earlier than phase 3 and could therefore be contemporary with both phases 1 and 2. If U1 and U2 are simply to be interpreted as fences or something like that, the earliest phase of the farm consisted of building U3, probably the undated building U5, and well KME. No finds were made in association with this phase, the dating of which is based on building typology. The stratigraphical relationship between trench IFX of phase 3 and well KME is uncertain, although the trench appears to cut the well. Building C7 above U3 (Fig. 8) could also possibly be assigned to this phase, though its dating is highly uncertain. The view of the stratigraphical relationship between these two buildings depends largely upon

Fig. 7 Phase 3. Stars: hearths. Arrow: entrance. R: modern cellar. TR/MSK/JP 1996.

whether one regards the precise overlaying of the eastern wall of the buildings as a constructional modification of a single building (from the post-built U3 to the sill stone-founded C7), or as a pure coincidence deriving from the boundary of the toft immediately east of here. Building C7 cannot be traced to the same northern and southern extent as U3. In the former case, with continuity between the two buildings, C7 would be contemporary with or earlier than the north-south trench IMP-V belonging to Vwest continues in trench GOA and IFX beneath building C19 (phase 4). The construction of building C7 could thus be earlier than or contemporary with C19 (fig. 8). In the other case, in which the superimposition of C7 upon U3 is attributed to chance, C7 can still be placed in any one or more of the subsequent phases 3 to 5. Stratigraphically, building C7 is quite isolated from the other High- and

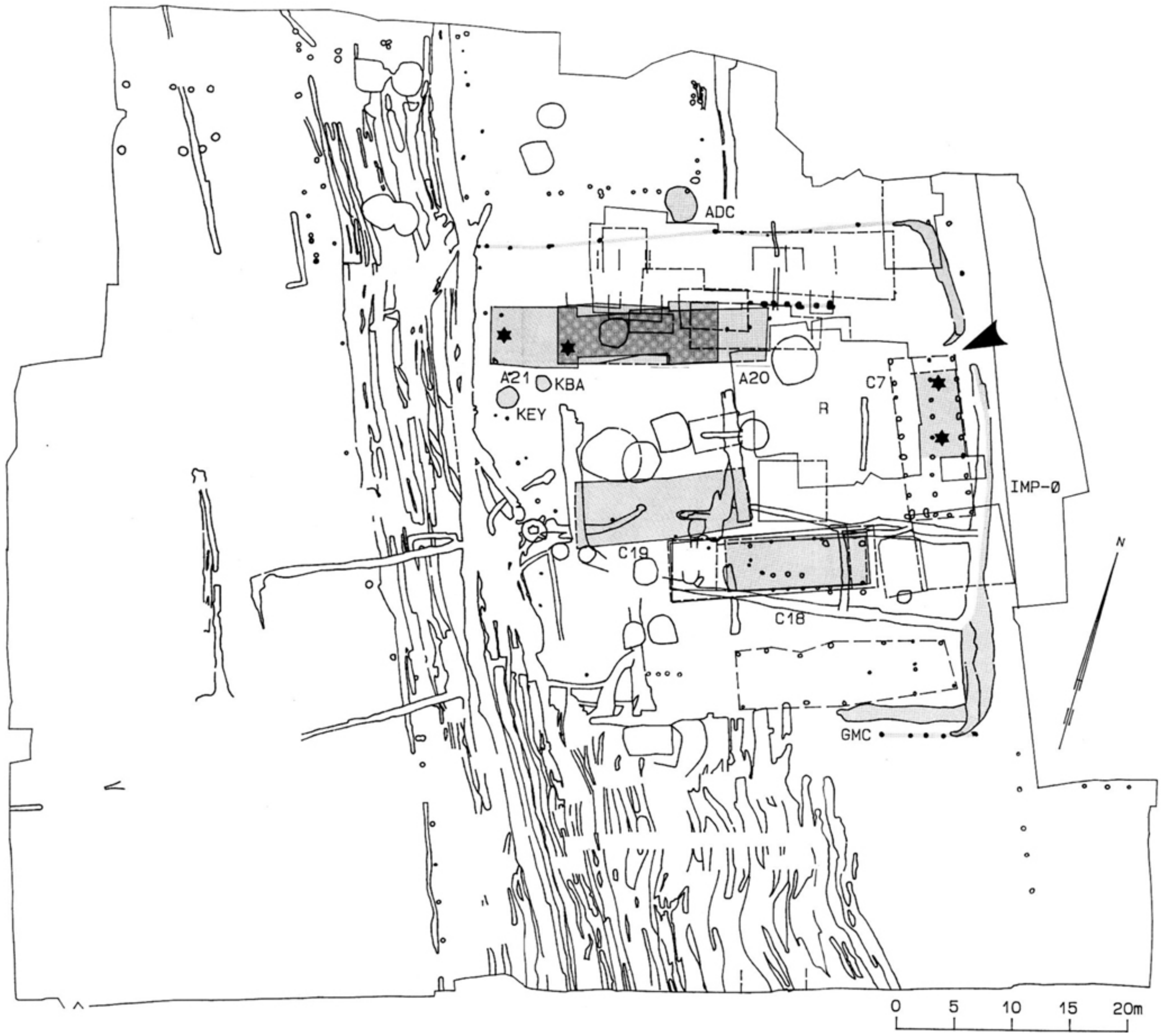

Fig. 8 Phase 4. The 13th-century farmstead in a two-winged, possibly three-winged, layout. Stars: hearths. Arrow: entrance. R: modern cellar. TR/MSK/JP 1996.

Late-medieval buildings of the farmstead. It should be noted that a few glazed jug sherds of the High Middle Ages were found in building C7.

The area in which U3 (C7?) and U5 lie was divided by trenches FBH and III together with the line of fencing on the inside of the western trench group. The gap between trenches FBH and III and the corresponding end of the fence line looks like an opening. This suggests an internal division of the farmyard into a cattle yard (fægård) and a stackyard (lægård).

Phase 3. An angular line of trenches with or without buildings

This phase (Fig. 7) is represented by enclosing trenches. The trenches overlie building U3 and well KME of phase 2. The southern limit of the trenches, at GMC, corresponds to the location of the toft-boundary trench FCZ in phase 2, indicating the maintenance of the boundary to the south though in a new physical form. The fence along the village street is now replaced by a trench, IKV and IMP-V. An entrance from the village street can be seen. The line of fencing to the north is undoubtedly to be associated with this phase. Note the northern end of trench IKV which merges into the fence line.

The only building of this toft is building A21 and possibly the abovementioned C7. Building A21 with the wells KBA and KEY cannot be related stratigraphically to the single ditches of phase 3. Phase 3 would thus have been a phase in which the area was not built upon, as it is not probable that C7 – for reasons of its size – was the only building there. A21 is dated to the thirteenth century. It overlies the north-south fence east of the western trench group. Similarly a layer contemporary with A21 may overlie the latest trench of the western trench group. Thus the abandonment of the western trench group took place either in this phase or the next, phase 4, according to where we place building A21.

Phase 4. A three-winged structure? Thirteenth century

From the thirteenth century onwards we find a continuous sequence of building foundations in the culture layers (Fig. 8). The settlement is of a very stable character, producing sequences of buildings involving several superimposed building grounds. Building A21 and with it the decommissioning of the western trench group may, as noted, belong to this phase or to its predecessor. With C19, the earliest building of the southern building group, the line of trenches GOA, IFX and IMP-V is likewise covered over. The northern east-west fence from phase 2 may have remained in use, as may trench GMC. In GMC a reduced-fired jug was found which can be dated to the thirteenth century at the earliest, and the trench must have been filling up at this date or later. Trench GMC is presumably equivalent to trench IMP-Ø. IMP-Ø may therefore be the continuing marker of the farmyard boundary against the village street.

The farmstead of this phase comprises the buildings A20, C19 and the later C18, possibly A21, and perhaps C7 too (cf. above), and the wells ADC, KEY, and possibly KBA (contemporary with A21). Of these, ADC and KEY may stratigraphically also belong to the following fourteenth-century settlement (phase 5). Building C18 burnt down before 1300-1320.

Building A21 lies to the north and was succeeded by building A20 which was shifted slightly eastwards. To the south building C19 can be seen to be followed by C18 with a shift towards the south-east. Out by the village street may have been C7, but if C7 belongs to either an earlier or a later phase there would only have been two parallel wings.

If one interprets hearths as evidence of occupation, this function is represented in the westernmost rooms of A21 and A20 and in C7. C18 and C19 are both functional buildings, as may have been the eastern rooms of A21 and A20. Since we must always assume at least one residential room, A21 or possibly A20 alone is placed in this phase. Since it is not possible to assign A21 and C7 to a particular phase with certainty, it is consequently impossible to determine which of the wings is the older, while regrettably the basic plan of the farmstead of the thirteenth century also cannot be explicated in detail. We do not know when the closed farmstead known from more recent times came into being, and definite evidence of a farmstead with three separate wings in the thirteenth century would have been of interest in this respect. Building A21 and its successor A20 may both, with their combination of a dwelling space and economic space, in fact have lain alone with no supplementary buildings. We also do not know whether A21 and/or A20 stood at the same time as the functional buildings C19 and/or its successor C18.

Phase 5. Re-organization of the layout of the farm, 1300-1350

This phase of the farm (Fig. 9) is dated by the presence of stoneware and civil-war coins. The south-

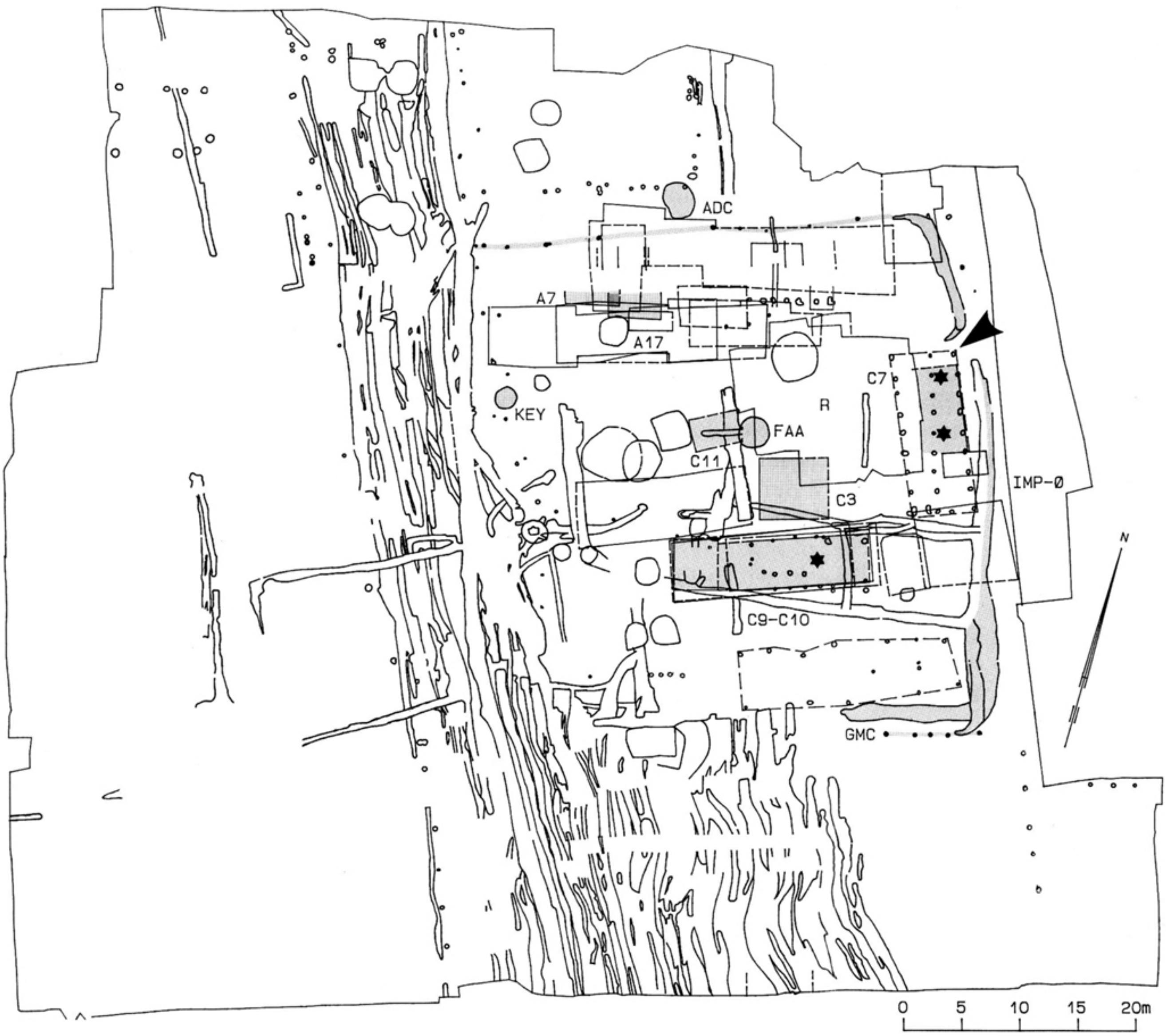

Fig. 9 Phase 5. At the beginning of the fourteenth century the dwelling area was moved from the northern part of the farmyard to the south. Stars: hearths. Arrow: entrance. R: modern cellar. TR/MSK/JP 1996.

ern boundary is not clearly represented in physical form in this phase. However, the boundary must have been maintained as it still is respected in phase 7. There is therefore no reason to suppose that there was any expansion of the toft southwards into the low-lying and possibly saturated area. In phase 5 or later trench GMC (=IMP-Ø) went out of use.

The dwelling house A20 was superseded by a stage involving the functional buildings A17 followed by A7 (both of them partly removed during the trial excavation in 1993), together with C11 in the centre of the farm area. C11 was cut by well FAA, which is in turn covered by the functional building C3. Because of the uncharacteristic and homogeneous layers we cannot tell if C3 is contemporary with or later than dwelling house C9-C10, so C3 could belong to both this and the next phase.

With the small economic buildings A17, A7 and C11, the residential function of the northern sequence of buildings came to an end. In order to keep

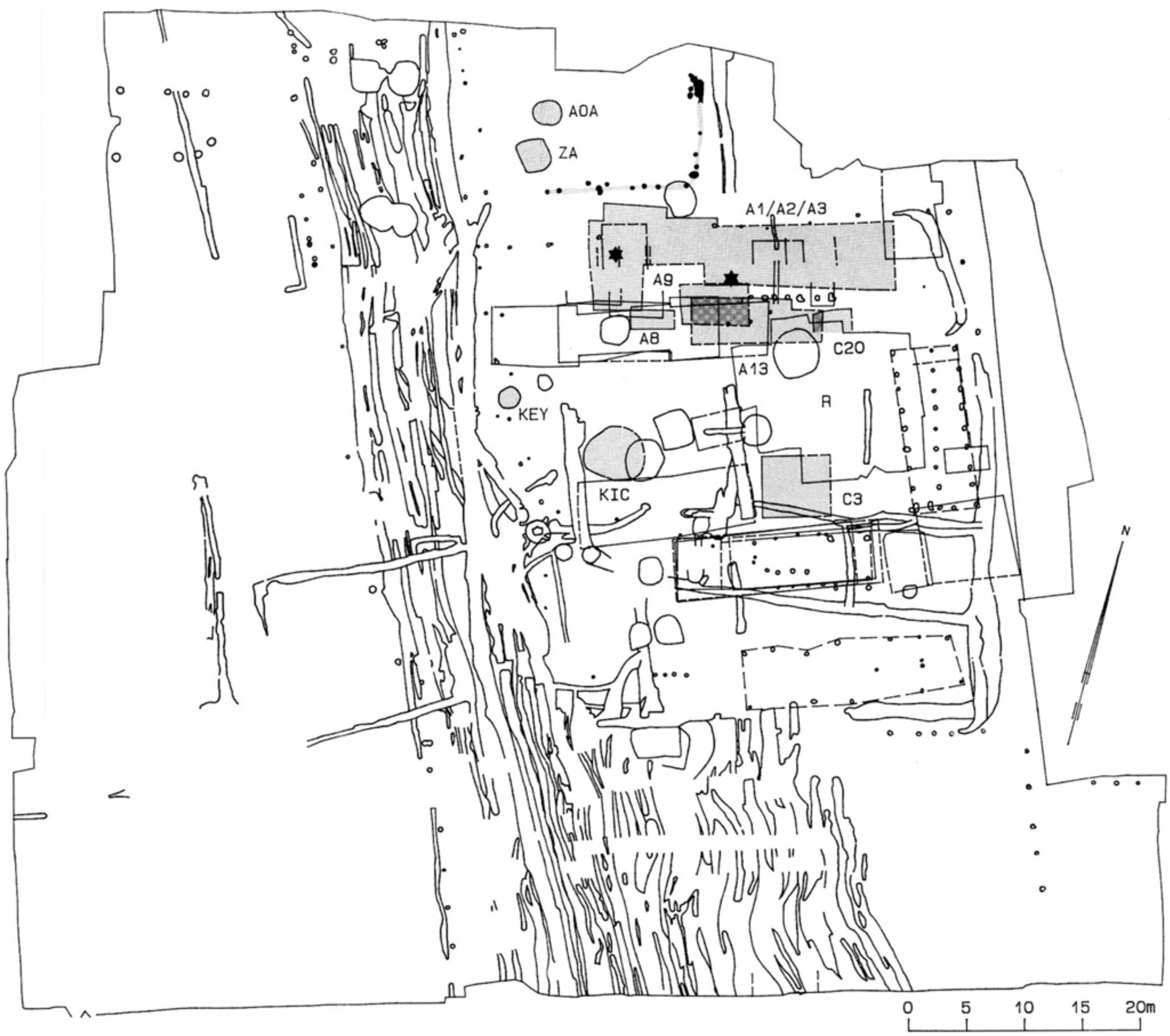

Fig. 10 Phase 6. With the construction of the largest of the medieval buildings in the fourteenth century the toft was probably extended towards the north. Stars: hearths. R: modern cellar. TR/MSK/JP 1996.

some dwelling place within the farmstead, either C7 or C9-C10 must be contemporary with those buildings. C9-C10 supersedes a functional building C18 of phase 4 in the southern building sequence after it was burnt, sometime before 1300-1320. From having an economic function, the southern area of the farmyard now assumes the residential role. Perhaps C7 was first demolished in this phase, and the residential function was moved to C9-C10? Three wells, ADC, KEY and FAA may also belong to this phase.

C9-C10 apparently burnt down in the mid-1300's, and it may have been on this occasion that the centre of gravity of the farmstead shifted northwards with A1/A2/A3, although the relationship between the dates of C9-C10 and those of A1/A2/A3 is completely unknown. It is therefore quite possible that the two buildings were both standing at the same time.

Fig. 11 Phase 7. Sixteenth to eighteenth centuries. Only dispersed buildings from farms II and III of the 1682 survey are preserved. Another trench group can be seen on the southern toft. Stars: hearths. Circles: stoves. Square: jamb stove. Arrow: entrance. R: modern cellar. TR/MSK/JP 1996.

Phase 6. Expansion of the toft, 1350-1500

With the construction of A1/A2/A3 at the latest (Fig. 10), the main building of phase 6, the northern fence line must have been decommissioned. If this were, as already discussed, a toft-boundary and not some internal partition, the farmyard was extended to the north in phase 6. The northern boundary of the toft must then lie outside of the area excavated and the toft would now have been at least 55 m wide.

Building A1/A2/A3 is, at 27 m long, the longest building excavated, and it accommodated a dwelling space to the west and economic functions to the east. It was supplemented by the small functional buildings A8 and A9. C20, the only turf-built structure excavated, superseded A9, to be replaced in turn by functional building A13. Building A13 can at least be dated to the end of the fifteenth century although it could still belong to the sixteenth century. The possible earth cellars ZA and AOA may be assignable to this phase too, but both their function and their date are highly uncertain. A fence line between these cellars and the main building may belong either to this or to some later phase. Wells KIC and possibly KEY are of this phase too.

Phase 7. Buildings and the latest trenches, sixteenth to eighteenth century

The post-medieval farmstead in the central toft (labelled farm II in the survey of 1682) is poorly preserved because of later digging and gardening, although some building grounds have been fully uncovered (Fig. 11). Building C8, also the only building in the culture layers with earth-fast roof-bearing posts throughout its eastern half, and the overlying building C1, are both well-preserved houses and it is possible to trace their changing layouts. The buildings contain stoves, the only ones recorded in the history of the farm. A curious detail is that building C1 eventually abandoned its chimney in favour of a hearth placed directly upon the clay floor. This farm also comprised cellars C5 and C6 and barn C2. To the east, by the village street, one can see a long manure bunker (KMD). The arrow marks an entrance across this. Buildings A4, A5, A6, A18 and A22 (all partly removed in 1993) and D1 lie in the boundary zone between farm II and farm III to the north. This phase also comprises wells OGF, ACX, ILG, KBE, BVA, KIP, IRP, and GHP together with six undated but probably contemporary wells. After 1682, the width of the central toft was again reduced (according to the toft-widths given in the Land Survey of 1688), but the northern toft-boundary has left no physical traces in the area excavated.

On the southern toft, which may have belonged to the parsonage, the southern trench group, of unclear function, was established. This may be datable to the sixteenth or seventeenth centuries. The northern limit of the trenches agrees with the course of trench FCZ of phase 2 and the southern limit of the single trenches of phase 3. Certain trenches of the western trench group, probably from one continuous line, show that the function of this group had been resuscitated. In the seventeenth to eighteenth centuries building is found in the southern toft for the first time, in the fragmentary form of building B1, cellar B2 and a few extremely badly damaged building remains (not marked on figure 13) which may have belonged to 'the old parish clerk's house', the predecessor of Hallinggården immediately south of the area of excavation. This building is later than the southern trench group.

THE STRUCTURE OF THE VILLAGE

The development of the village can only be considered retrospectively in the absence of written sources. It is based on just three archaeological observations, namely the excavation of Tårnby Torv described here, a minor trial excavation immediately west of the church, the site called 'Mrs Olsen's house',[12] and the investigation of the Viking-period settlement on the later toft fields east of Englandsvej.

Nowadays Tårnby has the character of a strip village north of the church along Englandsvej, a road which was probably the route between Copenhagen to the north and Dragør at the southern end of the island as early as the Middle Ages. The northern and southern halves of the village are of fundamentally different character (Fig. 2). The strip village to the north has typically elongated, regular, defined tenements, each one with its own droveway or with a shared droveway out to the common and the coastal meadows to the east. Around the church in the southern part of the village, however, the picture is radically different, with small house plots lying this way and that in small, coherent blocks surrounded by droveways. The excavated area of Tårnby Torv lies exactly over the area between these two types of village layout. These completely different patterns of division have led to discussions of the development of the village (Mahler 1994), and it has

12 This site was subjected to trial excavation in 1994 (J.nr. SØL 476). Sherds of glazed jugs were found and some more recent pottery. Culture layers were also recorded, and features cut into the natural which continued underneath the churchyard wall.

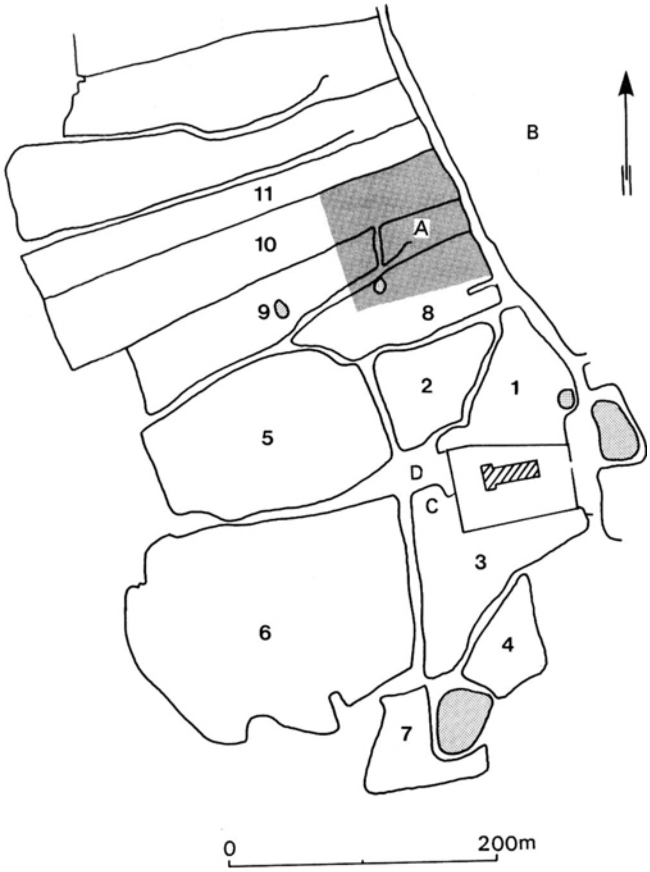

Fig. 12 A: excavated area. The excavated medieval farmstead is in the middle toft marked. B: Viking-period settlement. C: 'Mrs Olsen's house'. Suggested original village layout: areas 5 and 6 are both individual tofts. Areas 1, 3, 4 and 7 can be regarded as one integral toft. Area 2 may be part of a toft although it could also be the village green, which survived on to the 1811 map as a small area (D) in front of the church. Area 8 fits into a natural space north of 2 and 5, while the character of the droveway between 2, 5 and 8 indicates that 8 fits in the original picture as yet another toft. The northern part of the toft is covered by the later, narrow, regulated tofts. 9 presumably originally belonged to 8, but a droveway was placed between 8 and 9 when the tenements were redefined (after Mahler 1994).

been suggested that the original village consisted of four large tofts arranged around a green (Fig. 12). The church was built on the largest toft. The row of narrow tofts to the north is later and crosses the old toft pattern. The strip village may have developed slowly, but its consistently regular plan rather suggests its establishment in one go. To corroborate this theory it would be important to be able to demonstrate the existence of an eleventh-century settlement in the southern half of the village by means of archaeology.

The results of the excavation at Tårnby Torv seem to support this theory. The earliest phase of the western trench group in the large, undefined area without building, phase 1, may be part of the northern toft of the old village layout. With trench FCZ in phase 2 (twelfth century?) settlement within the excavated area was regulated. Whether this regulation is of only local relevance or could have been applied to as much as the whole village depends, however, on the interpretation of the northern east-west fence line of phase 2.

If this fence is interpreted as no more than an internal division of a larger toft, the extent of this regulation is not known, nor is it known when the organized strip village was established. It could in this case just as well have been caused by, for instance, the Swedes' burning of the village on October 10th, 1658, as it would have been undertaken in the earlier Middle Ages. If, by contrast, the fence is considered to have been a real toft-boundary, is shows that the establishment of the strip village probably took place in the twelfth century. Since the strip village is so regular, it was probably laid out in its entirety at a single time. Could this re-organization have been undertaken by bishop Absalon, making the main farm of Borgby more efficient, by splitting up the four farms of the eleventh century into smaller units in the new strip village?

The extension of the toft in the fourteenth to fifteenth century, phase 6, can be interpreted as a unification of the central toft in the excavated area and the one to the north. This may be the first archaeological example of the development recorded in written sources from cultivation by poor cottagers (landbo) and villeins (gårdsæde) to the larger 'equal-sized' copyhold farms (fæstegård)? The toft was reorganized once more before 1682, when it was reduced in width (the situation in figure 2). The sizes of the farm tofts in the whole village are now indirectly given by the 1682 field book's measurements of the farms' associated toft fields.

AN EQUAL-SIZED COPYHOLD FARM?

Written sources for the social status of the farm

It would be helpful to shed some light on the social status of the farm in relation to other medieval farms under the Bishop of Roskilde, and to try to classify it as cottager or villein farming. Tårnby is imperfectly recorded in the Land Book of the See of Roskilde. The number of farms and the tax dues from each one are not given. A calculation of the size of the medieval farms of Tårnby and a comparison between Tårnby village and the excavated farmstead on the one hand, and other villages of Sjælland and farms in the Land Book is therefore, unfortunately, impossible.[13] On the basis of an analysis of the Land Book of the See of Roskilde a general development away from the manorial estate/smallholding farm system in favour of the establishment of equal-sized copyhold farms has been demonstrated in the fourteenth and fifteenth centuries (Christensen 1964: 277). It does not, however, appear to be possible, as Christensen suggested, to demonstrate a liquidation of the Bishop's manor on Amager.[14]

An archaeological example of an 'equal-sized' copyhold farm?

Although there may be several ways of explaining the development of the plan of the farmstead through time, it is still tempting to turn to the archaeological record. The analysis of the possible toft-boundaries at Tårnby Torv suggests the occurrence of an expansion of the toft in the fourteenth century. On the basis of a presumption that the development from villeinage to an 'equal-sized' copyhold farm would also involve an increase in the size of the farm, the size of the farm will be considered to see if there were such an expansion in the fourteenth century.

In what follows, various possible building combinations are set up for the different farm phases of the Middle Ages and the roofed space of the farm. For this, a farmstead consisting of two parallel wings is assumed for the thirteenth century within which the two older and the two younger buildings in each sequence are contemporary, although in reality both A21 (85 sq m) and A20 (88 sq m) combining, as they do, residential and economic sections, could have stood alone.

Figure 13 shows a strong increase in the area of the farmstead in the fourteenth century (models 7-9). If building C9-C10 was in existence at the same time as building A1/A2/A3 (model 7-8) this growth can be dated to the first half of the fourteenth century. If these two buildings were not contemporary the date of the growth of the farm becomes more spread out since the construction of building A1/A2/A3 can be dated to the fourteenth century generally (model 9). The increase in area coincides with the possible extension of the toft in the fourteenth century, which was maintained throughout the rest of the Middle Ages. Is this, then, an example of what the Land Books call an equal-sized copyhold farm, or is this just a local development affecting this one farm?

CONLUSION

Through the excavation in Tårnby village, with its well-preserved culture layers and the extent of the area uncovered, it has, for the first time, been possible to follow the development of a farmstead, probably in its entirety, through several phases from its foundation in the twelfth century to its abandonment in the nineteenth century in favour of another building. Most of the farmyard has been defined, although its western limits are missing and the interpretation of the northern limit is uncertain.

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13 The scope for assessing the social status of the Tårnby farm is considerably better in more recent times where one can base oneself upon the Land Survey of 1688. About half of the farms in Tårnby were of the size of 4 to 8 tdr htk (='barrels of hard corn'), along with about 52% of the farms on Sjælland, while the remainder were of 8 to 12 tdr htk, as about 19% of the Sjælland farms (Christensen 1964, 283). The excavated farm II was one of the latter group.

14 Information from dr. phil. K.-E. Frandsen, Institute of History, Copenhagen University.

Phase	Models: possible building combinations	Floor m²
1?-2	1. U3+U5	157 (182)
3	2. A21? (+C7)	85? (110)
4	3. A21+C19 (+C7)	160 (185)
4	4. A20+C18 (+C7)	136 (161)
5	5. C9-C10+A17+C11 (+C7)	98 (123)
5	6. C9-C10+A17+C3 (+C7)	114 (139)
5-6	7. C9-C10+A1/A2/A3+A8+A9 (+C7)	246 (271)
5-6	8. C9-C10+A1/A2/A3+A8+A9+C3 (+C7)	275 (300)
6	9. A1/A2/A3+A8+A9+C3 (+C7)	205 (230)
6	10. A1/A2/A3+A13+C3 (+C7)	202 (227)

Fig. 13 The changing area of the farmstead through the Middle Ages. The models show various possible combinations of contemporary buildings within the different phases of the farm. Model 1 represents the twelfth century, models 2-4 the thirteenth century, models 5-9 the fourteenth century, and model 10 the fifteenth century. The sizes given for A13, A17, C7 and C11 are minimum sizes as these buildings were not preserved to their full length and width.

Thirty-one complete or partially preserved building grounds were uncovered, eighteen of which are medieval. The 16 building plots in the culture layers of the High and Late Middle Ages give a massive boost to the quantity of building evidence from this period. The change from earth-fast posts to structures resting on the ground surface is very clear. Unfortunately this transition cannot be dated with certainty as the earliest buildings, with earth-fast posts, can only be dated by typology. The earliest building grounds within the culture layers are dated by finds to the thirteenth century, and an architectural change in this period would fit the general picture well. This agreement may, however, be purely coincidental, as the shift from earth-fast posts to structures resting on the ground surface was probably regionally governed. Unlike in earlier investigations of High- and Late-medieval rural settlements, a high proportion of the buildings excavated are economic buildings and small outhouses. The absence of clear evidence of stalling is noteworthy. In addition to the building remains, 20 wells were recorded, fourteen of which are from the Middle Ages, together with various trench and fence systems which are interpreted as possible dyke structures, toft-boundaries and internal partitions within the farmyard.

The buildings of the Tårnby farm lie in the same place in the toft beside the village street throughout the Middle Ages, with different layouts, until they were superseded by the four-unit farmstead known from the survey map of 1811. It is thus possible for the first time to demonstrate continuity in the position of buildings lying beside the street back to the earlier Middle Ages, a view which is otherwise only afforded by the villages' surviving census topography of the seventeenth and eighteenth centuries. The layout of the Tårnby farm, with its freestanding units placed parallel or at angles to each other, confirms the hitherto feeble archaeological image of the medieval farm.

The earliest form is the farmstead with two units placed at an angle in the cattleyard and stackyard respectively. The buildings are constructed with earth-fast posts, and are typologically dated to the twelfth century. The farm was presumably established on an earlier toft after a re-organization of the village, which was transformed from a village around a green to the regular strip village. It is possible that the eastern side of three farm tofts can be seen in the excavated area, but the interpretation of a fence in the northern part of the area is debatable. If not, only two tofts can be seen, and the establishment of the tightly regulated strip village may be a later development. In the thirteenth century the farm apparently consisted of units placed parallel to one another in a northern and a southern wing, possibly combined with an eastern wing along the village street. In the northern unit residential and economic functions were combined while the southern unit served working functions. Around the fourteenth century this layout was changed. The southern wing burned and a new building was raised for dwelling purposes alone and the northern wing was replaced by small outbuildings. Contemporary with the new southern wing, or perhaps not until after it was burnt in the middle of the fourteenth century, a large main building with both residential and economic areas was constructed. This was associated with several successive outhouses. With this new main building in the farmstead, the roofed area of the farm was doubled, and the area of the farmyard was extended towards to the north. Could this be the first archaeologically discovered specimen of the fourteenth-century development known from the Land Books from the manorial/smallholding system to the establishment of equal-sized copyhold farms? The layout of the farm in the seventeenth and eighteenth centuries is less clear, but this can be remedied by written sources and cartographic evidence.

Translated by John Hines

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REFERENCES

Christensen, C.A. 1963-66: Ændringer i landsbyens økonomiske og sociale struktur i det 14. og 15. århundrede. *Historisk Tidsskrift* 12 rk. 1. 1964 (1963-66), 257-349

- (ed.) 1956: *Roskildekirkens jordebøger og regnskaber.* Danmarks middelalderlige Regnskaber 3. rk., bd. 1

Felgenhauer-Schmiedt, Sabine 1993: *Die Sachkultur des Mittelalters im Lichte der archäologischen Funde*, Europäische Hochschulschriften 42.

Frandsen, Karl-Erik 1983: *Vang og tægt. Studier over dyrkningssystemer og agrarstruktur i Danmarks landsbyer 1682-83.* Esbjerg.

- 1989: *Tårnby Landsby - historie og bygningsregistrant.* Kastrup.

Hoff, Annette & Jens Jeppesen: Todderup. En udgravet torpbebyggelse og torperne historisk belyst. *Kuml* 1991-92 (1994), 165-188.

Jeppesen, Torben Grøngaard 1982: Aastrup II - to sulehuse fra middelalder og renæssance. *Fynske Minder* 1981 (1982), 59-71.

- 1983: Fynske gårdundersøgelser - med udblik til resten af landet. In H. Thrane & T.G. Jeppesen (eds.): *Gårdens udvikling fra jernalder til nyere tid.* Beretning fra 7. Odensesymposium 28-30 april 1982. Skrifter fra Historisk Institut, Odense Universitet 11, 162-180. Odense.

Kristiansen, Mette Svart, Ditlev L.Dall Mahler, Thomas Roland & Eliza Fonnesbech-Sandberg 1994: *Udgravningen ved Tårnby Torv. Foreløbig rapport 1994. Status og sammenfatning.* Med bidrag fra Inge Bødker Enghoff: Rapport over analyse af fiskeknoglermateriale fra Tårnby Torv, 1993, SØL 457, David Robinson: Status over arkæobotaniske analyser af materialet fra Tårnby, Pia Brandsnes: Formidlingsrapport. Ed. Ditlev L. Dall Mahler. Københavns Amtsmuseumsråd.

Kroman, Erik (ed) 1942: *Valdemars Sjællandske lov.* Danmarks gamle landskabslove med kirkelovene bd. 7, København

Liebgott, Niels-Knud 1979: *Stakhaven. Arkæologiske undersøgelser i senmiddelalderens Dragør.* Nationalmuseets skrifter. Arkæologisk-historisk række XIX. København.

Mahler, Ditlev L. Dall 1994: Stabilitet - Labilitet. Tanker om den middelalderlige landsby: Tårnby. *Hikuin* 1994, 85-98.

Mejdahl, Ulla 1987: Poghøj - et tidligt middelalderligt gårdsanlæg. *Meta* 1987/1-2, 31-37.

Nielsen Oluf (ed.) 1872: *Kjøbenhavns Diplomatarium* bd. 1, København.

Porsmose, Erland 1991: Landsbyen i renæssancearkæologien. *Hikuin* 18, 1990 (1991), 191-196.

Rasmussen, Ulla Fraes 1990: Klemmenstrup - en udgravning af en middelaldergård. *Køge Museum* 1989 (1990), 37-54.

Siemen, Palle 1991: Middelalder i Tjæreborg og Allerup. *Mark og Montre* 26, 74 - 83.

Steensberg, Axel 1952: *Bondehuse og vandmøller i Danmark gennem 2000 år.* København.

- 1986: *Hal og gård i Hejninge: En arkæologisk undersøgelse af to sjællandske gårdtomter.* Det kongelige danske videnskabernes selskab. Historisk-Filosofiske skrifter 11. 1986.

Steensberg, Axel & J.L. Østergaard Christensen 1974: *St. Valby. Historisk arkæologisk undersøgelse af en nedlagt landsby på Sjælland bd.I-III.* Det Kongelige Videnskabernes Selskab. Historisk-Filosofiske Skrifter 8.

Sterum, Niels 1976: Tangen. En sydvestjysk gårdtomt fra senmiddelalder og renæssance. *Mark og Montre* 12, 53-61.

Weibull, Lauritz (ed.) 1963: *Diplomatarium Danicum*, I. rk., bd. 2, København

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2 Roesdahl, Else 1988: Vikingetidens befæstninger i Danmark - og hvad siden skete. In Torsten Madsen (ed.): *Bag Moesgårds maske*, pp. 203-216. Århus, Aarhus Universitetsforlag
3 Hvass, Steen 1988: Jernalderens bebyggelse. In Peder Mortensen & Birgit M. Rasmussen (eds.): *Jernalderens stammesamfund. Fra Stamme til Stat i Danmark 1.* Jysk Arkæologisk Selskabs Skrifter 22, pp. 53-92.
4 Ørsnes, Mogens 1988: *Ejsbøl I. Waffenopferfunde des 4.-5. Jahr. Nach Chr.* Nordiske Fortidsminder, Serie B 11.
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