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Vegetation History and Archaeobotany

Reconstruction of environment and history of plant use during the late Mesolithic (Ertebølle culture) at the inland settlement of Bökeberg III, southern Sweden

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Abstract. Pollen, plant macrofossils and charcoal were analysed from a lake-sediment sequence, including a refuse layer, from the Late Mesolithic settlement at Bökeberg III, southern Sweden. The chronology was established by means of AMS-dated plant macroremains. The results of the biostratigraphical studies indicate two settlement phases (A and B), at ca. 6650-6400 B.P. (5560-5320 cal. B.C.) and ca. 6150-5800 B.P. (5200-4680 cal. B.C.), respectively. The two settlement phases are associated with periods of low lake-level contemporaneous with the second major period of low lake levels during the Holocene in southern Sweden, and thus with a period of generally drier climate. The pollen analytical data suggest only minor human impact on the local vegetation during the two settlement phases. Three elm declines at ca. (1) 6200 B.P. (5200-5100 cal. B.C.), (2) 5450 B.P. (4340 cal. B.C.), and (3) 5150 B.P. (3980 cal. B.C.) are discussed. Elm decline 3 is synchronous with the classical north-west European elm decline. Elm declines 2 and 3 may be due to outbreaks of elm disease rather than to strong human impact or climate change. The charcoal analyses show that wood of a wide range of species was collected for fuel or other purposes. During phase A, plants used included acorns, hazelnuts and, possibly, *Cornus sanguinea*, and also *Prunus spinosa, Sorbus aucuparia* and *Rubus idaeus*. There is convincing evidence that *Cladium mariscus* was used for thatching. The second occupation phase, B, is characterised by the use of hazelnuts for food. The possible use of several other identified species is discussed.

Key words: South Sweden – Late Mesolithic – Human impact – Plants as food – Palaeoenvironment

Introduction

During the past two decades, research on the last phase of the Late Mesolithic, Ertebølle culture, in South Scandinavia has been intensive. Excavations of well preserved occupation layers and cemeteries have added important information about the society that preceded the introduction of farming. Much effort has been put into explaining the processes that initiated a change from the extensive use of a wide spectra of resources during the Mesolithic to the more intensive use of a smaller range of resources during the Neolithic, when food production became a major part of the economy (Rowley-Conwy 1985; Zvelebil 1986).

Several models have been proposed to explain the strategies behind the spatial distribution of Late Mesolithic settlements and stray finds. An overall assumption is that the use of resources, and, as a result, settlement distribution, were directed towards the boundaries between different ecological zones, where species diversity and density is high (the so-called "edge effect", Odum 1971) (Paludan-Müller 1978). A very popular model argues that the use of coastal and inland resources was differentiated: permanent settlements were situated on the coast, whereas inland settlements, most often at lake shores, were used during the warmer part of the year (Andersen 1975; Larsson 1983, 1991). On the basis of the ^{13}C content of human bones from Late Mesolithic coastal settlements, Tauber (1982, 1986) proposed that the consumption of marine species dominated at these sites. However, human remains from inland sites provided ^{13}C values indicating the predominance of a terrestrial diet. Therefore, different groups of people may have used different food resources (Noe-Nygaard 1983, 1988).

In prehistoric subsistence, plants, in addition to providing food, wood for construction and fuel, fibres for clothing, tools and other crafts, also supplied ingredients for medicine and the components of socio-religious practices (Ford 1979). Apart from designated tools and crafts, very little is known of the use of plants as food during the Mesolithic. Hazelnuts are known from many sites and were obviously an important food resource. Iversen (1973) argues that the fast expansion of hazel during the Holocene can partly be attributed to human influence. The collecting of the water chestnut (*Trapa natans*) has also been documented throughout southern Scandinavia (Digerfeldt 1972; Price 1989).

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Even though the importance of plants to Mesolithic society has not been neglected, archaeobotanical studies carried out routinely when material and resources admit, would certainly increase our knowledge of the role of plants within the overall diet in any interpretations and modelling of Late Mesolithic society.

Aims and research strategy

The major aim of the present study was to gain new insights into, and an understanding of, the role of plants in Late Mesolithic society by combining archaeological and biostratigraphical investigations at a lake-shore settlement. Moreover, the investigation should provide an environmental reconstruction in order to place the settlement in a wider context. The research strategy consisted of studying the botanical content of the preserved organic material encountered during the archaeological excavation in a terrestrial environment linked with a refuse layer included in a littoral lake-sediment sequence. It was assumed that a comparison of the different biostratigraphical data would possibly give a clue as to which plants were gathered and used by humans. In order to test this assumption as rigorously as possible, the site investigated should fulfil a number of conditions including (1) the Late Mesolithic site should be situated close to a former lake-shore, (2) the littoral shore-sediments should include a refuse layer (or refuse layers) from the occupation period(s), (3) the preservation of organic material in the refuse layer(s) and, ideally, in the occupation layers should be good, and (4) the time span of the occupation period(s) should be as short as possible to avoid chronological complications. There were several potential settlement sites around Lake Yddingesjön, south Skåne, but only the settlement at Bökeberg III could be assumed to have been used for a limited period in the Late Mesolithic (Althin 1954; Karsten 1986).

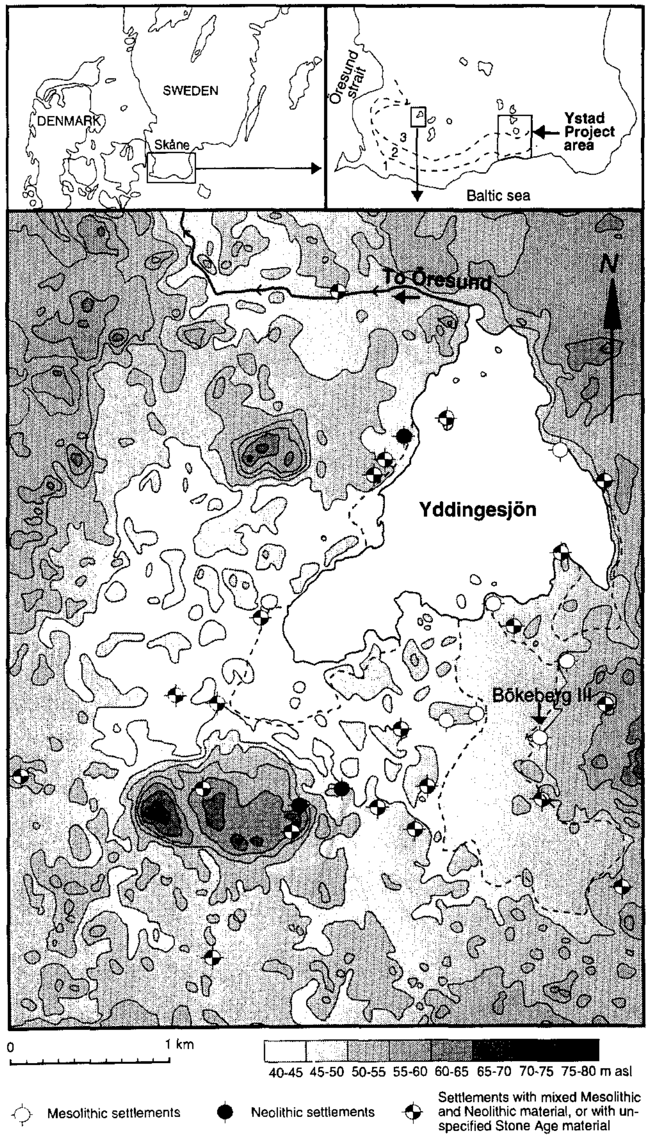


Fig. 1. A map of southern Skåne showing the three geomorphological zones: *1*, coastal zone; *2*, outer hummocky zone; and *3*, inner hummocky zone as defined in the Ystad project (Berglund 1991); **B** Topographical map and location of the Mesolithic and Neolithic settlements recorded in the area around Yddingesjön, including Bökeberg III. The broken line shows the former lake area before major lowering activities during the 19th and 20th centuries

Study area and site description

The Late Mesolithic site of Bökeberg III is situated in south-western Skåne, south Sweden, close to the present southern lake shore of Yddingesjön (Fig. 1). South-western and southern Skåne can be subdivided into three geomorphological zones as follows: a flat coastal zone, an outer hummocky zone, and an inner hummocky zone (Berglund 1991; Fig. 1). The innermost zone, where Yddingesjön is located, has a moderately hilly topography, with altitudes ranging from 30 to 80 m. Silty, clayey till dominates (Fig. 2). Until the last century, this zone was rich in smaller lakes, wetlands and brooks. This wetland aspect is reflected today in extensive peat deposits (Fig. 2). Modern agriculture and urban demands have greatly changed the former landscape so that it has become much less complex and diverse.

Yddingesjön has an area of approximately 2.1 km^2. The outlet drains the lake towards the Öresund Strait. During the late 19th and early 20th centuries, the lake-level of Yddingesjön and many other lakes in Skåne was lowered by about 1.5 m. This artificial lowering, coupled with the long-term natural in-filling processes, explains the significant decrease in the lake area. The former extent of the lake, before the major lowering, is shown in Fig. 1. It corresponds more or less to the extent of peat deposit in Fig. 2.

The archaeological site, Bökeberg III, is situated on a small peninsula in a former bay of Yddingesjön. Today, the site is situated on a slight elevation. The area is grazed and has not been ploughed since the forties. There are about thirty Mesolithic and Neolithic settlements known in the vicinity of the lake (Karsten 1986). The majority of these settlements, especially those dating to the Mesolithic, are situated at the former shore or close to it (Figs. 1, 2).

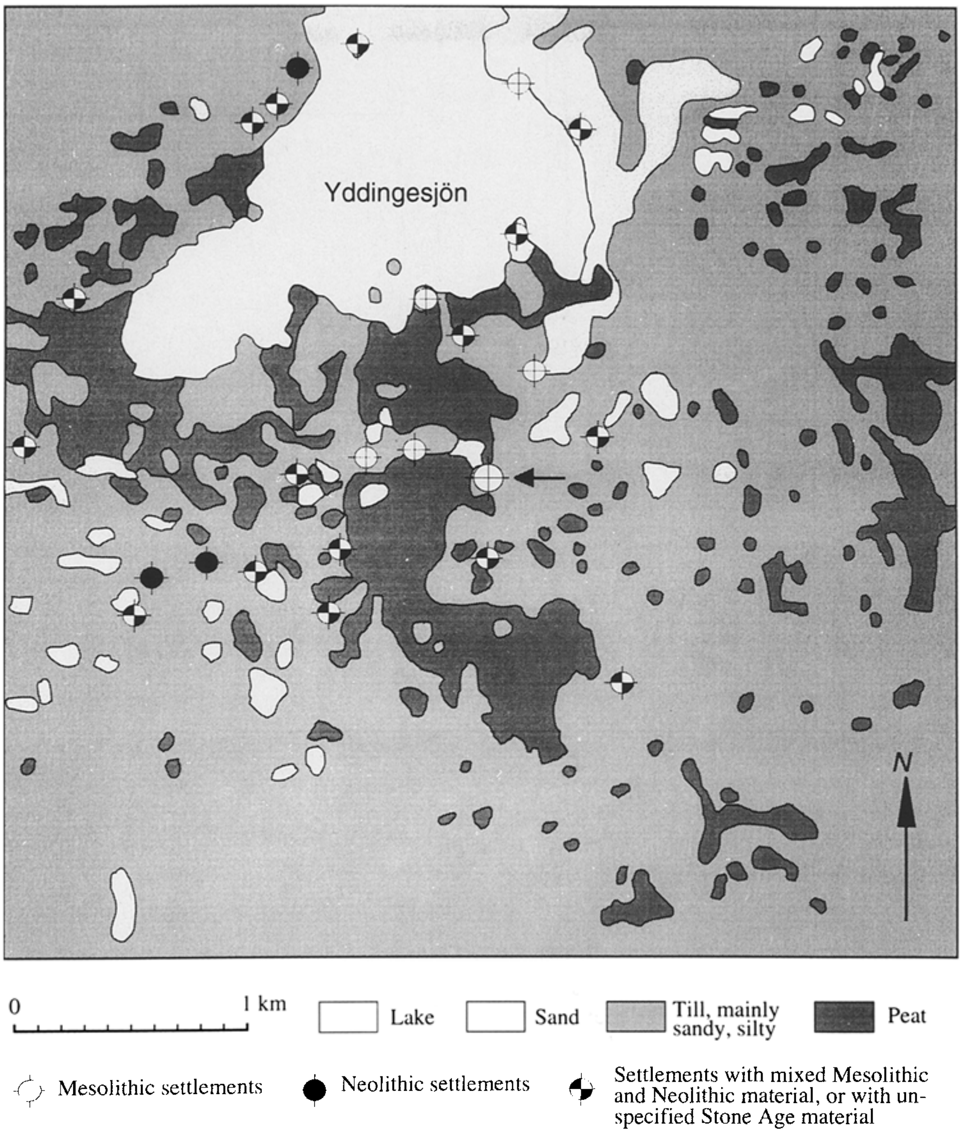


Fig. 2. Map showing the distribution of Quaternary deposits and location of the Mesolithic and Neolithic settlements recorded in the area of the Mesolithic site, Bökeberg III, which is indicated by an arrow

Methods

Field sampling and sub-sampling

So far, 522 m² of the settlement area has been excavated. A profile perpendicular to the former lake-shore was dug in the area of the littoral zone of the ancient lake (profile A-B, Fig. 3). A large quantity of flint tools and debris, and well preserved bones and antlers were gathered from the refuse layer deposited in the telmatic zone (Figs. 3, 4). In addition, several constructions such as pits and ditches were documented (Fig. 3). The archaeological excavation has not yet been completed, and the documentation of the archaeological material has not yet proceeded far enough for any report to be made (Karsten and Regnell, in preparation).

A column sampler 50 cm long, 11 cm broad, and 13 cm deep was pressed into the refuse layer in the deepest part of the profile A-B (Figs. 3, 4). The sampling site (BI) is situated in the distal part of the refuse layer where visible archaeological artefacts (flints, bones, antlers) were rare. This sampling strategy was chosen in order to avoid as far as possible any disturbance from the settlement activities, without foregoing the possibility of tracing the human activities related to the settlement in the stratigraphy.

The lithology of this sequence is given in Fig. 4. The term drift gyttja refers to a coarse detritus lake deposit that generally accumulates in shallow water conditions and contains both autochthonous and allochthonous material eroded from the shores or transported by waves (cf. Lundqvist 1927). A second lake-sediment sequence was cored about 100 m from the settlement area, in the central part of the former bay. The results from this core will be discussed elsewhere (Regnell, in preparation). Finally, a large number of soil samples were collected in pits and other constructions in the settlement area for plant macrofossil analysis and ^{14}C dating (Fig. 3).

Core BI was taken to the laboratory for sub-sampling. Samples of 2 cm³ volume, were taken for pollen analysis at every centimetre from 1-5 cm, and at every 2 cm from 5-49 cm. Samples of 5 cm³ volume were taken at every centimetre for physical analysis. The core was then divided into 1-cm-thick slices for macrofossil analysis. The volume of each macrofossil sample was measured before analysis (Fig. 12).

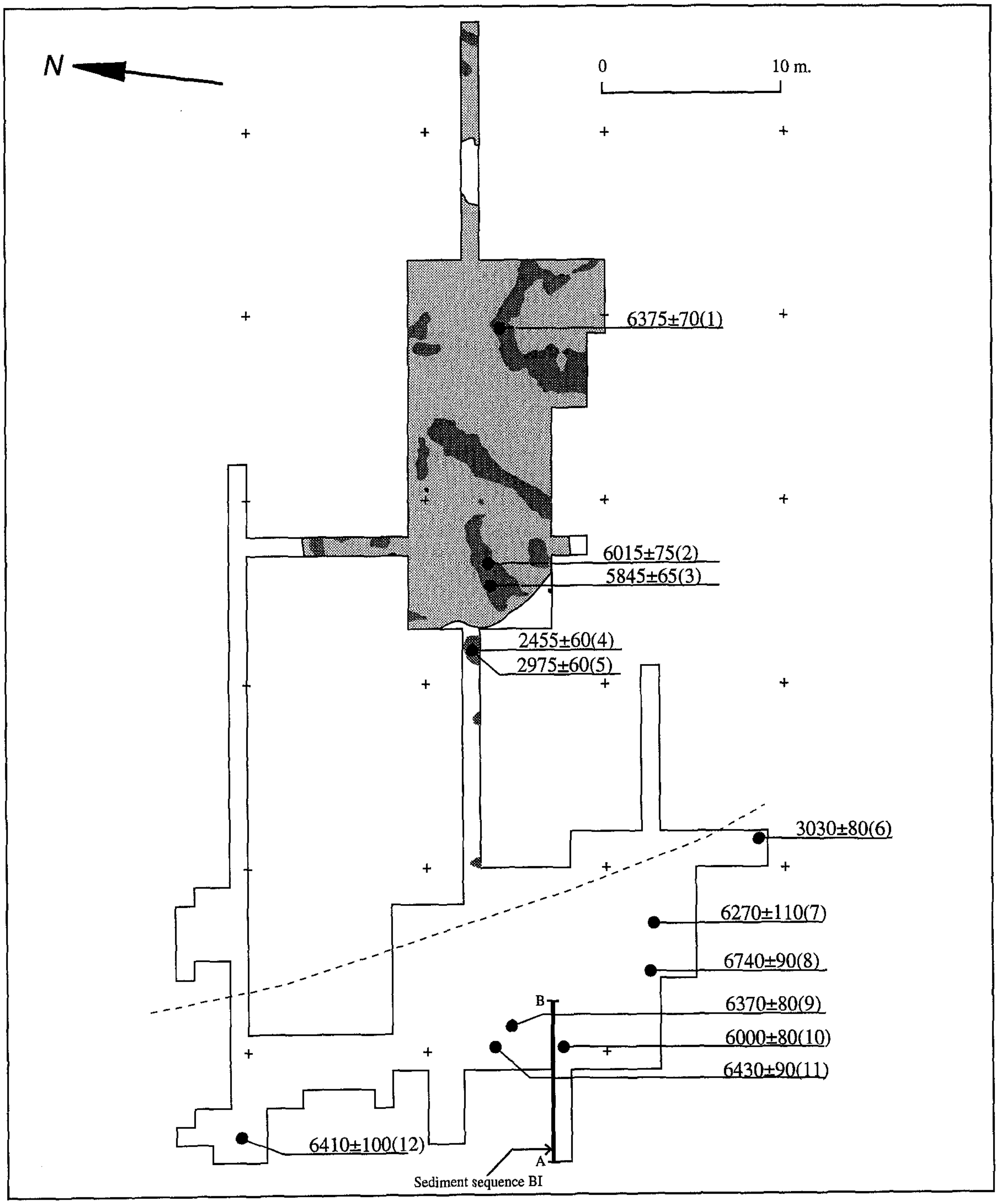


Fig. 3. Sketch showing the excavation area (as of September 1993, 522 m^2) and the location of ^{14}C-dated samples from within the settlement area (*1-5*) and the refuse layer (*6-12*) (see Table 1). The dashed line marks the boundary between the mineral soil and the telmatic sediment. The light grey and dark grey areas indicate the areal extent of the cultural layer and constructions (pits and ditches), respectively. The lithology along the transect A-B is shown in Fig. 4. The location of the profile (*sediment sequence BI*) on transect A-B is indicated by an arrow

Physical analysis

Loss-on-ignition was performed according to Bengtsson and Enell (1986). Samples were dried at 105°C overnight. The organic content was estimated by ignition at 550°C for 4 h. The results (ignition residue) are expressed as percentages of the dry weight of the sample (Fig. 12).

Pollen analysis

The samples were treated according to standard chemical methods (Berglund and Ralska-Jasiewiczowa 1986) and mounted in glycerine. A known amount of *Lycopodium* spores was added to each sample for calculation of pollen concentration. Pollen analysis was performed at a magnification of

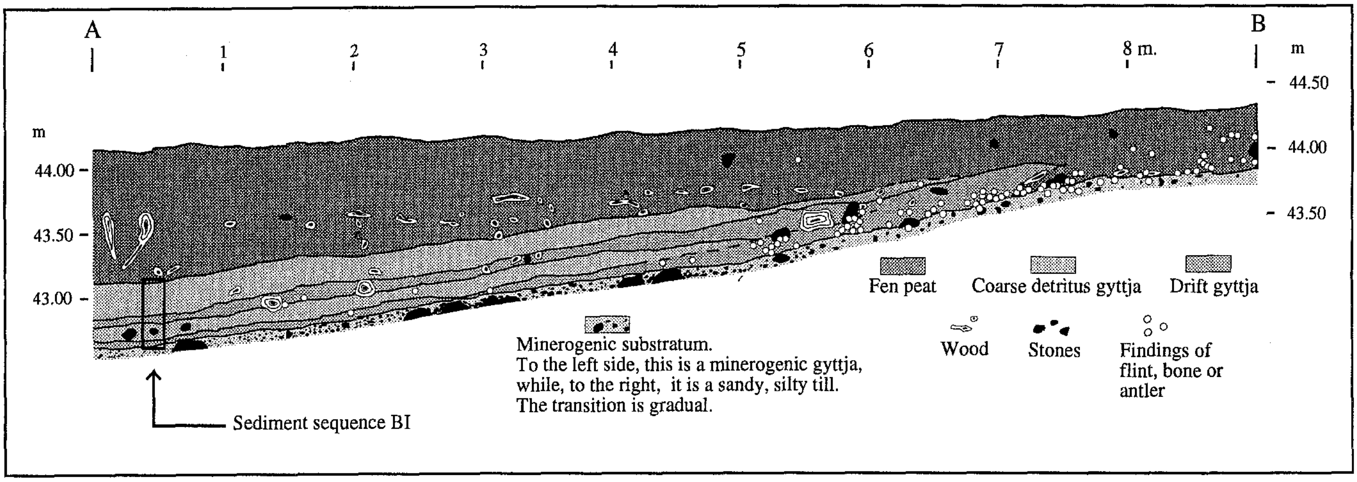


Fig. 4. Stratigraphy along the transect A-B in the former littoral zone of Yddingesjön at Bökeberg III (see Fig. 3). The location of the profile (*sediment sequence BI*) on which pollen, plant macrofossil and charcoal analyses were carried out is indicated by an arrow

x320 and x800, using a Leitz microscope. Phase contrast was used when necessary. A minimum of 1000 pollen grains was counted for each sample, except the two lowermost samples that had very low pollen concentrations. Identification involved the use of pollen keys (Erdtman et al. 1962; Fægri and Iversen 1975; Moore et al. 1991). Gramineae and Cerealia pollen were distinguished on the basis of the criteria given in Beug (1961) and Fægri and Iversen (1975). The key of Punt (1991) was used for identification of Apiaceae (Umbelliferae) taxa. In addition, the reference collection at the Department of Quaternary Geology, Lund University, was a major help. Two size fractions of microscopic charcoal (10-25μm and >25μm) were counted (cf. Berglund 1991). Pollen taxonomy follows the pollen keys mentioned above, and plant nomenclature follows Flora Europaea (Tutin et al. 1964-1980). The results are presented as percentages of the sum of terrestrial taxa (aquatics, spores of Pteridophytes and *Sphagnum*, and the alga, *Pediastrum*, are excluded from the calculation sum) (Fig. 10) and as pollen concentrations (grains per cm^3) for selected taxa and microscopic charcoal (Fig. 11). The pollen taxa are grouped into trees, shrubs, herbs of variable ecology (or indifferent herbs), possible anthropochores, telmatophytes and limnophytes (Fig. 10).

Macrofossil analysis

All samples were diluted in warm 5% NaOH and sieved through a 0.25 mm mesh. The macroremains were sorted and determined under a binocular microscope at magnifications of x8-50. The identification of seeds and fruits was carried out using keys and atlases (Katz et al. 1965; Berggren 1969, 1981; Beijerinck 1976; Jacomet et al. 1989), and the reference collection at the Department of Quaternary Geology, Lund University. The results are given as number of macrofossils per litre of sediment and are presented in Fig. 12 where the taxa are arranged in ecologically meaningful groups.

Charcoal analysis

The macroscopic charcoal fragments were removed from the macrofossil samples, dried and weighed. For identification the charcoal fragments were broken into smaller pieces to get fresh fractured surfaces (transverse, radial and tangential). The charcoal pieces were determined under a binocular microscope with magnification up to x200, and using the reference collection at the Department of Quaternary Geology, Lund University. The total weight of macroscopic charcoal (per litre of sediment) at each level is shown in the macrofossil diagram (Fig. 12). The results are expressed as mg charcoal per litre of sediment for each taxon (Fig. 13).

Dating

Several radiocarbon determinations were performed on material from the excavated area. Terrestrial plant macroremains were extracted from soil samples and dated by AMS (dates 1-5, 7 and 11 in Fig. 3, Table 1). Five mammal bones were dated by conventional radiocarbon dating (dates 6, 8-10 and 12 in Fig. 3; Table 1). In addition, terrestrial plant remains from 12 levels of core BI were AMS-dated (Fig. 6; Table 1). At three levels, dating was performed both on terrestrial plant macroremains and on charcoal fragments, for comparison. The time-depth curves in Fig. 6 are based on second degree polynomial regression involving (i) all dates and (ii) excluding the dates from charcoal fragments. The AMS ^{14}C dates were calibrated using the calibration curve published by Stuiver and Pearson (1993, Fig. 8).

Note

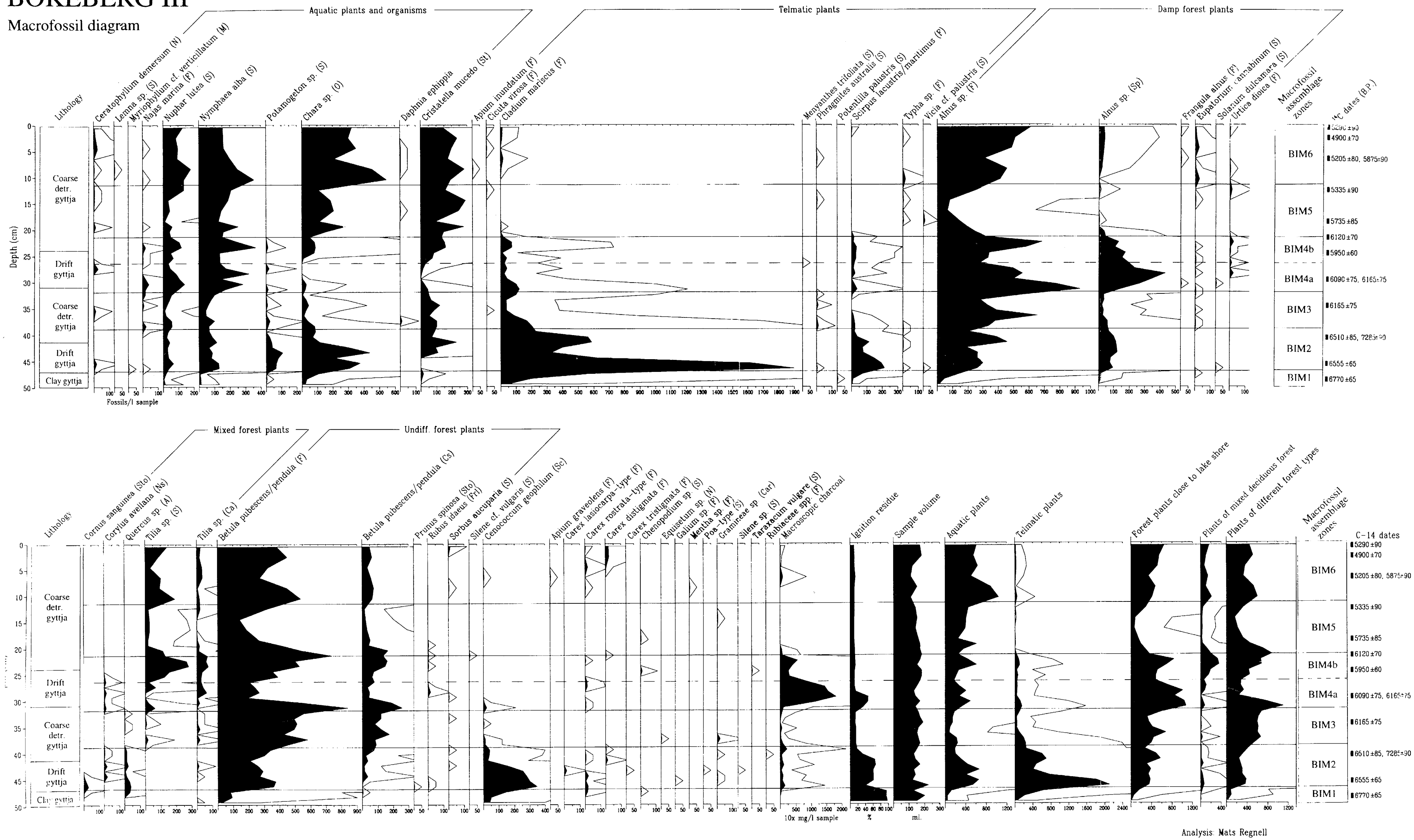
Mats Regnell and Per Karsten are responsible for all fieldwork relating to the archaeological excavations, collecting of samples, and the preliminary interpretation of the archaeological data. Thomas Seip Bartholin carried out the identification of the macroscopic charcoal. Mats Regnell performed the pollen and macrofossil analyses and is the author of the major part of this paper. Marie-José Gaillard supervised the biostratigraphical investigation, helped in the identification of critical pollen grains and plant macroremains, and wrote parts of the synthesis (lake-level fluctuations, elm declines).

Taphonomy of the plant remains

It is of great importance to have some idea about the taphonomy of the micro- and macroremains used in an interpretation of the palaeoenvironment, especially in those contexts where natural factors are not the only processes involved in the deposition and preservation of

BÖKEBERG III

Macrofossil diagram



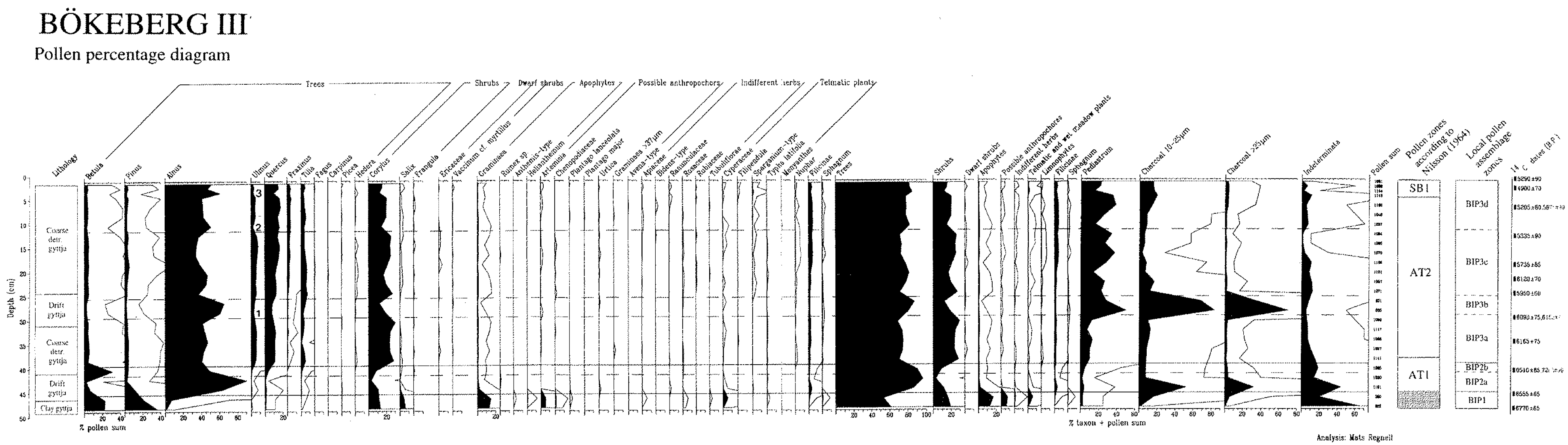


Fig. 10. Pollen percentage diagram from the sediment sequence BI at Bökeberg III. Aquatics, spores of Pteridophytes and *Sphagnum*, and the algae, *Pediastrum* spp., are excluded from the calculation sum

Table 1. Details of ^{14}C dates from Bökeberg III

Origin of sample	Material	Age (B.P.)	^{14}C Lab. No.
Core B1			
(Depth, cm)			
1	*Alnus* (spindle)	5290±90	Ua-2691
3	*Alnus* (spindle)	4900±75	Ua-3307
7	*Alnus* (charcoal)	5875±90	Ua-2690
7	*Alnus* (spindle)	5205±80	Ua-2689
13	*Alnus* (spindle)	5355±90	Ua-2688
19	*Alnus* and *Betula* (fruit)	5735±85	Ua-2687
22	*Alnus* (spindle)	6120±70	Ua-3306
25	*Alnus* (spindle)	5950±60	Ua-2686
30	*Alnus* (spindle)	6165±75	Ua-2685
30	*Corylus* (charcoal)	6090±75	Ua-2684
35	*Alnus* (spindle and fruit)	6165±75	Ua-2683
41	*Corylus* (charcoal)	7285±90	Ua-2682
41	*Alnus* (spindle)	6510±85	Ua-2681
46	*Alnus* (spindle)	6555±65	Ua-2680
49	*Alnus* (spindle)	6770±65	Ua-2679
Occupation area			
(Construction No./No. in Fig. 5)			
A 23/5	*Corylus* (charcoal)	2975±60	Ua-2678
A 23/4	*Corylus* (charcoal)	2455±60	Ua-3552
A 9/3	*Quercus* (charcoal)	5845±65	Ua-3550
A 9/2	Undetermined charcoal	6015±75	Ua-3549
A 100/1	Undetermined charcoal	6375±70	Ua-3551
Refuse layer			
(No. in Fig. 3)			
6	*Bos taurus* (tooth)	3030±80	Ua-2656
9	*Cervus elaphus* (bone)	6370±80	Lu-3452
10	*Cervus elaphus* (antler)	6000±80	Lu-3451
11	*Capreolus capreolus* (antler)	6430±90	Lu-3454
8	*Cervus elaphus* (bone)	6740±90	Lu-3453
7	*Corylus* (nutshell)	6270±110	Ua-2027
12	*Corylus* (nutshell)	6410±110	Ua-2028

Spindle refers to catkin axis. Radiocarbon laboratory codes are as follows: *Ua,* Uppsala (Svedberg Laboratory; AMS dates); *Lu,* Lund (Radiocarbon Laboratory, Department of Quaternary Geology; conventional dates)

the remains. Taphonomy is seldom discussed in biostratigraphical studies of Holocene lake sediments, because it is assumed that, normally, the processes of deposition and preservation of the plant remains are well known to palaeoecologists. However, at lake shores, the processes may be rather complex, and it is well known that the deposition of pollen (e.g. Ammann 1989; Hopkins 1950) and plant macrofossils (Birks 1973) in the littoral zone, differs from that in the profundal part of a lake. Moreover, in the case of Bökeberg, the human presence at the lake shore over long periods of time is a further complicating factor.

Very few plant remains were found in the occupation area. From more than twenty soil samples analysed so far, only one sample (from a deep trench) provided, apart from charcoal fragments, a single carbonised caryopsis of a wild grass. Most plant remains were obviously totally decomposed by oxidation in the mineral soil. This is a common problem encountered in the study of terrestrial settlements (e.g. the Late Mesolithic settlements at Skateholm, Göransson 1988a). Therefore, in such cases, it is impossible to get a realistic picture of the use of plants by people based only on the analysis of material from the occupation area.

The sequence, which has been analysed, consists of layers of coarse detritus gyttja and drift gyttja deposited under conditions of relatively shallow water (Figs 10, 12, 13). In the littoral zone of lakes, pollen from the local vegetation are generally well represented. In particular, those of high pollen producers such as alder, birch, and Gramineae (e.g. *Phragmites*), may even be over-represented in such a situation, whereas pollen from the vegetation on high ground will be under-represented. Moreover, pollen originating from the forest undergrowth (shrubs and herbs) are generally very poorly represented. However, during periods of human activity on the lake shore, pollen from plants which have been gathered while in flower, may be transported by water to the lake and be incorporated in the refuse layer(s).

Plant macroremains (seeds, fruits, twigs, etc.) from the local vegetation are usually concentrated in the littoral sediments, especially in and just outside the reed vegetation belt (Birks 1973). Even though seeds and fruits may be transported by wind (e.g. birch, alder and pine), they often float on the lake surface and are transported towards the lake shores by waves. Therefore, most seeds and fruits from the local shore vegetation, as well as those from dry land plants (birch, pine, etc.), will be represented in the littoral sediments. Seeds and fruits from terrestrial species may also be transported by water during periods of high precipitation and soil erosion, providing the slope towards the lake shore is steep enough. During periods of human activity close to the lake, seeds and fruits gathered by people for consumption may be transported to the lake by water (soil erosion) or by people themselves (rubbish), and incorporated in the refuse layer(s). In addition, seeds and fruits may also originate from plants used for other purposes (fuel, thatching, etc.).

Microscopic charcoal particles are transported mainly by wind and may originate from local and/or regional fires (natural or human induced). Changes in the curve of microscopic charcoal particles may indicate fluctuations in the relative frequency of fires in a region (Clark et al. 1989). These fires may be forest-clearance fires or hearth fires or merely fires resulting from natural causes. Macroscopic charcoal particles originate, for the most part, from local fires close to the lake shore and are transported to the lake by water or by people, for example as refuse. A natural fire or a clearance-fire can be expected to affect a whole vegetation unit (e.g. shore vegetation, forest on high ground close to the lake shore, etc), so that macroscopic charcoal particles from a wide range of species might be deposited in the littoral lake sediments. In contrast, a hearth-fire would probably produce macroscopic charcoal particles from a selection of taxa collected for this particular purpose or for construction and tools. However, tree species giving small firewood (bushes and smaller trees), and species with light wood (e.g. *Tilia* and *Populus*) may be under-represented in the analysed charcoal material (Bartholin et al. 1981).

Processes other than the natural and human-induced factors discussed above, may also be involved in the deposition and preservation of plant remains. During periods of falling water-level and low lake-levels, exposed lake sediments may be eroded and redeposited in more profundal zones. In this way, pollen, plant macrofossils and charcoal from earlier periods can be re-incorporated in younger lake sediments. Moreover, sediment hiatuses may occur in certain parts of the littoral zone. Such phenomena also have to be considered in the case of Bökeberg, as two periods of low lake-level were demonstrated (see below).

All the factors and processes discussed above have been taken into consideration in the interpretation of the botanical data from Bökeberg in terms of palaeoecology, human impact, and the possible use of plants by people during the Late Mesolithic.

Results and interpretation

The archaeological context

A complete documentation, interpretation and discussion of the archaeological material will be presented elsewhere (Karsten and Regnell, in preparation). Here we provide a summary of the results and those interpretations that are relevant to the discussion of the biostratigraphical data.

The youngest Mesolithic phase in southern Scandinavia, the Ertebølle culture, is dated from ca. 6500-5100 B.P. (ca. 5400-3900 cal. B.C.) (Vang Petersen 1984; Larsson 1983). As in Denmark (Paludan-Müller 1978), most of the Ertebølle sites in Skåne are located at the coast and close to inland lakes (Fig. 5). Around

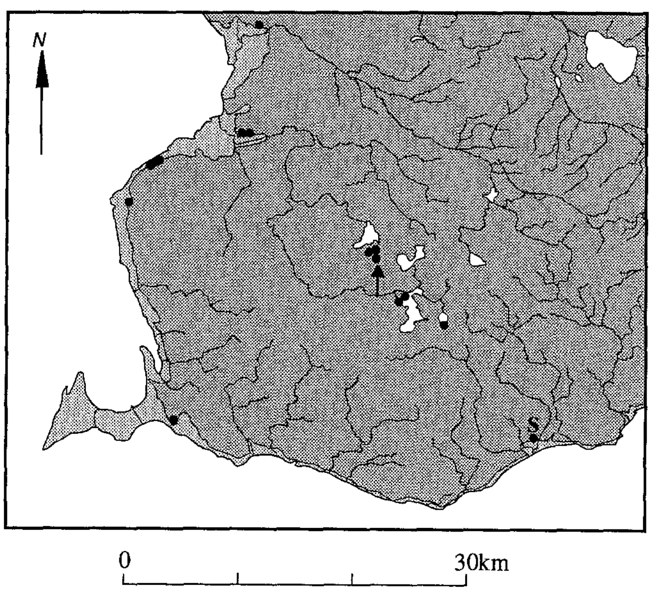


Fig. 5. Inland and coastal Late Mesolithic settlements in south-western Skåne, southern Sweden. Bökeberg III is indicated by an arrow. *S*, Mesolithic settlement of Skateholm (Larsson 1988a)

Yddingesjön, there are six known sites with Mesolithic material (Althin 1954; Karsten 1986). But, so far, Bökeberg III is the only known site close to Yddingesjön with material almost exclusively from the Ertebølle culture. No remains of Mesolithic pottery were found at Bökeberg III, which implies that the youngest phase of the Ertebølle culture, with which pottery is generally associated, is not represented at this site. The introduction of pottery in southern Scandinavia is dated to ca. 6000 B.P. (ca. 4900 cal. B.C.) (Persson 1987). The ^{14}C dates from bones and seeds recovered from the culture and refuse layers at Bökeberg III span the interval 6700-5900 B.P. (ca 5600-4800 cal. B.C.) (see below), which agrees with the interpretation above. However, the exact duration of the settlement is not yet known.

A common definition of a base-camp is the presence of graves (Larsson 1988a). However, it is obvious from the literature, that the definition of settlement permanence is controversial (Rowley-Conwy 1981, 1983). Even though no graves were found at Bökeberg III, it is clear from the archaeological record that the site was not just used for short periods during occasional explorations from a main camp located elsewhere. The amount of artefacts, debris and various constructions point towards repeated or 'semi-permanent' use.

A substantional minority of the red and roe deer antlers found at the site where shed, which indicates that deer hunting mainly took place from August to March. However, there are many other seasonal indicators that remain to be analysed (Karsten & Regnell, in progress).

During the Late Mesolithic, contacts between southern Scandinavia and the continent south of the Baltic Sea were established. This is demonstrated by finds of shoe-last wedges or Danubian shaft-hole axes *(Schuhleistenkeile)* in Skåne and Denmark. These axes are associated with contemporaneous agricultural economies in these parts of central Europe (Fischer 1982). Another artefact of southern origin is the flat-pick (*Flachhacke*), i.e. axes with one flat and one vaulted side, which is considered to be the antecedent of the shoe-last wedge. Until now, flat-picks had only been reported in Skåne from the Late Mesolithic cemetery at Skateholm, south Skåne (Larsson 1984, 1988b). Four axes of the *Flachhacke*-type were found at Bökeberg. These finds indicate contacts with the continent at a time when agriculture had already been introduced.

Chronology

All ^{14}C dates, both conventional and AMS, are listed in Table 1. Material from the settlement area and bones from the refuse layer show two clear clusters, i.e. between 6700-5900 B.P., and 3000-2500 B.P. (Fig. 7). The younger dates, three in all, are from charcoal fragments recovered from a pit (dates 4 and 5, Fig. 3; Table 1) and from a tooth of *Bos taurus* recovered from the refuse layer (date 6, Fig 3; Table 1). These dates demonstrate activities at the site during the Late Bronze Age. In the lithic material (several thousand implements), only one find, an arrow point, can possibly date to the Bronze Age. Post-Mesolithic activities at the site are, therefore, considered to be minor.

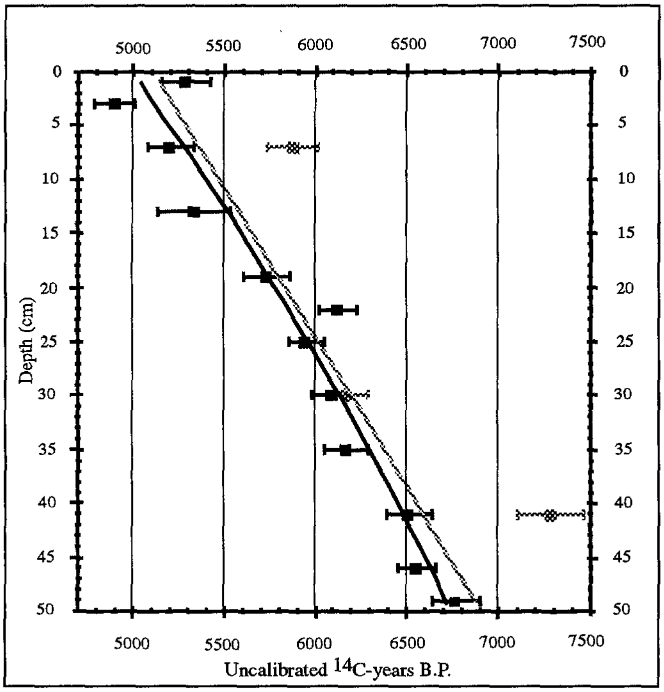


Fig. 6. Depth/age curves (polynomial regression lines) based on ^{14}C AMS dates of plant macrofossil remains (curve and 12 dates shown in black) and macroscopic charcoal (three dates shown in grey; curve, also in grey, based on 15 dates) from the sediment sequence BI at Bökeberg III

The AMS dates on plant macrofossils from core BI are plotted in Fig. 6. In two instances, the dates obtained on charcoal (*Alnus*) are over 500 years older than those obtained on fruits and seeds. In one instance, the dates are almost identical. These discrepancies cannot be explained by the age of the trees at the time of burning since *Alnus* is not known to live for as long as 500 years, or by the plateaux of constant ^{14}C ages around 6600, 6400, 6200 and 5300 B.P. known from the calibration curve of Stuiver and Pearson (1993; Fig. 8). It is more likely that these charcoal fragments were redeposited

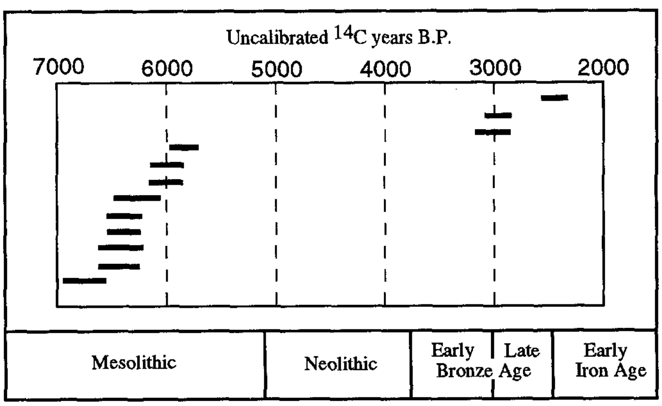


Fig. 7. A plot showing the distribution of the radiocarbon dates from the settlement area and refuse layer (see Fig. 3; Table 1) in the context of the archaeological periods recognised for southern Sweden (Berglund 1991)

from older sediments during periods of lake-level fluctuation. The two time-depth curves presented in Fig. 6 do not show very large differences. However, the chronological scheme used here is based upon the time-depth curve which excludes the charcoal dates. According to the twelve ^{14}C dates available, the sequence analysed covers the time span 6700-5000 B.P. (ca. 5600-3800 cal. B.C.; Fig. 9).

The widely used Nilsson's pollen zones for south Sweden (Nilsson 1961, 1964; Gaillard et al. 1991) are difficult to recognise in the Bökeberg pollen diagram (Fig. 10). The two bottom levels with their relatively high percentages of *Pinus*, *Betula*, *Salix*, *Artemisia*, Gramineae, and other NAP may be compared to zone PB (here, and in the following text, Nilsson's zones are referred to) (10 000-9500 B.P.). However, the *Corylus* percentages indicate a younger age (zone BO1; 9500-8500 B.P.). The two following levels with 60 to 80% *Alnus* and low values of *Betula* and *Pinus* may be compared with zone BO2 (8500-7900 B.P.). The effect of a local over-representation of *Alnus* must also be considered. The increase in *Quercus, Ulmus, Fraxinus* and *Tilia* from 39 cm may be correlated with the transition between zones AT1/AT2 (6400 B.P.). Finally, the classic elm decline is difficult to detect in the Bökeberg diagram, as *Ulmus* percentages are very low throughout the profile. Rather, there are three substantial elm declines (Fig. 10). Declines 2 or 3 could represent the classical elm decline and the AT2/SB1 boundary of Nilsson (5100 B.P.). This zonation, based on pollen stratigraphy, implies (i) a sediment hiatus between 45 and 47 cm since zone BO1 (9500-8500 B.P.) with its typically high percentages of *Corylus* is missing, and (ii) a sediment hiatus or very slow accumulation rate between 39 and 43 cm, i.e. zone AT1 (7900-6400 B.P.). is lacking or very compressed.

The Bökeberg pollen diagram has striking similarities with the pollen diagram of Ageröd V, a Mesolithic bog site in central Skåne dated to 6800-6500 B.P. (Göransson 1983). At Ageröd V there are also pollen stratigraphical hiatuses and mixed pollen spectra in the bottom of the analysed sequence (gyttja), and a 'drift peat' accumulated during the early Atlantic (Nilsson's AT1).

There are obvious discrepancies between the chronology based on the pollen stratigraphy and the AMS dates at the base of the sequence (40-50 cm). The AMS dates do not reveal any hiatus in sediment accumulation between 6700 and 6500 B.P. These contradictory data may be explained by a lake-level lowering around 6700-6500 B.P. that eroded older sediments down to the deposits of Preboreal time (Nilsson's PB). It is concluded that the sediments between 40-50 cm were deposited at ca. 6700-6500 B.P. and are mixed with sediments of earlier periods. A similar process would also explain the older date obtained on charcoal at 41-42 cm (7285 B.P.). Finally, on the basis of the AMS dates, elm decline 3 (ca. 5150 B.P. according to the time/depth curve in Fig. 6) probably corresponds to the classic elm decline in N.W. Europe (Huntley and Birks 1983; Gaillard et al. 1991; Andersen and Rasmussen 1993).

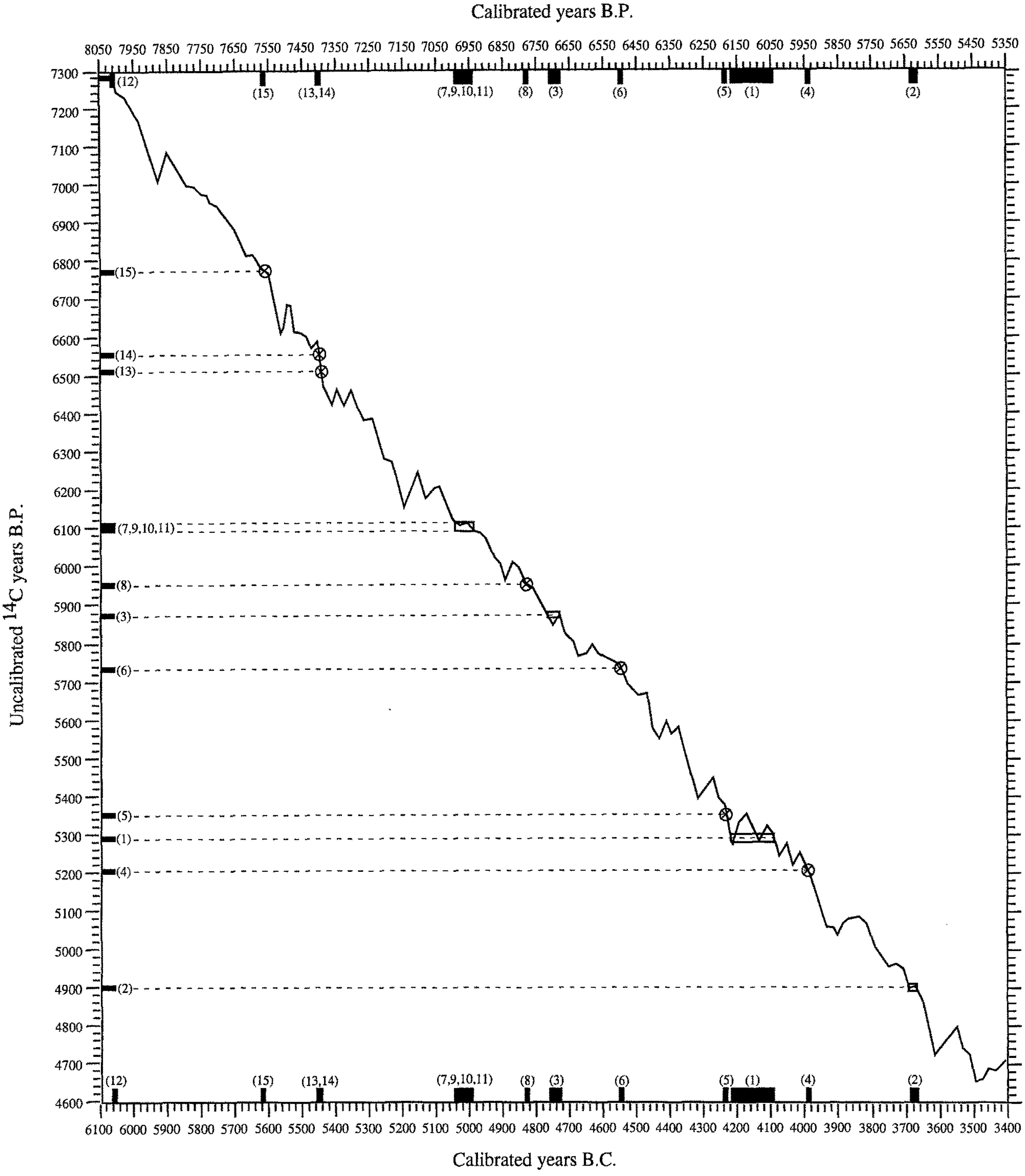


Fig. 8. Calibration curve of Stuiver and Pearson (1993) for the period between 7500 and 4800 (uncalibrated ^{14}C years B.P.), and calibration of 15 AMS dates obtained on plant macrofossil remains and macroscopic charcoal particles from the sediment sequence BI at Bökeberg III

Biostratigraphy

Local pollen assemblage zones (LPAZs) and inferred vegetation. The local pollen assemblage zones are described primarily on the basis of the arboreal pollen taxa (AP), although herb pollen percentages (NAP) and microscopic charcoal were also taken into account (Fig. 10). The pollen diagram may be subdivided into 3 zones which are now described.

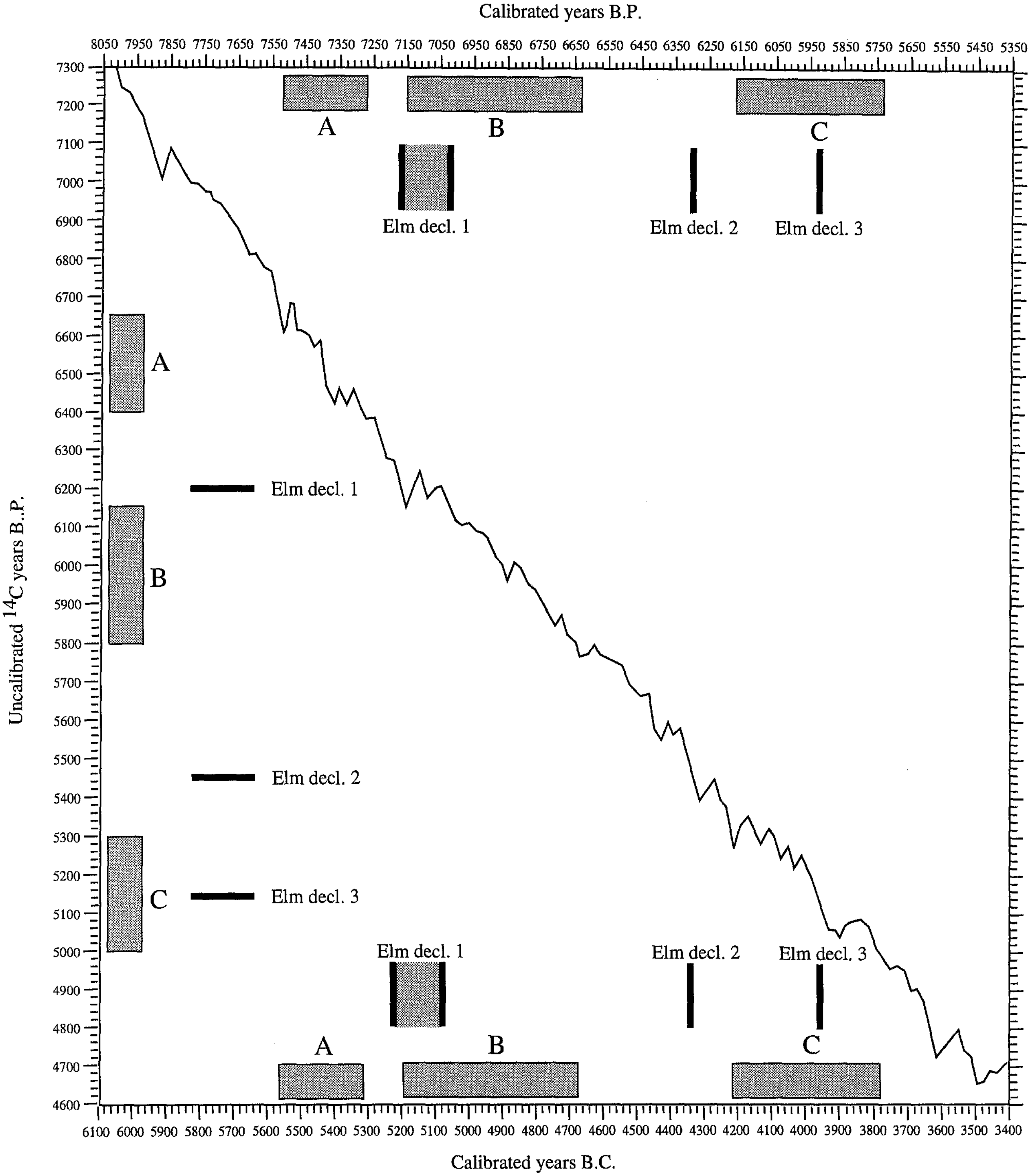


Fig. 9. Dating and calibration of the three settlement phases A, B, C defined on the basis of the biostratigraphical analyses of sediment sequence BI at Bökeberg III. The three elm declines 1, 2, 3 (see Fig. 10) are shown for comparision. The calibration curve is that of Stuiver and Pearson (1993)

LPAZ BIP1 (46-49 cm). This zone is characterised by high *Betula* and *Pinus* percentages, whereas *Alnus*, *Corylus* and *QM* have low values. *Salix*, *Populus*, *Artemisia* and Cyperaceae have relatively high representation. Upper limit: distinct increase in *Alnus*.

This LPAZ may be compared to Nilsson's zone PB (10 000-9500 B.P.). It is, however, atypical because of the occurrence of relatively high percentages of *Corylus*. As discussed above, these pollen spectra may be due to the mixed nature of the sediments, as a result of a lake-level lowering, erosion and re-deposition of older sediment.

Inferred vegetation: at the end of the period of deposition of this sediment sequence (ca. 6700-6550 B.P.), the vegetation on high ground was characterised by dominant hazel with some oak and lime, and a few alder along the lake shore. The relatively abundant pollen of *Pinus*, *Betula*, *Salix*, Gramineae, Cyperaceae, *Artemisia* and Chenopodiaceae were probably re-deposited together with older sediments.

LPAZ BIP2 (40-46 cm). Alnus is dominant (40-90%), *Ulmus*, *Quercus* and *Tilia* occur regularly but with low representation and *Corylus* percentage representation is also low. Upper limit: increase in *Corylus* and rational limits of *Ulmus*, *Quercus* and *Tilia*.

Two subzones can be distinguished as follows:

Subzone BIP2a (42-46 cm): *Alnus* has very high values (60-90%), whereas *Betula* and *Corylus* percentages are low. However, the concentration diagram (Fig. 11) shows no decline in *Betula* and *Pinus* even though there is a sharp increase in *Alnus* (both concentration and especially percentage values). This subzone is also characterised by a peak of microscopic charcoal particles. Upper limit: substantial increase in *Betula*.

Subzone BIP2b (40-42 cm): increase in *Betula* (30%), decrease in *Alnus* (40%), slight increase in *Corylus*, *Ulmus*, *Quercus*, and *Tilia*. A distinct *Betula* peak in the concentration diagram (Fig. 11). Upper limit: decrease in *Betula*, increase in *Corylus, Ulmus, Quercus* and *Tilia*, and empirical limit of *Fraxinus*.

The absence of *Fraxinus* is characteristic of the vegetation during the Late Boreal and Early Atlantic (Nilsson's zones BO2 and AT1) in Skåne. However, the very low *Corylus* representation at Bökeberg is atypical for these periods and may be due to the local dominance of *Alnus*.

Inferred vegetation: local development of a littoral belt of alder. On high ground, elm, oak, lime, and hazel start to expand. The peak of birch during subzone BIP2b may be due to high accumulation of birch pollen just outside the littoral belt (i.e. at the sampling point) at that time. Birch was probably growing at the lake shore during the whole period represented by BIP2, but was certainly not as common as alder.

LPAZ BIP3 (2-40 cm): Alnus (30-60%) and *Corylus* (15-30%) are dominant. *Ulmus, Quercus, Fraxinus* and *Tilia* are relatively well represented. This zone is subdivided into four subzones as follows:

Subzone BIP3a (30-40 cm): *Alnus* (40%) and *Corylus* (25%) are dominant, and *Ulmus* (5%), *Quercus* (10%), *Fraxinus* (0.5-1%), and *Tilia* (3-5%) are sub-dominant. *Pediastrum* has low percentages. Upper limit: increase in *Alnus* and decrease in *Corylus*.

Subzone BIP3b (26-30 cm): high percentages (60%) of *Alnus*. *Ulmus* shows a slight decrease (elm decline 1). The values of *Pediastrum* increase substantially. Microscopic charcoal particles show a distinct peak. Upper limit: decrease in *Alnus* and increase in *Corylus*.

Subzone BIP3c (12-26 cm): The pollen spectra are very similar to those of subzone BIP3a. However, *Fraxinus* has higher percentages than before. Upper limit: increase in *Alnus*, decrease in *Corylus*, and slight decline of *Ulmus* (elm decline 2). Interestingly, the peak in *Alnus* percentages does not match the peak in *Alnus* concentration, the latter occurring slightly later. Elm decline 2 is also a distinct feature in the concentration diagram.

Subzone BIP3d (2-12 cm): *Alnus, Quercus,* and *Corylus* are dominant. Microscopic charcoal particles show a gradual increase towards the top of the profile. There is a third and last slight decrease in *Ulmus* (elm decline 3) in the upper part of the diagram.

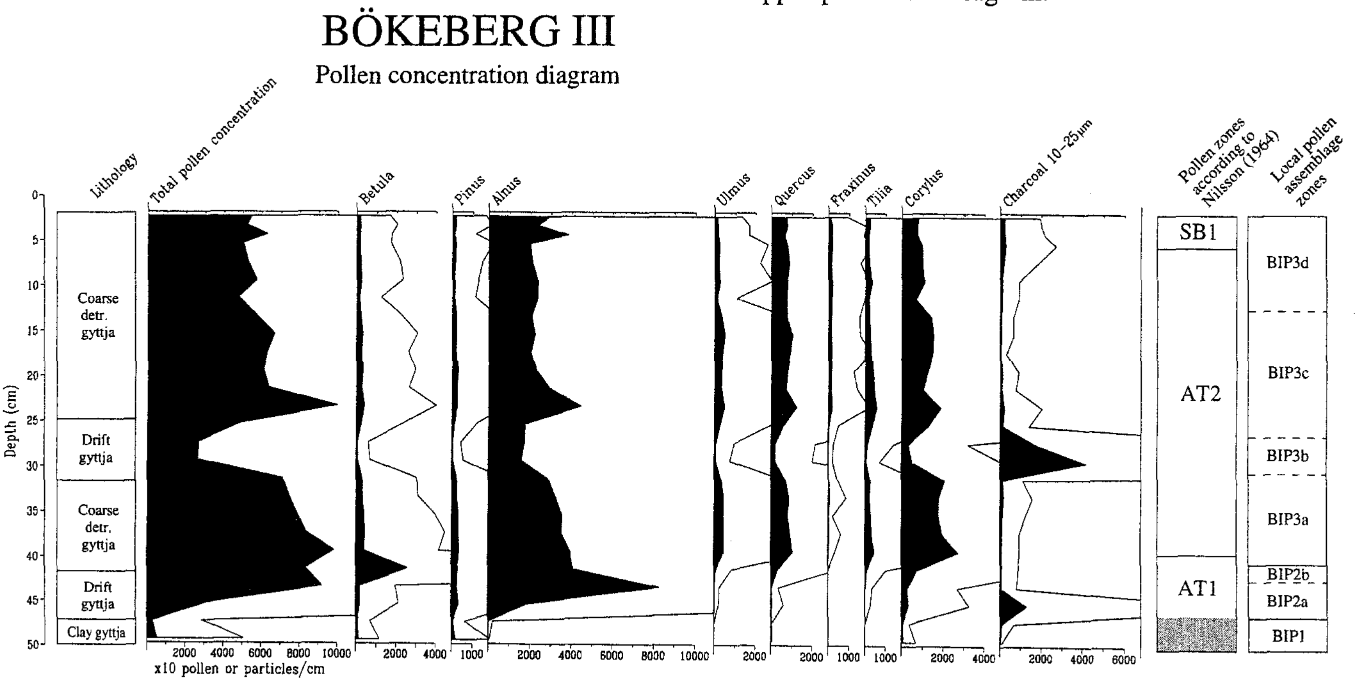


Fig. 11. Pollen concentration diagram of selected taxa and microscopic charcoal particles (10-25 m) from the sediment sequence BI at Bökeberg III. A unit on the horizontal scale represents x10 pollen grains/charcoal particles per cm³

The LPAZ BIP3 may be compared to Nilsson's zone AT2 (6400-5100 B.P.). As discussed above, the third elm decline probably corresponds to the classic elm decline dated to ca. 5100 B.P. in N.W. Europe, and marks the Nilsson's zone boundary AT2/SB1.

Inferred vegetation: alder is still dominant locally. The fluctuations in the pollen curve of *Alnus* (subzones P3a, P3b, and P3c) may be related to changes in the distance between the alder belt and the sampling point. These changes may, in turn, correspond to lake-level changes (see below). On high ground, elm, oak, lime and hazel are all common. Ash appears at the beginning of zone P3 and increases significantly in subzones P3c and P3d. The three elm declines are not associated with other distinct vegetation changes. However *Artemisia*, and *Urtica* are represented more regularly and by slightly higher percentages in subzones P3b, P3c, and P3d, and Chenopodiaceae in subzone P3c. The percentages of *Pediastrum* are significantly higher from the beginning of zone P3, which may be related to higher production of this algae in the littoral zone of the lake as a response to eutrophication.

Macrofossil assemblage zones (MAZs) and inferred vegetation and environment. The macrofossil assemblage zones are described mainly on the basis of the aquatic and telmatic vegetation, the damp forest vegetation and changes in the occurrence of macroscopic charcoal. The macrofossil diagram (Fig. 12) is divided into six zones as follows:

MAZ BIM1 (47.5-50 cm). This zone is very poor in macrofossils. The only abundant taxa, particularly in the last level, are *Chara* spp., *Cladium mariscus, Scirpus lacustris/maritimus, Alnus* and sclerotia of the terrestrial fungus *Cenococcum geophilum.* Upper limit: increase in aquatics (e.g. *Nuphar lutea, Nymphaea alba*), telmatophytes (e.g. *C. mariscus, S. lacustris/maritimus*), *Alnus* and *Betula.*

Inferred vegetation and environment: progressive development of a littoral zone with *C. mariscus, S. lacustris/maritimus* and alder close to the sampling point. With the exception of a few capsule fragments of *Tilia*, the macrofossils belong to taxa characteristic of the local littoral vegetation. The occurrence of *C. geophilum* indicates soil erosion from the lake shore. This zone probably represents a transitional phase towards a lower water-depth.

MAZ BIM2 (40.5-47.5 cm). High values of aquatics (*Nuphar lutea, Nymphaea alba, Potamogeton* spp., *Chara* spp.) and telmatophytes (*C. mariscus, S. lacustris/maritimus, Typha* sp.); *Alnus* and *Betula* are well represented; and occurrence of *Cornus sanguinea, Corylus avellana, Quercus* sp. and *Tilia* sp. *C. geophilum* shows a peak in the first part of the zone. There is a low but steady occurrence of macroscopic charcoal fragments. Moreover, there is a large number of charred achenes of *C. mariscus*, and scattered finds of charred caryopses of Gramineae (Fig. 16). Upper limit: increase in *Betula*, decrease in several aquatics and telmatophytes, and decrease in *C. geophilum* and macroscopic charcoal fragments.

Inferred vegetation and environment: development of the littoral zone close to the sampling site, with alder and birch, *C. mariscus* and *S. lacustris/maritimus*, and aquatics suggesting relatively shallow water at the sampling point. The occurrence of *Cornus sanguinea, C. avellana, Quercus, Tilia, Prunus spinosa, Rubus idaeus* and *Sorbus aucuparia* indicate that these trees and shrubs were growing on high ground in the mixed deciduous forest. The *C. geophilum* records suggest that soil erosion was particularly important at the beginning of the zone. The macroscopic charcoal fragments indicate regular fire (natural or of human origin) close to the shore, and the numerous charred fruits of *C. mariscus* suggest that this species was selectively burnt. An explanation for this phenomenon is proposed below (see Synthesis and discussion).

MAZ BIM3 (33.5-40.5 cm). Low frequencies of aquatics (*Nuphar lutea, Nymphaea alba* and *Chara*) and telmatophytes (*C. mariscus* and *S. lacustris/maritimus*, and *Typha* sp.), but occasional records of *Eupatorium cannabinum* and *Phragmites australis.* Fruits and catkin scales of *Betula* are abundant. There are scattered but regular finds of *Tilia* spp. and only rare finds of *Quercus* spp. *C. geophilum* and macroscopic charcoal fragments show significantly lower values than before. Upper limit: increase in aquatics, telmatophytes and *Alnus.*

Inferred vegetation and environment: the littoral zone together with the associated aquatics, *C. mariscus* and *S. lacustris/maritimus*, are now some distance from the sampling site. However, the abundant fruits of alder and the higher birch representation indicate that the sampling site is still close to the littoral zone, although probably outside it. The macrofossil data suggest, therefore, a slightly greater water depth than earlier at the sampling site. The decrease in *C. geophilum* also suggests that the distance to the shore has increased. The few finds of *Quercus* sp. and *Tilia* sp. indicate that these trees were growing on high ground. The absence of hazel may be explained by the decrease (or lack) of human activity at the shore. There is little macroscopic charcoal, which shows that fire (natural or of human origin) may have been less frequent than before.

MAZ BIM4 (21.5-33.5 cm). This zone is characterised by a renewed abundance of aquatics, in particular *Nuphar lutea* and *Nymphaea alba*, telmatophytes (*C. mariscus* and *S. lacustris/maritimus*), and alder. Note the

Fig. 12. Plant macrofossil diagram from the sediment sequence BI at Bökeberg III. The results are expressed as numbers of remains per litre sample. The total weight of macroscopical charcoal particles per litre of sediment (see Fig. 13), the loss-on-ignition as a percentage of the dry weight of the sample and the sample volume in cm³ are also shown. For a correlation of the local pollen assemblage zones and the plant macrofossil assemblage zones see Fig. 15. Key to abbreviations of fossil types: *A*, acorn; *Ca*, capsule; *Car*, caryopsis; *Cs*, catkin scale; *F*, fruit; *Frl*, fruitlet; *M*, mericarp; *N*, nutlet; *Ns*, nutshell fragment; *Nd*, node diaphragm; *O*, oogonia; *S*, seed; *Sc*, sclerotia; *Sp*, spindle (catkin axis); *Sta*, statoblast; *Sto*, stone

occurrence of *Urtica dioica* and *Rubus idaeus*. Macroscopic charcoal fragments are abundant. Two subzones are recognised as follows:

Subzone BIM4a (26.5-33.5 cm): *Nuphar lutea* and *Nymphaea alba* are well represented, whereas *Chara* sp. and *Cristatella mucedo* have low values. There are substantial peaks for both *Alnus* and *Betula* in this subzone. *Corylus* and *Tilia* are consistently recorded. Macroscopic charcoal reaches its greatest abundance. Upper limit: increase in *Tilia* and *Betula*, and decrease in macroscopic charcoal.

Subzone BIM4b (21.5-26.5 cm). This subzone is characterised by higher values of *Chara* spp. and *Cristatella mucedo*, peaks in the representation of *Alnus* and *Betula* fruit, much *Tilia* seeds and a decline in macroscopic charcoal compared with the previous subzone. Upper limit: sharp decrease in *C. mariscus* and *S. lacustris/maritimus*, decline in *Alnus*, *Betula* and *Tilia*, and lower values for macroscopic charcoal.

Inferred vegetation and environment: there is a renewed development of the littoral zone close to the sampling site. Plants involved included alder and birch, *C. mariscus* and *S. lacustris/maritimus*, and various aquatics. However, the local vegetation has a slightly different character than in zone M2. The belt of *C. mariscus* seems to be of smaller extent, whereas alder and birch are more important. Moreover, *Chara* is poorly represented. These features indicate very shallow conditions at the sampling site and possibly a lake-level lowering. *Tilia* was perhaps quite abundant in the neighbourhood of the site at the end of the zone. As the records for *C. avellana* relate to subzone BIM4a, this may be connected with human activity on the lake shore. The lack of oak may be explained by the fact that it was not gathered at that time (see zone BIM3). The abundance of macroscopic charcoal indicates frequent fires close to the lake shore.

Zone BIM5 (12.5-21.5 cm). *C. mariscus* and *S. lacustris/maritimus* are absent and other telmatophytes are rare. *Alnus* and *Betula* have very low frequencies, as well as *Tilia*. Hazel, oak and other forest species are absent. The species diversity in this zone is significantly lower than in the previous zones. Upper limit: increase in aquatics (*N. lutea, N. alba, Chara* sp.), *Alnus, Betula* and *Tilia.*

Inferred vegetation and environment: the absence of *C. mariscus* and *Scirpus* species implies that the littoral vegetation belt has disappeared or is at too great a distance from the sampling site to be registered. The low representation of alder and birch also speaks in favour of a greater distance to the shore. However, aquatics are still abundant, which indicates that the littoral zone is not very far from the sampling site. These data suggest an increased water depth at the sampling site, and, therefore, a second rise in lake-level. The absence or low frequencies of remains from trees and shrubs on high ground and the lack of macroscopic charcoal may be explained by the greater distance between the sampling site and the shore, and/or by a decrease in human activity (gathering, fires) at the shore.

Zone BIM6 (1-12.5 cm). High frequencies of aquatics (*N. lutea, N. alba, Chara* spp.). Regular occurrence of *Ceratophyllum demersum*. The terriphytes are represented by a few finds of *C. mariscus, Typha* sp. and *Eupatorium cannabinum. Alnus, Betula* and *Tilia* are relatively abundant. There is a little macroscopic charcoal in the four upper levels.

Inferred vegetation and environment: the slight increase in the aquatics and terriphytes, and the higher frequencies of birch and alder remains may indicate that the littoral vegetation belt is again closer to the sampling site, which implies a slight lake-level lowering. Lime seems to be relatively common on high ground. The absence of oak and hazel may indicate that these trees were not growing in the neighbourhood, or that human activity was low, and/or that these fruits were not gathered by people at this time. The few finds of macroscopic charcoal also suggest a low frequency of fires (natural or of human origin) close to the shore.

Charcoal assemblage zones (CAZs). The charcoal assemblage zones are defined on the basis of the quantitative representation of macroscopic charcoal, and the subzones are distinguished by differences in specific composition of the charcoal. The charcoal diagram (Fig. 13) is divided into five zones as follows:

Zone BIC1 (47.5-49 cm). Very low representation of macroscopic charcoal. All the charcoal identified consisted of *Alnus*. Upper limit: increase in charcoal, i.e. *Quercus*.

Zone BIC2 (37.5-47.5 cm): Dominance of trees of the mixed deciduous forest (*Quercus*, *Ulmus* and *Corylus*), regular occurrence of *Pinus*, and *Alnus* and *Betula* are very poorly represented. There are scattered finds of *Salix*, *Frangula alnus* and *Viburnum opulus. Cornus sanguinea* is well represented at 40 cm. Upper limit: decrease in charcoal and, in particular, *Quercus* and *Corylus*.

Zone BIC3 (33.5-37.5 cm). Zone poor in charcoal fragments. *Alnus*, *Ulmus*, *Tilia*, *Corylus* and Pomoideae are present in very low quantities. Upper limit: increase in *Ulmus*.

Zone BIC4 (20.5-33.5 cm). Greatest amount of charcoal in the sequence. Alder, oak and hazel are dominant, elm and lime are also well represented. Two subzones are recognised as follows:

Subzone BIC4a (26.5-33.5 cm). High representation of alder, elm, oak, lime, hazel, and ivy (*Hedera helix*), especially between 27 and 30 cm. Elm is already common at the beginning of the subzone. The peaks in hazel and ivy at 31 cm are followed by the peaks in alder, elm, oak, and lime at 30 cm. The values for elm and lime remain high at 29 cm, and those for oak at 29, 28 and 27 cm. Note the occurrence of Pomoideae at 29 cm, and of *Populus* at 28 cm. There is a peak in ivy at 28 cm, and a second peak in alder at 27 cm. *Salix* is also relatively well represented. Upper limit: sharp decrease in alder, oak, lime and hazel.

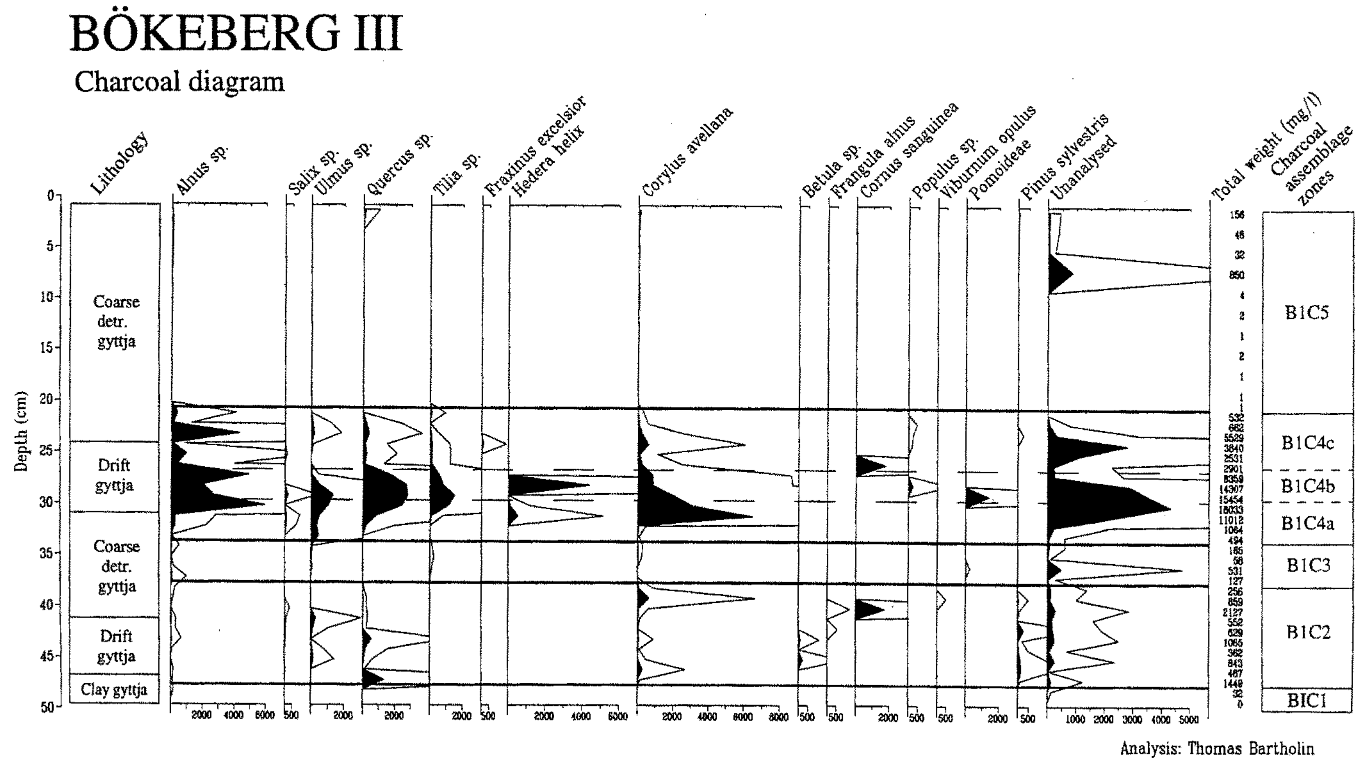


Fig. 13. Charcoal diagram from the sediment sequence BI at Bökeberg III. The results are expressed as mg charcoal per litre of sediment. The total weight of macroscopic charcoal per litre sediment at each level is also shown

Subzone BIC4b (20.5-26.5 cm). Low values of elm, oak, lime and hazel. Alder is also poorly represented, except for one level at 23 cm. There is a significant peak in *Cornus sanguinea* at 26 cm, and scattered finds of *Salix, Fraxinus excelsior, Populus,* and *Pinus*. Upper limit: sharp decrease in charcoal fragments, as a whole.

Zone BIC5 (1-20.5 cm). This zone is very poor in charcoal fragments. They occur only in the four upper levels. There is a peak in charcoal at 7 cm. Since this charcoal was very fragmented, most of it could not be identified to either species or genera. A few scattered fragments could be identified to alder (5, 3, 1 cm), oak (1 cm), hazel (9, 5, 3, 1 cm) and pine (1 cm).

The charcoal diagram clearly shows two main periods of major input of charcoal fragments to the sediment, the first between 47-39 cm (2 g charcoal/l sediment), and the second one between 33-21 cm (15 g charcoal/l sediment). There is a later period with minor input in the upper part of the sequence (1-7 cm). The presence of macroscopic charcoal in the sediments indicates the occurrence of fire of human or natural origin close to the lake-shore. Furthermore, the fragments may have been deposited in situ, or they may be re-worked from older deposits. During the oldest period (ca. 6600 - 6400 B.P.), the charcoal fragments are mainly from trees and shrubs growing on high ground (*Ulmus*, *Quercus*, *Corylus*, *Pinus* and *Cornus sanguinea*). A natural fire at the lake-shore would probably have produced mainly charcoal of birch and alder. It is hard to believe that a natural fire in the mixed deciduous forest on high ground could be registered by macroscopic charcoal in the lake sediments, since these fragments cannot be easily transported over long distances. Therefore, we assume that people gathered wood on the high ground, which was burned at the settlement. We also argue that these fragments were deposited in situ, except possibly a few reworked fragments of pine, birch and alder in the lowest part of the sequence. The differences in the taxa composition between the two major periods with charcoal point to a selection of tree species by people and/or a difference in the species available at the time. During the second period (ca. 6200-5800 B.P.), a wider spectrum of shrub and tree species was obviously used from both the shore vegetation and the forest on high ground. From the amount of charcoal, it seems that the period of highest relative fire frequency was between ca. 6200 and 6000 B.P. Moreover, the stratigraphical sequence of the different taxa may be interpreted in terms of species selection by people. Hazel was used mainly at the beginning of the period, whereas alder, elm, oak, and lime were burnt in abundance slightly later. The few charcoal fragments found in the upper part of the profile may indicate some minor, temporary human activity at the shore between 5300-5000 B.P.

Synthesis and discussion

The natural environment

The local vegetation during the interval 6700-5000 B.P. (5600-3800 cal. B.C.) at Bökeberg. The results of the combined pollen, macrofossil, and charcoal analyses of the same sediment sequence provide a detailed picture of the local vegetation at the lake-shore and on the adjacent high ground.

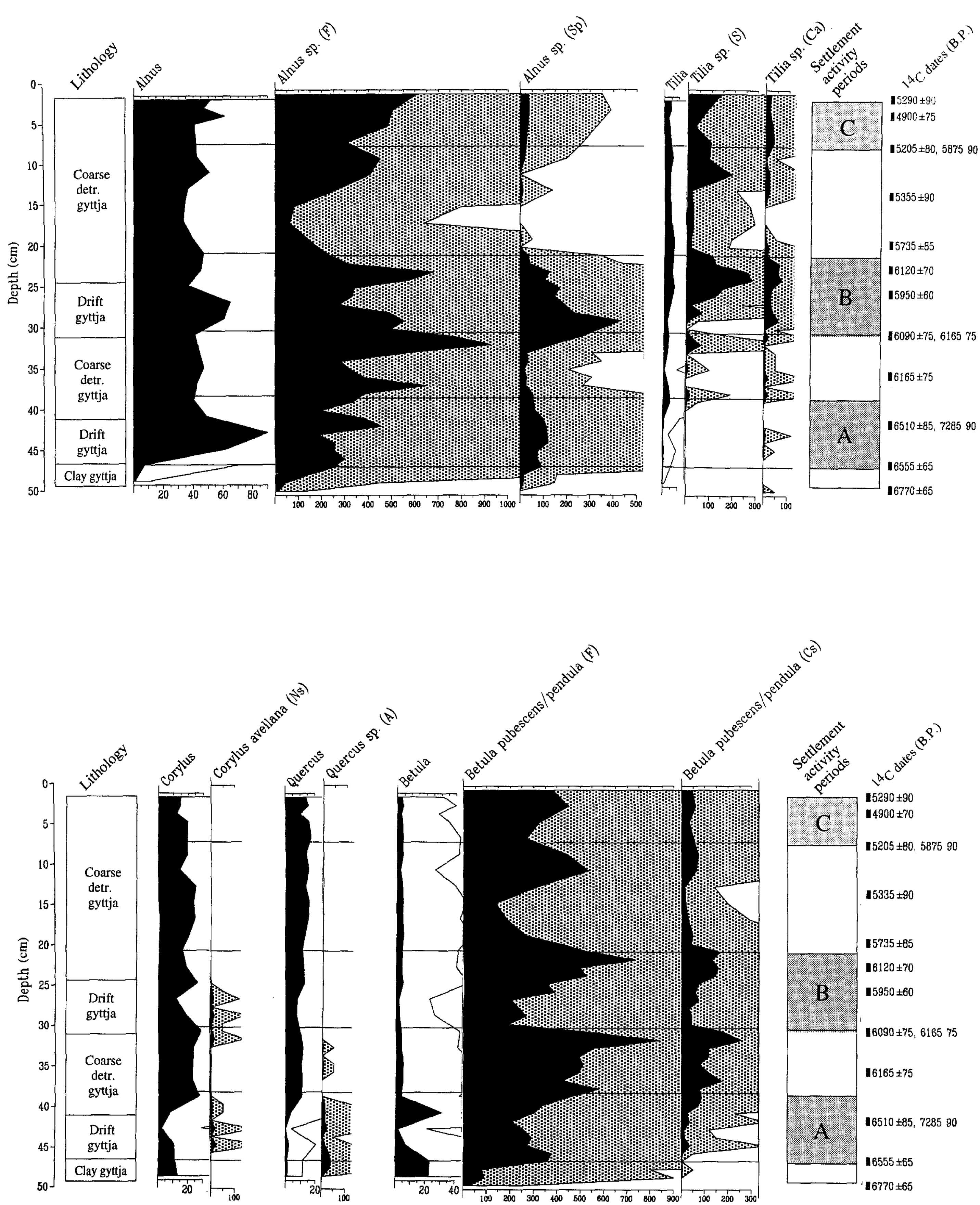


Fig. 14. A comparison between the percentage pollen and plant macrofossil (numbers of remains per litre of sediment) data from the sediment sequence BI at Bökeberg III for *Alnus, Tilia, Corylus, Quercus* and *Betula*. Exaggeration of the curves x10 is indicated by a non-shaded area and stippling in the case of pollen and macrofossil curves, respectively. For abbreviations used for the macrofossil types, see legend to Fig. 12

From ca. 6500 to 5000 B.P., alder was the major tree at the lake-shore (Figs. 10-12). Species such as *Frangula alnus, Eupatorium cannabinum, Urtica* and *Solanum dulcamara* were growing in these riparian woods. Though a large number of fruits and catkin scales of birch were recorded (Fig. 12), this tree was probably not very common. The pollen percentages of birch are relatively low during the whole period, except for a short time between ca. 6700-6400 B.P. (Figs. 10, 11, 14). The latter may be accidental (high concentrations of birch pollen at the sampling point) or due to a real temporary development of birch at the lake-shore. Note that people probably gathered birch at that time (occurrence of macroscopic charcoal, Fig. 13). The discrepancies between the fluctuations in the pollen and macrofossil curves (Fig. 14) may indicate that birch was not growing directly on the shore. The fluctuations in the amount of birch macrofossils are probably related primarily to movements in the littoral vegetation belt. Birch fruits can be transported over long distances, and float for some time before they are caught by the littoral vegetation and finally deposited in this zone.

The littoral vegetation was characterised by an extensive belt of *C. mariscus* and *Scirpus* species, especially between 6600 and 6400 B.P. After 6400 B.P., these plants fail to achieve high representation in the macrofossil record, and from 5800 B.P., the belt of *C. mariscus* was more restricted and/or situated at too great a distance from the sampling site for this species to be recorded as a macrofossil (Fig. 12). *Phragmites australis* and plants of similar habitat, e.g. *Typha, Menyanthes trifoliata*, and *Cicuta virosa*, were present during the whole period, but probably did not cover large areas. The aquatic vegetation consisted mainly of *Nymphaea alba* and *Nuphar lutea* (Fig. 12), but *Najas marina* and *Ceratophyllum demersum* also occurred. *Potamogeton* species are represented only during the period 6600 to 5900 B.P. after which they may have dissapeared locally, or they may still have been present in the lake but they fail to register at the sampling site.

The vegetation on the high ground is best described from the pollen data. From ca. 6700 to 6400 B.P., oak, elm, and hazel were common trees in the area. Lime was probably more abundant than is suggested by the pollen percentages, as its under-representation in the pollen record is well known (Andersen 1970). However, the low representation of *Tilia* in the macrofossil record in comparison with the following period (Figs. 12, 14) suggests that lime was not yet very common. These taxa did not necessarily grow together and they probably included several species of the same genera. Sessile oak (*Quercus petraea*) and lime (*Tilia cordata* and perhaps *T. platyphyllos*) may have grown on the driest soils, possibly on the most elevated areas, whereas wych elm (*Ulmus glabra* and, perhaps, *U. carpinifolia*) and hazel may have preferred deeper, fresher soils in the depressions. Pine may have grown on the drier soils, especially those in which the sand fraction was important.

The absence of pollen, macrofossils and charcoal of *Fraxinus* and *Hedera* indicates that these species did not occur locally until ca. 6400 B.P. This is of interest, as the rational limit of *Fraxinus* pollen in Skåne is a characteristic of Nilsson's zone boundary AT1/AT2 at 6400 B.P. (Nilsson 1964). This would imply that the rational limit of *Fraxinus* corresponds to the local expansion of this tree. Moreover, it is striking that the establishment of this tree, and its further expansion at Bökeberg, coincide with periods of rising water-level (at ca. 6500 B.P. and 5800 B.P.). This may speak in favour of a possible climate-induced spread of *Fraxinus* during the Holocene. *Hedera* pollen have been found in earlier periods in pollen diagrams from Skåne. The late arrival of ivy at Bökeberg may be a local feature. The plant macrofossil and charcoal analyses also show that the forests on high ground included shrub species such as *Cornus sanguinea, Viburnum opulus*, and *Prunus spinosa*. The forests may have been more open than traditionally has been assumed, and human activity may have produced locally a diverse landscape with forested areas and small clearings with shrubs and scattered trees.

From 6400 to 5000 B.P., the composition of the forest on high ground was very similar to that known from earlier investigations relating to this period. Oak, elm, and lime were common trees. The significant and synchronous increase in *Tilia* pollen and macrofossils after 6400 B.P., as well as their regular occurrence through to the top of the sequence (Fig. 14), may indicate that lime was growing on high ground close to the sampling site and therefore very close to the lake-shore and the Ertebølle settlements. *F. excelsior* was the only additional tree species. It probably thrived on deeper, wetter soils in depressions. It may have grown along the lake-shores as well. From ca. 5900 B.P., ash became even more abundant, whereas the other trees maintained their earlier representation. Ivy was probably common as a climber on deciduous trees. The charcoal analyses indicate that *Populus* was also present, however, probably only in small amount (no pollen or macrofossils). *Sorbus aucuparia*, and *Cornus sanguinea* were still components of the deciduous forest. *Rubus idaeus* was probably also present during the whole of the period. Various Pomoideae (for instance species such as *Prunus spinosa, P. avium, Malus sylvestris*, etc.) also occurred (see charcoal record). The three elm declines are discussed below.

The reconstruction of the vegetation on high ground at Bökeberg may be compared with that proposed by Göransson (1988a) for the site of Skateholm during the Late Mesolithic settlement phases.

Lake-level fluctuations of Yddingesjön between 6700 and 5000 B.P. and their environmental implications

The macrofossil data from the littoral sequence of Bökeberg provide valuable information about past water-level changes in the ancient bay of Yddingesjön. The fluctuations in the abundance of macroremains from the aquatics, telmatophytes and shore trees (alder and birch) suggest a major period of low lake-level between 6700 and 5800 B.P. (Fig. 12). This can be subdivided into two periods of particularly shallow water at the coring point and possibly of low lake-level (6700-6500 and 6250-5800 B.P.) separated by a time of slightly higher level. A substantial rise in water-level occurred around 5800 B.P. There was another decrease in water-depth (or lake lowering) at ca. 5500 B.P., but until 5000 B.P. the lake was not as shallow as earlier. Palaeohydrological reconstructions based on the analysis of a single core are, of course, highly hypothetical (Digerfeldt 1986; Gaillard and Digerfeldt 1991). However, a comparison with the palaeohydrological trends reconstructed in Skåne and southern Sweden (Digerfeldt 1988; Gaillard and Digerfeldt 1991) enable us to give this tentative interpretation.

The date of the first possible lowering in water-level registered in the sequence of Bökeberg (6700 B.P.) corresponds to that of the second major Holocene water-level lowering in southern Swedish lakes, in particular in Bysjön, situated ca. 25 km north-east of Yddingesjön (Digerfeldt 1988). A lake-level lowering of this amplitude also explains why most of the early Holocene sediments were eroded at Bökeberg. The dating of the lowest lake-level at Bökeberg (ca. 6250-5800 B.P.) also agrees relatively well with the period of lowest level in Bysjön between 6000 and 5500 B.P. Furthermore, it coincides with the longest settlement phase (B) at Bökeberg. Whether the minor fluctuations during the major period of low level and the second lake-level lowering around 5500 B.P. at Bökeberg have equivalents at the regional scale cannot be decided on the basis of this comparison. The palaeohydrological reconstructions available for southern Sweden do not provide the degree of detail which would allow a correlation of changes of such short duration. However, it has already been suggested that "the climate was obviously not constantly drier during this period (Late Atlantic AT2), since minor lake-level changes were recorded in some of the lakes studied" (Gaillard and Digerfeldt 1991, p. 280).

In conclusion, the major period of low lake-level at Bökeberg (6700-5800 B.P.) belongs to a time of generally low lake-levels in southern Sweden (Harrison and Digerfeldt 1993). This trend has been interpreted in climatic terms, i.e. as representing significantly drier conditions (higher temperatures and/or lower precipitation). This implied locally favourable conditions for the development of reed vegetation and alder woodlands along the lake-shore and for the establishment of trees such as oak, elm and lime on higher ground. It also provided larger areas of relatively dry soils where people could settle for some time.

Evidence of settlement activities and their influence on the natural environment

Comparison of the archaeological and biostrati-graphical data. Settlement activities may be traced in the present biostratigraphical data by means of the following indicators:

1. Fluctuations in charcoal representation. The curves for microscopic and macroscopic charcoal serve as measures of changes in the relative frequency of fires in the wider area and close to the lake shore, respectively.
2. Fluctuations in the pollen curves of tree taxa. These may reflect forest clearance/regeneration.

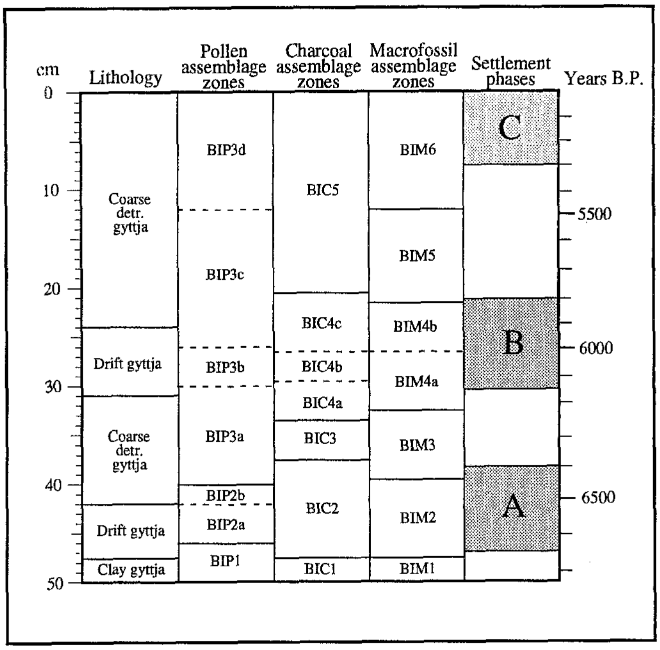


Fig. 15. Diagram showing the correlation of the local pollen assemblage zones, plant macrofossil assemblage zones, and charcoal assemblage zones from the sediment sequence BI at Bökeberg III (see also Figs 10, 12, 13). The settlement phases A, B, C as defined on the basis of the biostratigraphical data (see text) and the lithology are shown for comparison

3. The occurrence of pollen indicators of human activities such as ruderals (*Artemisia, Plantago* and Chenopodiaceae).
4. The occurrence of plant macrofossils or charcoal during restricted periods. This suggests processes related to human activities.

On the basis of these different indicators, settlement activities can be demonstrated for three periods (Figs. 9, 15, 16) as follows:

A. ca. 6650-6400 B.P. (ca. 5560-5320 cal. B.C.): increase in microscopic and macroscopic charcoal fragments (Fig. 16), occurrence of macroscopic charcoal of elm, oak, hazel, birch, pine and a few other species (Fig. 13), increase in charred fruits of *C. mariscus*, and occurrence of hazelnuts and acorns (Figs. 12, 14, 16). The relative frequency of fires at the regional scale may have been higher during the first half of phase A (6650-6550 B.P., ca. 5560-5450 cal. B.C.).

B. ca. 6150-5800 B.P. (ca. 5200-4680 cal. B.C.): increase in microscopic and macroscopic charcoal fragments (Figs. 13, 16), first elm decline (both percentage and pollen concentration) at ca. 6200 B.P. (5200-5100 cal. B.C.) (together with decline in oak, lime, pine, birch, hazel) (Figs. 10, 11), occurrence of *Artemisia* pollen grains at ca. 6200 B.P., and Chenopodiaceae at ca. 5950 B.P. (Fig. 10), occurrence of macroscopic charcoal of alder, elm, oak, lime, ivy, hazel, and some other species (Fig. 13), and occurrence of hazelnuts and fruitlets of *Rubus idaeus* (Fig. 12). The relative frequency of fires at the regional scale and close to the lake-shore may have been higher during the first half of phase B (6150-5950 B.P., ca. 5200-4820 cal. B.C.).

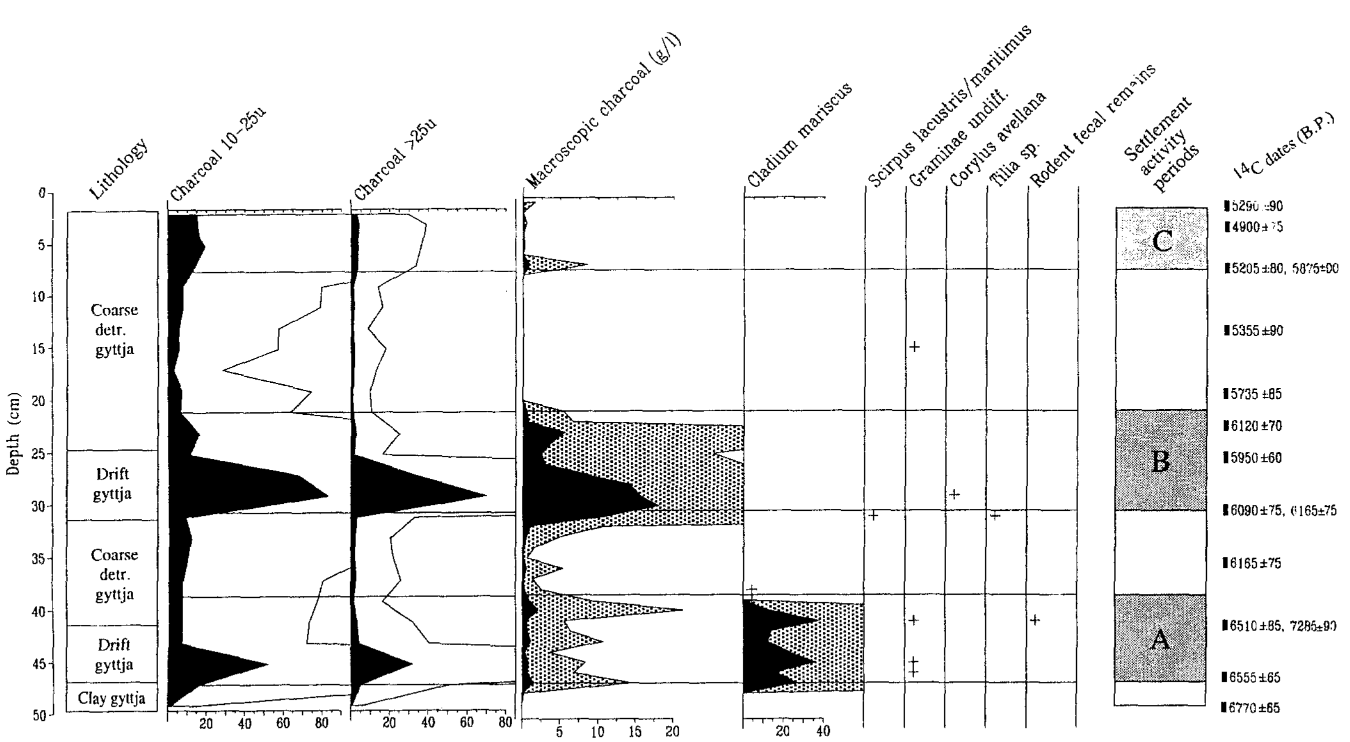


Fig. 16. Synthesis diagram of the microscopic charcoal particles as a percentage of total terrestrial pollen (see Fig. 10), macroscopic charcoal particles as g l^{-1} of sediment (see Fig. 12), and charred macroremains for selected plant taxa (as number of remains per litre sediment; +, single find)

C. ca. 5300-<5000? B.P. (ca. 4200-3800 cal. B.C.): increase in microscopic and macroscopic charcoal fragments (Fig. 13), second and third elm declines at ca. 5450 (4340 cal. B.C.) and 5150 B.P. (3960 cal. B.C.) (Fig. 10), occurrence of *Artemisia*, *Plantago lanceolata*, *Avena*-type and Gramineae (>37μm) from 5300 B.P. (Fig. 10), few occurrences of macroscopic charcoal of alder, oak, hazel, and pine between 5200 and 5000 B.P. (Fig. 13).

Phases of human activity A and B are obviously related to the settlement remains excavated at the shore which, according to the archaeological artefacts and to the ^{14}C dates from bones and constructions, date to the period ca. 6700-5800 B.P. (ca. 5600-4700 cal. B.C.).

Phases A and B cover ca. 250 and ca. 500 calendar years, respectively (Fig. 9). These two phases are separated by a time span of about 80 calendar years and are synchronous with periods of low lake-levels, whereas the intervening interval is characterised by higher water level. Whether phases A and B correspond to two separate phases of occupation on the small hill at the lakeshore cannot be demonstrated on the basis of the biostratigraphical data. The decrease in indicators of human activity during the period 6400-6150 B.P. could be due to the rise in water level and the greater water depth at the sampling site. The massive deposition of remains from the settlement activities (hazelnuts, macroscopic charcoal from different tree species, etc) may have followed the movements of the littoral belts in response to lake-level fluctuations. However, there are clear differences between the two proposed periods of settlement activity, especially in terms of human impact on the natural vegetation (see below). This points to two occupation periods, separated by a time when the hill at Bökeberg was not settled, or was visited only temporarily. Moreover, in the series of ^{14}C dates from the occupation area, two subgroups may be distinguished which are separated by a gap between 6300 and 6000 B.P. This may be regarded as another indication of two separate settlement phases.

The third phase of human activity (C) may also be assigned to the Ertebølle culture. However, on the basis of the archaeological artefacts and the ^{14}C dates from the excavation area, there is no clear evidence of settlement at Bökeberg during the latest phases of the Ertebølle culture (Karsten and Regnell, in preparation). The increase in the microscopic and macroscopic charcoal fragments indicates that fires did occur, and that there was probably some temporary human activity locally and/or in the area.

Göransson (1988b) argues that "garden cultivation" may have occurred at that time in Skåne and Östergötland. This hypothesis is based on the finds of cereal pollen grains during Late Atlantic time (6400-5100 B.P.) in several pollen diagrams, and on a model of the possible use of the forest on high ground during this period (Göransson 1982, 1986). There are few records of cereal pollen at Bökeberg (3 grains of Gramineae larger than 37μm, and one grain of *Avena*-type before the classic elm decline). Moreover, no remains of cereals were found in the macrofossils from the lake sediments and the soils of the excavation area. Therefore, there is no clear evidence of agricultural activities at Bökeberg III during the Late Mesolithic.

Indicators of seasonal activity. The distribution of various tool categories implies a structural organisation of the settlement. There are areas devoted to manufacturing, disposal, butchering cooking, dwelling, rituals, etc. This organisation was partly preserved during the total time of occupation (Karsten and Regnell, in preparation). This indicates a settlement with a permanent character rather than a repeated use of the site during short periods of the year. The latter would result in a much more irregular distribution of artefacts.

The hazelnuts found in the core and during the excavation of the refuse layer very rarely show signs of having been roasted for longer storage. This indicates that the nuts were presumably collected and consumed within the same season, i.e. in early autumn (September-October) and winter. The other plants that might have been collected for their seeds or fruits suggest activities from at least July-August [*Rubus idaeus* (raspberries)] to October-November [*Quercus* (oak), *Cornus sanguinea* (dogwood), *Prunus spinosa* (sloe) and *Sorbus aucuparia* (rowan)]. Finally, thatching may have taken place primarily when the fruits of *Cladium* were mature, i.e. in late summer (August-September).

The three 'elm declines'. As mentioned above, the *Ulmus* pollen curve shows three declines which are dated as follows: (1) ca. 6200 B.P. (5200-5100 cal. B.C.), (2) ca. 5450 B.P. (4340 cal. B.C.), (3) ca. 5150 B.P. (3980 cal. B.C.). Elm declines prior to the classical 'elm decline' of north-west Europe at ca. 5000 B.P. (Huntley and Birks 1983) have been discussed earlier with reference to different parts of central and north-western Europe (e.g. Heitz-Weniger 1976; Küster 1988; Ammann 1989; Ralska-Jasiewiczowa and van Geel 1992; Andersen and Rasmussen 1993). The closest site from which early elm declines have been described is Hassing Huse Mose in Denmark (Andersen and Rasmussen 1993). At this site, four elm declines were dated to ca. 5700, 5300, 5100 and 4700 B.P. The three first declines were then dated more precisely by radiocarbon wiggle dating to 4530 cal. B.C., 4130 cal. B.C., and 3870 cal. B.C. The age of elm decline 3 at Hassing Huse Mose corresponds with the dates of the classic and major elm decline of north-western Europe, and with the transition to the Funnel Beaker Culture. Elm decline 3 (ca. 3980 cal. B.C.) in Bökeberg may be compared with this event. Indicators of agriculture in the pollen data at Hassing Huse Mose are slight during elm declines 1 and 2. The authors propose that "outbreaks of elm disease provoked by stress from human activities may have occurred at elm declines 1, 2 and 3. Selective pursuance of elm woodland may have been due to the establishment of fields on particular sites or to the promotion of pig pannage" (Andersen and Rasmussen 1993, p. 134).

When the standard errors of the ^{14}C dates (non-calibrated) are taken into account (Table 1), the age of elm decline 2 in Bökeberg (ca. 4340 cal. B.C.) may be comparable with both elm declines 1 (4530 cal. B.C.) and 2 (4130 cal. B.C.) at Hassing Huse Mose. Elm decline 1 (ca. 6200 B.P., 5200-5100 cal. B.C.) is apparently older at Bökeberg than at the Danish site. At Bökeberg, there are no traces of agriculture at these elm decline events. Moreover, elm decline 1 is accompanied by a decline in the pollen percentage and concentration curves of many other trees (birch, pine, hazel, elm, oak, lime, as well as in pollen concentrations of alder). Unfortunately, neither the pollen percentage nor concentration curves provide absolute proof that these pollen decreases are related to comparable decreases in the frequency of these trees at that time. The general decrease in the percentage values may be due to high pollen concentration of *Alnus*, and the decline in concentration values may be a consequence of the sediment accumulation processes. The drift gyttja which is present in this part of the profile may have accumulated in a much shorter time than the coarse detritus gyttja above and below it, which would explain the lower pollen concentrations. However, it is obvious from the charcoal analyses (Fig. 13) that all the trees mentioned above were collected at that time, partly for burning but certainly also for construction and tools. Therefore, a slight decrease in the stands of these trees and some minor openings in the forest for these purposes cannot be excluded. Occasional pollen of *Artemisia* and Chenopodiaceae may indicate an increase in ruderal communities. There are no finds of cereal pollen other than two grains of Gramineae larger than 37μm at 37 cm, i.e. below elm decline 1.

Elm decline 2 at Bökeberg (ca. 5450 B.P.) is accompanied by a decrease in hazel. No settlement activities close to the lake are known for this time from the archaeological excavations. Neither the plant macrofossil nor the charcoal analyses provide any indicators of human activity close to the sampling site. Therefore, this elm decline, which does not seem to be an artefact, may well be due to an outbreak of elm disease (Andersen and Rasmussen 1993). However, the alternative explanation of a regional elm decline caused by human activities at sites other than Bökeberg cannot be ruled out. The first pollen records of *P. lanceolata* and a single Gramineae pollen larger than 37μm occur at 9 cm, just above elm decline 2, and one grain of *Avena*-type was identified at 7 cm. In the absence of any finds of cereal grains in the macrofossil and charcoal analyses, these pollen data cannot be regarded as definite indicators of agriculture at Bökeberg.

Elm decline 3 (ca. 5150 B.P., 3980 cal. B.C.) most probably corresponds to the major elm decline dated in Skåne to ca. 5100 B.P. (Gaillard et al. 1991; Regnéll 1992). It is synchronous with an increase in the percentage and concentration pollen representation of *Alnus*. In southern Skåne, the elm decline was accompanied by a decline of all tall canopy trees (except *Quercus*) so that *Betula* and *Corylus* were favoured on dry soils, and *Alnus* and *Salix* on wet soils (Berglund et al. 1991). It has been proposed that changes in the woodlands around 5100 B.P. were initiated by "a serious ecological disturbance of some kind - an "elm disease", a rapid climatic change, or both in combination - " (Berglund et al. 1991, p. 415). At Bökeberg, the palaeohydrological reconstruction does not indicate any drastic climate change at that time. Moreover, there was no intensive human activity locally. Therefore, like elm decline 2, elm decline 3 may be due to an outbreak of elm disease (Peglar 1993; Andersen and Rasmussen 1993) and/or to forest clearance at some distance from Bökeberg. The increase in *Artemisia* pollen representation and in microscopic charcoal particles speaks in favour of human interference at the regional scale.

The natural environment during the Ertebølle occupation phases at Bökeberg

Phase A, ca. 6650-6400 B.P. (ca. 5560-5320 cal. B.C.). The lake-level was low. Soil erosion was important (cf. *C. geophilum*) as a result of intensive human activities close to the shore. An extensive belt of *C. mariscus* and *S. lacustris/maritimus* formed the littoral zone. Behind it, alder marked the boundary between the high ground and the lake shore. On high ground, oak, lime, elm and hazel were growing with shrubs and herbs of the mixed deciduous forest. From the macrofossil and charcoal evidence, it appears that the people gathered hazel nuts, acorns, and mainly elm, oak, hazel and pine wood. In addition to alder, oak and hazel may have been the most common trees at that time.

Phase B, ca. 6150-5800 B.P. (ca. 5200-4680 cal. B.C.)

The lake-level was low. The lake shore was still occupied by a substantial belt of *C. mariscus* and *S. lacustris/maritimus*. However, it may have been less extensive than during phase A, while alder formed a wider belt around the lake. On high ground, elm, oak, lime, and hazel were common and ash was now present. Macrofossil analyses suggest that lime was growing very close to the sampling site, probably on the small hills close to the lake shore which were settled during that time. Oak, elm and hazel may have grown at some distance from the lake shore. People still gathered hazelnuts, but, apparently, acorns were no longer collected. A large variety of wood was collected from all types of woodlands around the site.

During both phases, advantage was taken of the low lake-levels which gave people the opportunity to settle on the slightly higher hills very close to the lake shore and at the boundary between the different vegetation types and biotopes, including the lake water, *C. mariscus* 'grasslands', alder carr and deciduous forests on high ground.

Possible use of plants

Trees and shrubs. Quercus acorns can be used as food, but they must first be soaked in water or roasted before being eaten in order to avoid the tannic acid that makes them very bitter and even toxic (Jacomet *et al.* 1989). In historical times, the leaves, cortex and acorns of oak were often used for tanning (Høeg 1974; Bröndegaard 1987). A comparison of the results from the pollen and macrofossil analyses (Fig. 14) clearly shows that acorns were purposefully gathered at Bökeberg. Acorns may have been used as food, at least during the oldest phase of the Ertebølle settlement (6650-6400 B.P.) and perhaps until 6200 B.P.

Macroremains of *Corylus avellana* are frequently found at Mesolithic sites in southern Scandinavia (Jessen 1935; Welinder 1971; Larsson 1983). It is presumed that the hazelnuts were roasted to preserve them longer (Larsson 1983). A comparison of the results from the pollen and macrofossil analyses indicates that hazelnuts were gathered at Bökeberg during both settlement phases A and B (Fig. 14). Hazelnuts are not very abundant in the analysed core and only one fragment was charred (Fig. 16) but in the total area of the refuse layer excavated so far, nearly six hundred hazelnuts have been documented. The majority of the nuts were cracked, and only a few were burnt. Because these finds are restricted to a particular time period, they cannot be explained by natural causes. It can be concluded with certainty that hazelnuts were consciously gathered at Bökeberg during both settlement phases. Hazelnuts were obviously used as food, but there is no firm indication that these were roasted for longer storage.

The wood of alder, elm, oak, lime, hazel, birch, and pine was collected for fuel, and probably for other purposes such as construction and tools, during settlement phase A. *Salix* sp., *Frangula alnus* and *Viburnum opulus* were also gathered, but probably only in small quantities. *Cornus sanguinea* was gathered for wood, too, at least for a short period. During phase B, the variety of species collected for wood is much larger. With the exception of *Betula*, *F. alnus* and *V. opulus*, all taxa collected during phase A were also collected during settlement phase B. In addition, lime and ivy were now commonly collected, at least during the early and middle part of the settlement phase (6150-6000 B.P.) and *Fraxinus*, *Populus* and Pomoideae species were possibly used for its wood during the middle and later part of phase B. The considerable quantities of macroscopic charcoal fragments from the first part of phase B suggests a high relative frequency of fire at the site, and consequently a comparatively more intensive collection of wood, in particular of hazel, alder, elm, oak, and lime. Ivy may have been collected non-intentionally together with oak or lime. Ash and pine were rarely collected. As in phase A, *C. sanguinea* (dogwood) wood was collected only during a brief period.

C. sanguinea grows naturally at the edge of woods and along brooks and shores. Its representation in the macrofossil assemblages is restricted to a short time period during the first part of phase A. However, this species certainly occurred in the woodlands around the site throughout the whole of the period studied. *C. sanguinea* has previously been found both in Mesolithic and Neolithic archaeological contexts in southern Scandinavia (Jørgensen and Fredskild 1978; Andersen et al. 1982; Grøn and Skaarup 1993; Göransson, in press) and there are numerous finds from the Swiss Neolithic pile dwellings (Heer 1865; Jacomet et al. 1989). Its stones are very rich in oil, and may have been used for both food and burning at Bökeberg.

Prunus spinosa (sloe) grows naturally on dry soils at the edge of woods or in clearings. At Bökeberg it was found in the older part of the settlement phase A. The ripe sloe berries can be eaten but are best after freezing and natural fermentation. In Switzerland, *P. spinosa* stones are not known from Early Neolithic contexts, but do occur in later Neolithic periods (Pfyner culture), and in particular during the Schnurkeramik culture (Jacomet et al. 1989). The rare finds at Bökeberg may indicate that *P. spinosa* was possibly gathered during the first part of settlement phase A. Sloe was probably rare during the Late Atlantic, since woodland edges and open land were still infrequent biotopes, but it may have been more common in the transition areas between different biotopes (lake-shores/woodlands on high ground), as at Bökeberg.

Sorbus aucuparia (rowan) is found during both settlement phases A and B, between these two phases, and also in the upper part of the stratigraphy (phase C). The findings are not restricted, therefore, to the periods when there was settlement on the hill at Bökeberg. Rowan usually grows on moderately moist soils and appreciates the light conditions found at the edge of woodlands. It may have occurred close to the lake shore throughout the whole of the period studied. Rowan has never been reported from cultural layers of Mesolithic age in Scandinavia. In historical times it has been reportedly used as a remedy for scorbutus (scurvy) and kidney stones. Fresh berries were also used to make cider and vinegar and dried for jam (Nyman 1868; Høeg 1974). In some regions they have been recognised as an important source of vitamin C (Oberdorfer 1990; Källman 1993). The fruits may be stored when they are cooked (Oberdorfer 1990). The possibility that rowan berries were collected for consumption at Bökeberg during settlement phases A and B cannot be excluded.

A piece of resin with distinct teeth imprints was found in the refuse layer (Fig. 17). A small sample of the resin was treated and analysed for pollen (400 pollen counted). The pollen spectrum obtained was dominated by *Pinus* (56%), followed by *Corylus* (18%) and *Quercus* (9%). The resin is obviously from *Pinus sylvestris*. Resin with chew marks is not rare in Mesolithic sites in which organic material is preserved (Larsson 1982). Chewing resin was common practice in northern Scandinavia in historical times (Vilkuna 1964; Eidlitz 1969). One can only speculate whether these 'chewing gums' were used just because of an enjoyable taste or whether chewing was needed to soften the resin before it was used for some other purpose, e.g. joining materials together.

Herbs from the lake shores. Fruits of *Cladium mariscus* are found in large numbers in both settlement phases A and B, but in greater quantity during phase A. In addition to fresh fruits, there were a relatively large number of carbonised achenes in phase A only (Fig 16). Natural fire in the littoral vegetation zone at that time may explain these finds. However, unless the stands of *C. mariscus* were monospecific, such an event should also result in accompanying plants such as *S. lacustris/maritimus*, *Carex* spp., etc., entering the fossil record of carbonised macroremains. However, these taxa were never found carbonised. Moreover, there are no finds of other carbonised parts of *C. mariscus*. It also seems improbable that fires of that kind would have occurred over such a long period of time. Therefore, we suggest that *C. mariscus* was used for thatching during phase A. The fruits would readily fall from the sedge-covered roof into the fire within the dwellings, and eventually be deposited with other waste in the refuse layer. It is well known that *C. mariscus* was very common during the early Holocene in southern Scandinavia (e.g. von Post 1925; Digerfeldt 1977). Its distribution decreased dramatically during the middle Holocene, probably because of unfavourable climatic and trophic conditions. At present, it occurs most abundantly on the Baltic islands of Öland and Gotland. In historical times, *C. mariscus* was commonly used for thatching and on Gotland it is still used today for thatching sheep huts.

Seeds of *Solanum dulcamara* (bittersweet) are found in the lower parts of each of the settlement phases A and B. Bittersweet has previously been recorded from cultural layers contemporary with the Bökeberg settlements (Jessen 1935; Larsson 1983). The ethnographical literature on this species describes a wide range of possible uses. Even though the plant is poisonous, bittersweet was used as a remedy for several illnesses such as hepatitis, rheumatic pain and intestinal parasites (Bröndegaard 1987). Gathering of *S. dulcamara* at Bökeberg during phases A and B cannot, therefore, be excluded. This species was probably relatively common in the alder woodlands and littoral vegetation along the lake shore.

Herbs from the vegetation on high ground. Urtica dioica (nettle), is a common ruderal plant and thrives around dwellings. It can also grow naturally along the lake

Fig. 17. Picture of a piece of pine resin with chewing marks found in the refuse layer at Bökeberg III. Scale in cm

shores in the alder vegetation belt. Fruits of *Urtica* have their strongest representation in zones BIM4a and BIM4b, i.e. during occupation phase B. In addition there are occasional specimens in the upper part of the sequence. Even though nettle is probably an indirect indicator of human settlement, it may have been gathered for food or for its fibres.

Rubus idaeus (raspberry), grows naturally in clearings and along the edge of woods. It can also grow close to lake shores, where the subsoil is moderately dry. Seeds of raspberry were found in the earliest part of phase A and discontinuously during phase B. The occurrence of this species may be due exclusively to the nutrient-rich soils around the settlements. Nevertheless, it is probable that raspberries were gathered for consumption during the Stone Age. There are, however, very few finds of raspberry reported from Mesolithic sites in Scandinavia (Jessen 1935; Göransson 1983).

Apium graveolens (wild celery) was recorded in phase C, at one level of the sequence investigated (Fig. 12). The fruit show similarities with those of *Apium inundatum*, but the rounded shape and total length (1.6 mm) enables it to be assigned to *A. graveolens* with confidence. Today, wild celery does not occur naturally in Skåne, but it can be rarely found along the coasts of the eastern Danish islands. Celery grows in sea-shore meadows, in salty ditches and in rich, moist, weedy fields in inland Europe (Oberdorfer 1990; Schoch et al. 1988). In southern Scandinavia and in north-western Europe, celery has been reported from several archaeological sites dating to the Iron Age and the Medieval period (Jensen 1985), but never from older sites. Celery must, therefore, be regarded as an exotic species at Bökeberg. The nearest place where celery might have grown naturally is along the coast of the Öresund strait (Fig. 1). If phase C is interpreted in terms of human activity, the find of *A. graveolens* implies a connection between the site and the coastal area, obviously via the Yddingesjön outlet. This conclusion, however, remains quite hypothetical since it is based on the find of a single fruit of celery and on the assumption that Bökeberg was effectively settled at that time (ca. 5300-5000 B.P., 4200-3800 cal. B.C.).

Conclusions

1. The research strategy chosen in this investigation, i.e. the combined biostratigraphical analyses of a lake sequence and refuse layers from settlements close to the lake shore, provides important information on the local environment during the periods of occupation at the site, and on the possible use of that environment by people. The combination of pollen, plant macrofossil and charcoal analyses proved to be very effective in interpreting the results and reconstructing the natural vegetation and human activities at the site and also in distinguishing natural processes from the effects of human activity.

2. The results of the pollen, macrofossil and charcoal analyses show that the local vegetation on high ground was characterised by a mixed deciduous forest throughout the whole of the period studied (ca. 6700 to 5000 B.P., 5600 to 3900 cal. B.C.). Hazel, oak and elm were the dominant trees until 6400 B.P. (5320 cal. B.C.) while lime became more abundant from that time onwards. Ash was established locally not earlier than 6400 B.P. and increased in abundance from 5900 B.P. (4780 cal. B.C.). The late establishment and expansion of ash may be due to periods of predominantly dry climate prior to 6400 B.P. and 5900 B.P.

3. The lake-shore vegetation at Bökeberg was characterised by a tree belt in which alder dominated from 6500 to 5000 B.P., and an extended littoral zone with *C. mariscus* and *S. lacustris/maritimus* from 6600 to 6400 B.P. After 6400 B.P., the *C. mariscus* and *Scirpus* belt was more restricted, whereas alder and birch were more common. From 5800 B.P., *C. mariscus* and *Scirpus* were very rare or were no longer present locally.

4. The biostratigraphic study at Bökeberg provides good evidence for a period of low lake level between 6700-5800 B.P. (5600-4680 cal. B.C.), which was interrupted by a short period of higher lake level between ca. 6500-6250 B.P. These records for low lake-levels may be compared with the second major episode of low lake-levels in south Sweden between 6700 and 5500 B.P. (Digerfeldt 1988; Gaillard and Digerfeldt 1991; Harrison and Digerfeldt 1993) and can be ascribed to a time of substantially drier conditions.

5. The biostratigraphical data point to repeated use of the site during the period ca. 6650-5800 B.P. (ca. 5550-4700 cal. B.C.) or a maximum of 850 calendar years. There is some evidence of two separate occupation phases, i.e. phase A between 6650-6400 B.P. (5560-5320 cal. B.C.) and phase B between 6150-5800 B.P. (5200-4280 cal. B.C.). On the basis of the biostratigraphical evidence, it is uncertain if Bökeberg III was occupied during two separate phases of ca. 250 and 500 calendar years, respectively, or during a single period of 850 calendar years. The phases A and B are synchronous with periods of low lake levels which were separated by a period with high water level. It is not clear whether the site was settled during the latter period. However, the ^{14}C dates from the occupation area and the archaeological data point to two separate settlement phases. The site may also have been used during the period 5300-5000 B.P. (4200-3900 cal. B.C.), but much less intensively or more episodically. So far, the archaeological material from Bökeberg III and the ^{14}C dates from the settlement area do not provide any evidence of occupation during that later period.

6. Three elm declines are described from the Bökeberg pollen diagram: (1) ca. 6200 B.P. (5200-5100 cal. B.C.), (2) ca. 5450 B.P. (4340 cal. B.C.), and (3) ca. 5150 B.P. (3980 cal. B.C.). The first elm decline falls at the beginning of the first phase of human activity at Bökeberg and may be the result of clearings and collecting of wood for fuel, construction and tools. However, this elm decline may also be an artefact connected with the littoral position of the coring site. The second elm decline may be explained by an outbreak of elm disease, as was also proposed by Andersen and Rasmussen (1993) for early elm declines at Hassing Huse Mose in Denmark dated to 4530 and 4130 cal. B.C. The third elm decline at Bökeberg obviously corresponds to the classical north-west European elm decline and to decline 3 at Hassing

Huse Mose (Andersen and Rasmussen 1993). At Bökeberg, this decline is not accompanied by any intensive human activity at the site nor by any drastic regional climatic change. It too may primarily be due to an outbreak of elm disease, as was recently most convincingly demonstrated by Peglar (1993) for the elm decline at Diss Mere in England.

7. During the stage of the Late Mesolithic represented at Bökeberg, there is no positive evidence of agriculture or animal husbandry in southern Scandinavia. However, the archaeological data from several sites in Skåne and from Bökeberg III clearly show that contacts did exist between Skåne and the continent, where farming had already been introduced.

8. Acorns may have been used as food during phase A. Hazelnuts were gathered during both settlement phases A and B, and were obviously used as food. However, there is no firm indication that they were roasted to facilitate long-term storage. *Cornus sanguinea* stones (phases A and B) may have been collected for oil and food. Berries of *Prunus spinosa* (phase A), *Sorbus aucuparia* and *Rubus idaeus* (phases A and B) were possibly also gathered for food. The chewed resin from pine could have been used as chewing gum or for joining materials together. It is suggested that *Cladium mariscus* was used for thatching during phase A. *Solanum dulcamara* seeds (phases A and B) may have been used as a medicine, and fruits of *Urtica dioica* for consumption and as a source of fibres. Elm, oak, hazel, birch and pine wood was used as fuel or for constructions and tools during phase A. A large variety of taxa, including lime, ash, aspen, dogwood and Pomoideae, from the various types of woodland around the site was used as a source of wood during phase B.

9. The present investigation clearly demonstrates that peoples of the Ertebølle culture chose settlement sites at the border between different biotopes in order to maximise their access to a wide range of resources. Both along the sea coast (as at Skateholm) and inland, the settlements are situated at the boundary between high-ground and a wetter environment, generally close to water (an inland lake or a lagoon at the coast). This is in agreement with the models generally proposed to explain the strategies behind the special distribution of Late Mesolithic settlements. Our data also show that the inland settlement of Bökeberg was obviously used throughout the summer, until September-October at least (cf. hazelnuts) and perhaps during the early winter. The faunal data (e.g. deer antlers) do not contradict these conclusions. The few seasonal indicators in our study, confirm, to a certain extent, the frequently used model of a differentiated use of coastal and inland resources, in which inland sites would have been used essentially during the warmer part of the year (Rowley-Conwy 1983; Larsson 1983, 1991).

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