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

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INTRODUCTION

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

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

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

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

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

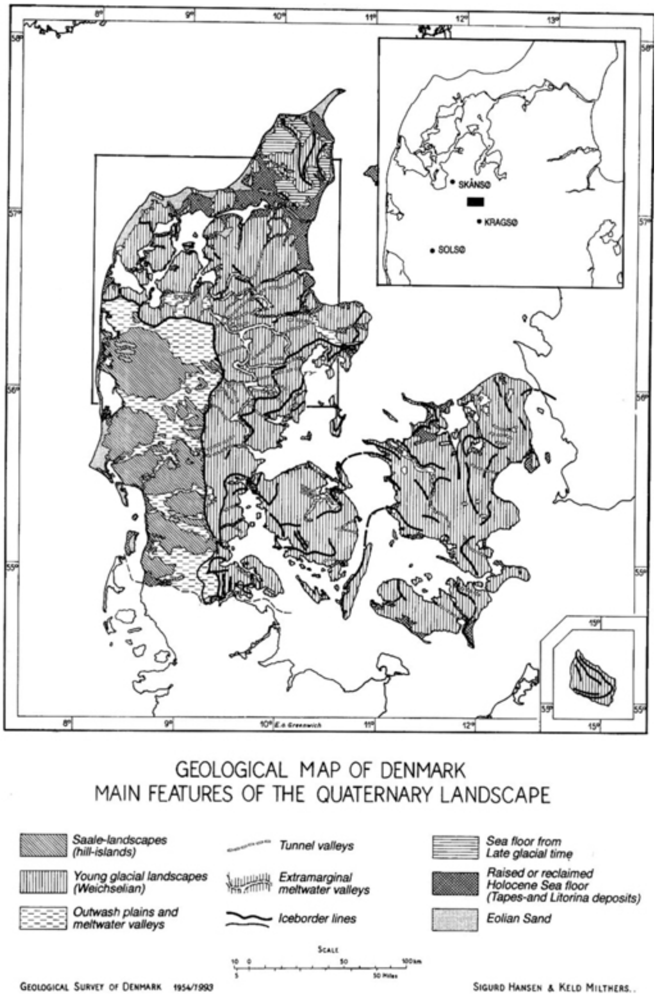

Fig. 1 The main surface deposits of Denmark. The insert map shows the investigation area at Vroue (black square) and three lake sites investigated by Odgaard (1994).

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

GEOLOGY OF THE VROUE AREA

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

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

SECTIONS IN THE BARROWS

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

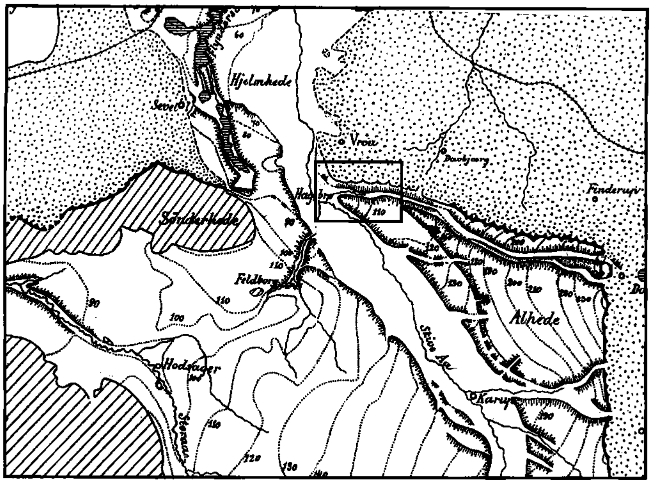

Fig. 2 Detail of N.V. Ussing's geomorpholocical map of West Jutland (Ussing 1903) showing the Weichselian glacial landscape (dotted), heath plains and meltwater terraces along the Karup valley (areas with height curves, in feet), and the Karup River (Skive Aa) valley (white). The investigation area south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

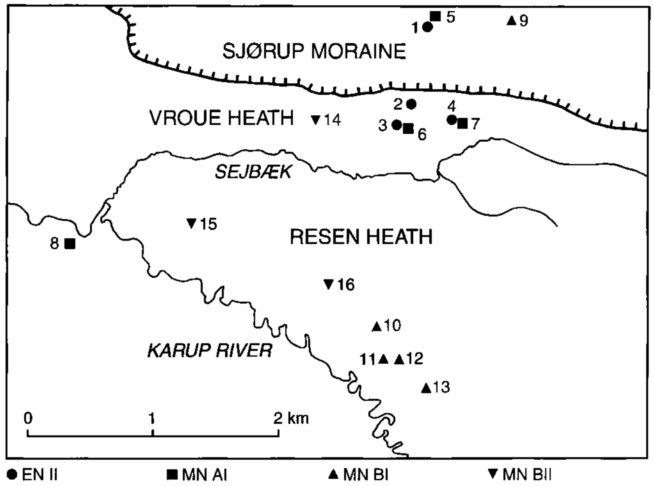

Fig. 3 The investigated Neolithic barrows on the Sjørup Moraine, and on Vroue and Resen Heaths. Early Neolithic barrows (EN II): 1, Sjørup 1a; 2, Vroue Heath 8; 3, Vroue Heath 4a; 4, Vroue Heath 1b. Early Middle Neolithic barrows (MN AI): 5, Sjørup 1b; 6, Vroue Heath 4b; 7, Vroue Heath 1a; 8, Hagebrogård.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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Summary of the barrow profiles

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

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

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

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

POLLEN ANALYSES FROM THE BARROW SECTIONS

Pollen analysis

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

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

Pollen deposition on the soil surface

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

Pollen burial in soils

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

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

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

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

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

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

Pollen deterioration

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

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

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

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

Pollen representation in soil samples in relation to area coverage

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

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

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

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

Anthropogenic influence on the vegetation

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

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

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

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

Deformed pollen. Evidence of burning

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

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

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

POLLEN DIAGRAMS FROM BARROWS

The pollen diagrams

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

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

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

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

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

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

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

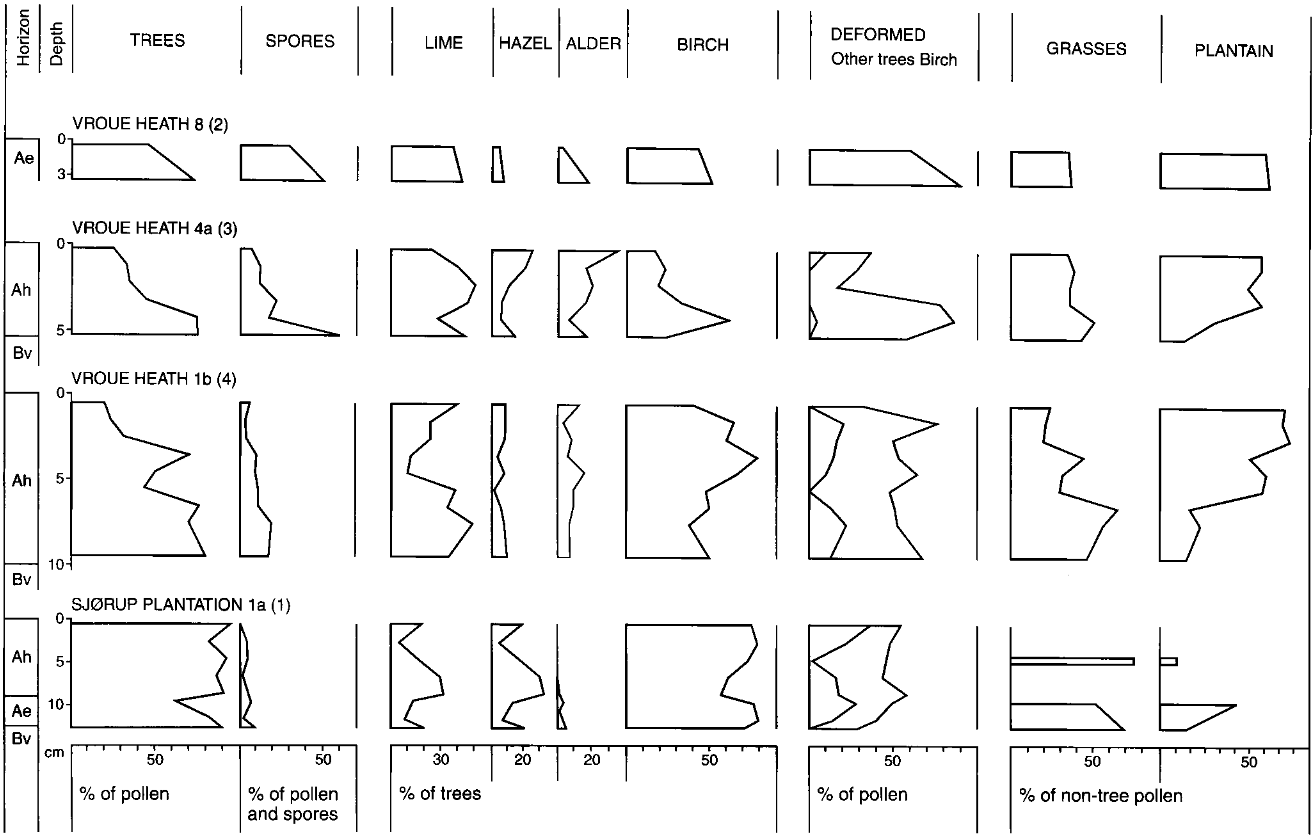

Fig. 4 Pollen diagrams from soils underneath the four late Early Neolithic barrows (EN II). The figures in brackets refer to the map in Fig. 3.

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

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

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

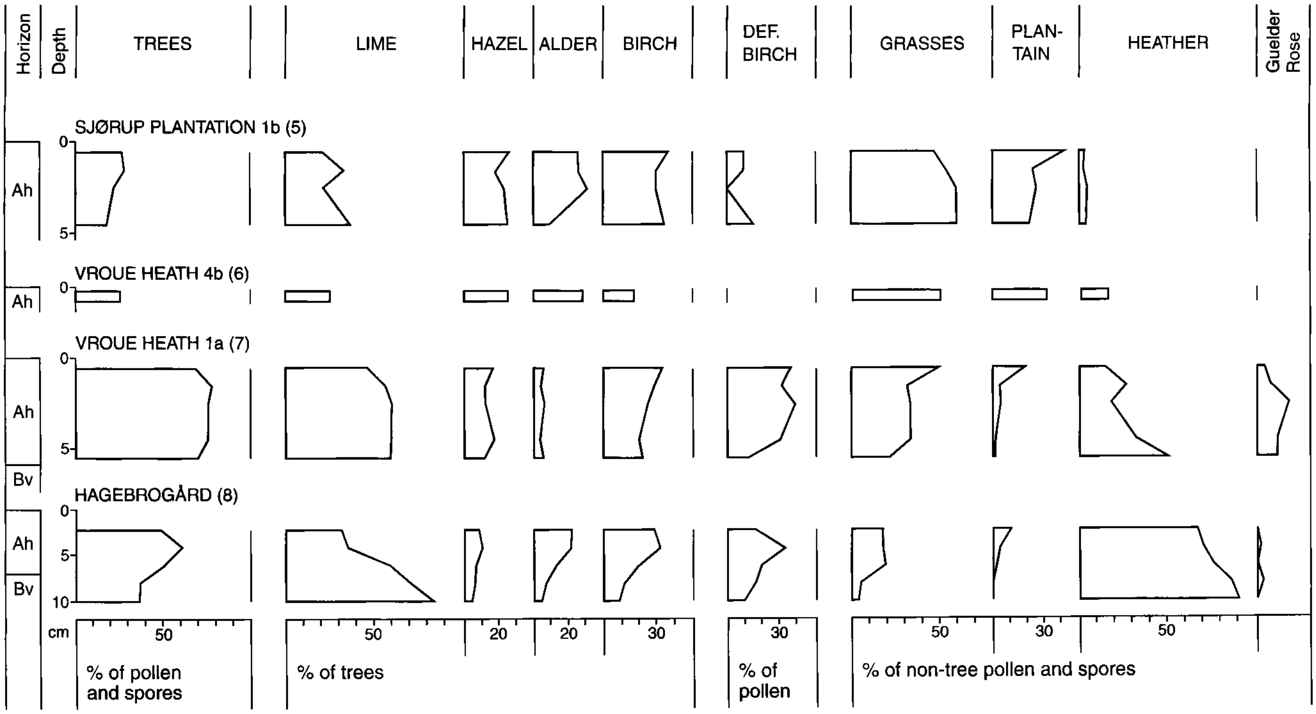

Fig. 5 Pollen diagrams from soils underneath four early Middle Neolithic barrows (MN AI).

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

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

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

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

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

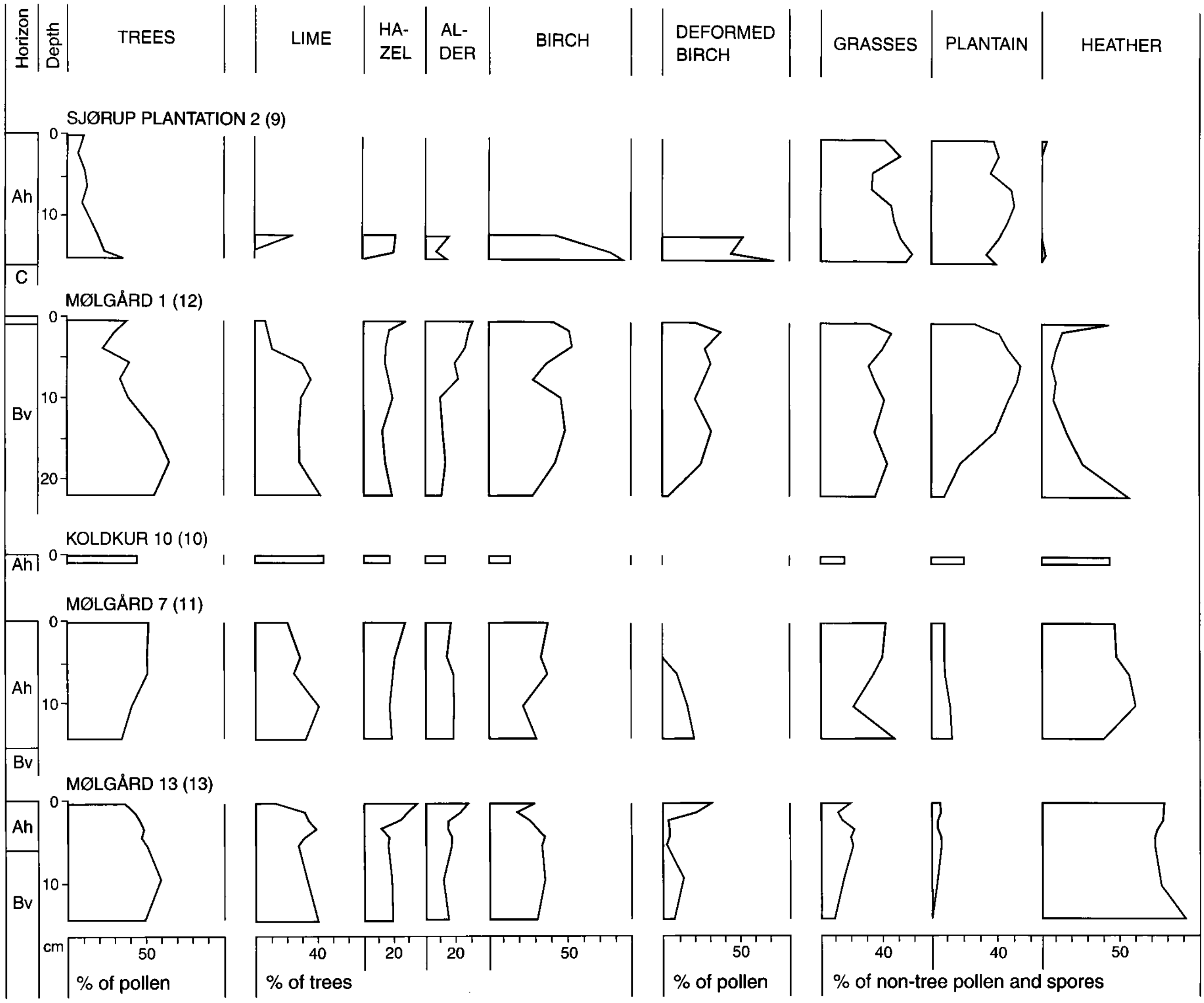

Fig. 6 Pollen diagrams from soils underneath five Single Grave barrows with undergraves (MN BI).

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

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

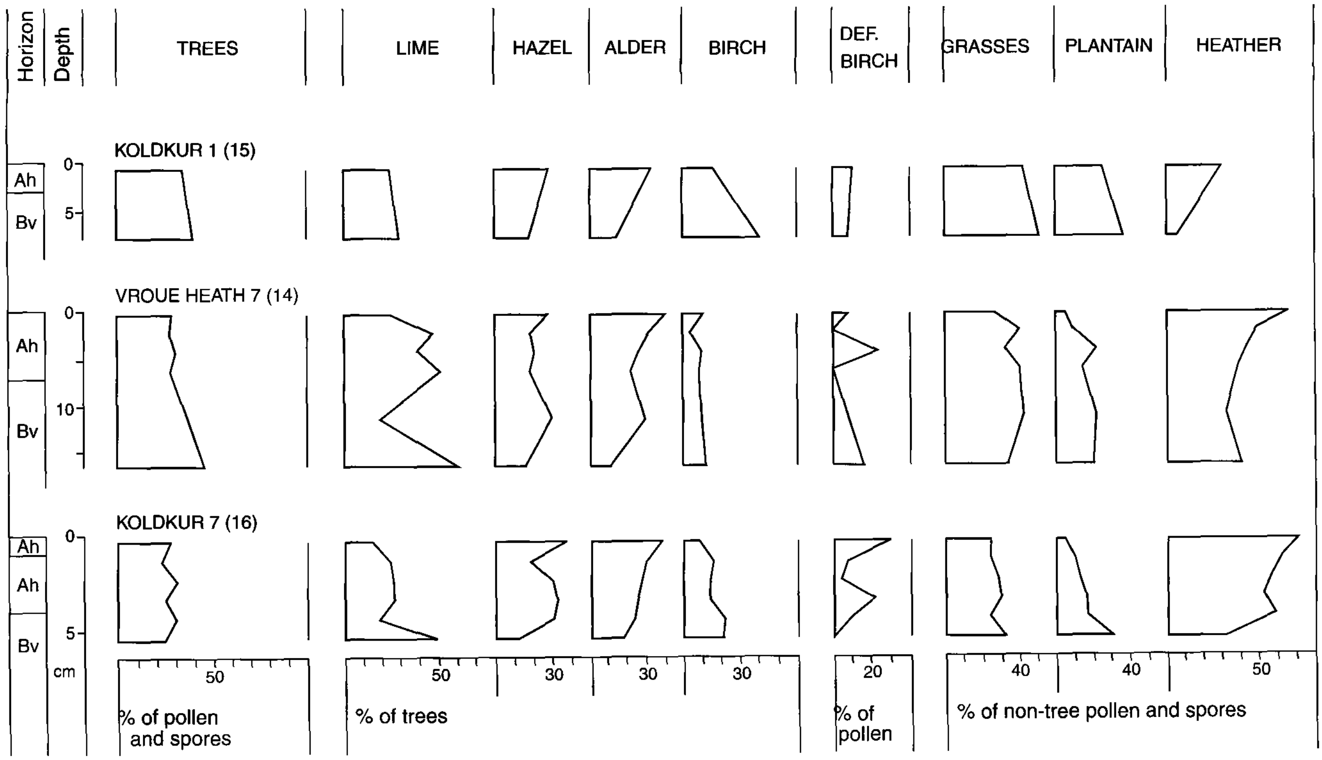

Fig. 7 Pollen diagrams from soils underneath three Single Grave Culture barrows with ground graves (MN B II).

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

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

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

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

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

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

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

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

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

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

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

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

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

Early Neolithic II

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

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

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

Vegetation around the Early Neolithic barrows on Vroue Heath was exploited by burning and grazing at the time of the establishment of the graves. Even the earliest woodland present at Vroue Heath 1b bears evidence of human disturbance. Woodland on sandy till at Sjørup Plantation 1a had been strongly altered by human disturbance and a short pasture phase. Three barrows were built in a late phase of the Early Neolithic (EN II). The dating of the Vroue Heath 8 barrow is somewhat uncertain. The pollen diagram from this site indicates that it was contemporaneous with the other barrows. The evidence from the soils beneath the barrows points to dense human settlement and exploitation already in the Early Neolithic.

Middle Neolithic AI

The pollen diagrams from the *Hagebrogård* and *Vroue Heath 1a* sites indicate at first lime-dominated woodland and patches of heath. The tree populations were altered by felling of lime and spreading of birch. The birch trees were felled and burned, and vegetation of grasses with traces of grazing expanded at the cost of heather. The felling of lime and burning of birch trees thus appear to have been done with the purpose to create areas for pasture. A similar course of events probably took place at the *Vroue Heath 4b* site. Trees were scarce and plantain was frequent.

The passage graves on Vroue Heath were built near Early Neolithic barrows (Vroue 4a and 8, Fig. 3). Nevertheless, these passage graves were built at sites with traces of heath. It appears that the sites with heath vegetation were avoided at the Early Neolithic occupation, and that these sites were then exploited in the Middle Neolithic, just before the passage graves were constructed.

The Middle Neolithic barrow in the *Sjørup Plantation (1b)* was built very near the Early Neolithic barrow (1a). The trees had been removed. The area was used for pasture, and there was no heath.

Areas on the heath plain with lime forest and heath patches were thus occupied and exploited for grazing during the early Middle Neolithic, whereas formerly occupied areas on the Sjørup Moraine were continuously used for pasture.

Guelder rose was frequent in the lime woodland at Hagebrogård and Vroue Heath 1a (Fig. 5). Other non-tree pollen types are scarcely represented.

Site	% pollen	% of trees				% of non-tree pollen		
	Trees	Lime	Hazel	Alder	Birch	Grasses	Plantain	Heather
Hagebrogård	34	85	4	4	7	3	+	90
Vroue Heath 1a	70	59	12	5	23	22	2	51
Mølgård 13	44	39	17	13	31	9	-	89
Vojens	67	43	24	19	6	13	1	78
Harreskov	60	29	17	14	36	25	2	63
Skarrild	77	10	-	42	36	61	-	-

Table 2 Pollen spectra with original vegetation in soils underneath Middle Neolithic A and Middle Neolithic B barrows in West Jutland.

Middle Neolithic BI

Scattered tree vegetation occurred at the barrows on the southern part of Resen Heath (*Mølgård 13, Mølgård 7, Koldkur 10, Mølgård 1*). Trees were cleared away some time before the erection of the barrows at Mølgård 13 and Mølgård 1. The tree populations were originally rich in lime. Birch was favoured at the cost of lime. Heath was widespread at these sites. There are indications that birch trees were burned and that patches of grassland were used for grazing. This procedure is very similar to that used by the early Middle Neolithic people in areas with heath vegetation. The promotion of grazing areas was most successful at the Mølgård 1 site with slightly clayey soil, and least successful at Mølgård 13, where only small patches of grassland appeared. Increased heather percentages near the top of the soils under the barrows at Mølgård 1 and 13 indicate that pasture was reduced or abandoned a short time before the construction of the graves.

The four barrows on Resen Heath derive from the younger Undergrave Period. The conversion of heath to pastureland can, therefore be linked with occupation of areas that were unoccupied at the onset of the Single Grave Period.

The barrow on the Sjørup Moraine (*Sjørup Plantation 2*) dates from the older Undergrave Period, and, therefore, from the first phase of the Single Grave Culture. Trees were nearly absent at the Sjørup Plantation 1b barrow and this area was grazed intensively in the early Middle Neolithic Period. Clearance and burning of birch trees at the Sjørup 2 site may belong to the Funnel Beaker Culture, and it is indicated that the barrow was built in an area that was strongly exploited for pasture.

Non-tree plants other than grasses, plantain and heather are few in number and scarce. Pollen of barley-type and a few bare-soil plants (sheep's sorrel, knotgrass, perennial knawel, and the chenopod family) occurred at the Mølgård 2, Koldkur 10 and Mølgård 1 barrows, indicating weak traces of agriculture. A pollen grain of *Fagopyrum tataricum* L. was found at Mølgård 1. This plant probably was introduced as a weed.

Middle Neolithic BII

Trees were scarce at the sites of the three barrows with ground graves on Resen Heath and Vroue Heath (*Koldkur 1* and *7*, *Vroue Heath 7*). Lime trees still occurred, and birch was very scarce at Koldkur 7 and Vroue Heath 7 and more common at Koldkur 1. Grassland with heath patches at Koldkur 7 and Vroue 7 had been used for pasture, and heath was scarce at Koldkur 1. The commonness of plantain reflects the slightly clayey soils at the three sites. Grazing was abandoned and heath expanded on the barrow sites some time before the barrows were built.

A few finds of pollen of barley-type and bare-soil plants (sheep's sorrel, perennial knawel and chenopods) are week traces of agriculture. One pollen grain of common buckwheat (*Fagopyrum esculentum*) was found at Koldkur 7. This plant was probably introduced as a weed. Other herbaceous plants were scarce and occurred with low pollen frequencies.

Natural vegetation in the Vroue area

Pollen studies from lakes demonstrate that the heath areas of northern West Jutland were covered by open woodland up to the times of land clearance by humans (Odgaard 1994). One of the sites, Kragsø, is situated on the southern part of the Karup heath plain (Fig. 1). The natural woodlands in this region consisted of lime, birch, hazel, oak and alder. Grassland and heath vegetation were widespread. The grasses had the lowest (2,6 %) and heather the highest frequencies (8,6 %) at Kragsø , the site with the poorest soil. Heather was promoted by fires, which Odgaard (1992; 1994) considered most likely to have been natural. A pollen diagram from a soil beneath a barrow from the Ground Grave Period (Harreskov) indicated initially natural woodland of mainly lime, birch and hazel on freely-drained meltwater sand (Odgaard & Rostholm 1987). Grasses and heather were widespread at this site. Another pollen diagram from a site on moist eolian sand (Skarrild) indicated dominant alder and birch with frequent grasses and no heather (Odgaard & Rostholm 1987; Odgaard 1990).

Natural vegetation is scarcely represented in the pollen diagrams from the Early Neolithic barrows on the Sjørup Moraine and on Vroue Heath. There are traces of human disturbance already in the earliest pollen spectra. These areas probably supported woodlands of lime, birch, hazel and alder. A few pollen diagrams from sites occupied in early Middle Neolithic time and by the Single Grave Culture indicate undisturbed vegetation at the lowermost levels. Pollen spectra from these sites are compared with pollen spectra from the Harreskov and Skarrild sites mentioned above (from Odgaard & Rostholm 1987; Odgaard 1990) and a pollen spectrum from a bottom grave near Vojens (from Jørgensen 1965) in Table 2.

The pollen spectra in Table 2 indicate more or less open tree communities with frequent heather and some grasses in the non-tree vegetation. Ribwort plantain was scarce or absent. They support the conclusion of Odgaard and Rostholm (1987) that lime, birch, hazel, alder, heather and grasses characterized undisturbed vegetation on dry ground, in contrast to moist-ground vegetation (Skarrild), that was characterized by alder, birch and grasses. Other trees such as oak, elm, ash and pine were scarce. In view of the conclusions of Odgaard (1992; 1994) about the fire-dependence of heather, the occurrence of heath vegetation on dry ground was probably due to former natural fires.

Anthropogenic vegetational changes

The woodlands found in the Early Neolithic Period on the Sjørup Moraine and on Vroue Heath were changed into secondary coppice woods rich in birch. These coppice woods were exploited for pasture in a swidden rotation system.

Sites with woodland and heath at Hagebrogård and on Vroue Heath were exploited in the early Middle Neolithic by felling of lime trees in favour of birch. The secondary birch populations were then felled and burned to be replaced by pasture vegetation. On the Sjørup Moraine, trees were scarce. The area was used for pasture and the swidden rotation system had been abandoned.

Sites with woodland and heath on Resen heath were occupied in the Undergrave Period of the Single Grave Culture. Birch populations were favoured and were replaced by pasture after felling and burning. It is indicated that grazing was abandoned just before the building of some of the barrows. Grazing had been continuous for some time before the barrow on the Sjørup Moraine was built. This barrow represents the earliest Single Grave Culture and was built in an area, that had been occupied in early Middle Neolithic time.

The barrows from the Ground Grave Period on Resen Heath and Vroue Heath were built on sites where trees were scarce. Heath occurred at one of the barrows on Resen Heath and on Vroue Heath. The sites had been used for pasture for some time, but the grazing was abandoned and heath expanded before the construction of the barrows.

LANDSCAPE AND LAND-USE AT THE TIME OF THE EARLY AND MIDDLE NEOLITHIC AND SINGLE GRAVE BARROWS

The pollen diagrams from the soils beneath the barrows in the Vroue area indicate modifications of the vegetation at the barrow sites prior to the building of the barrows. Vegetation at the barrow sites and in the area around the barrows at the time of construction of the barrows is reflected in the topmost soil pollen spectra and in pollen spectra from soil horizons enclosed in the fill material. Vegetational diversity indicated by these pollen spectra are illustrated in triangular diagrams on Figs. 8-9.

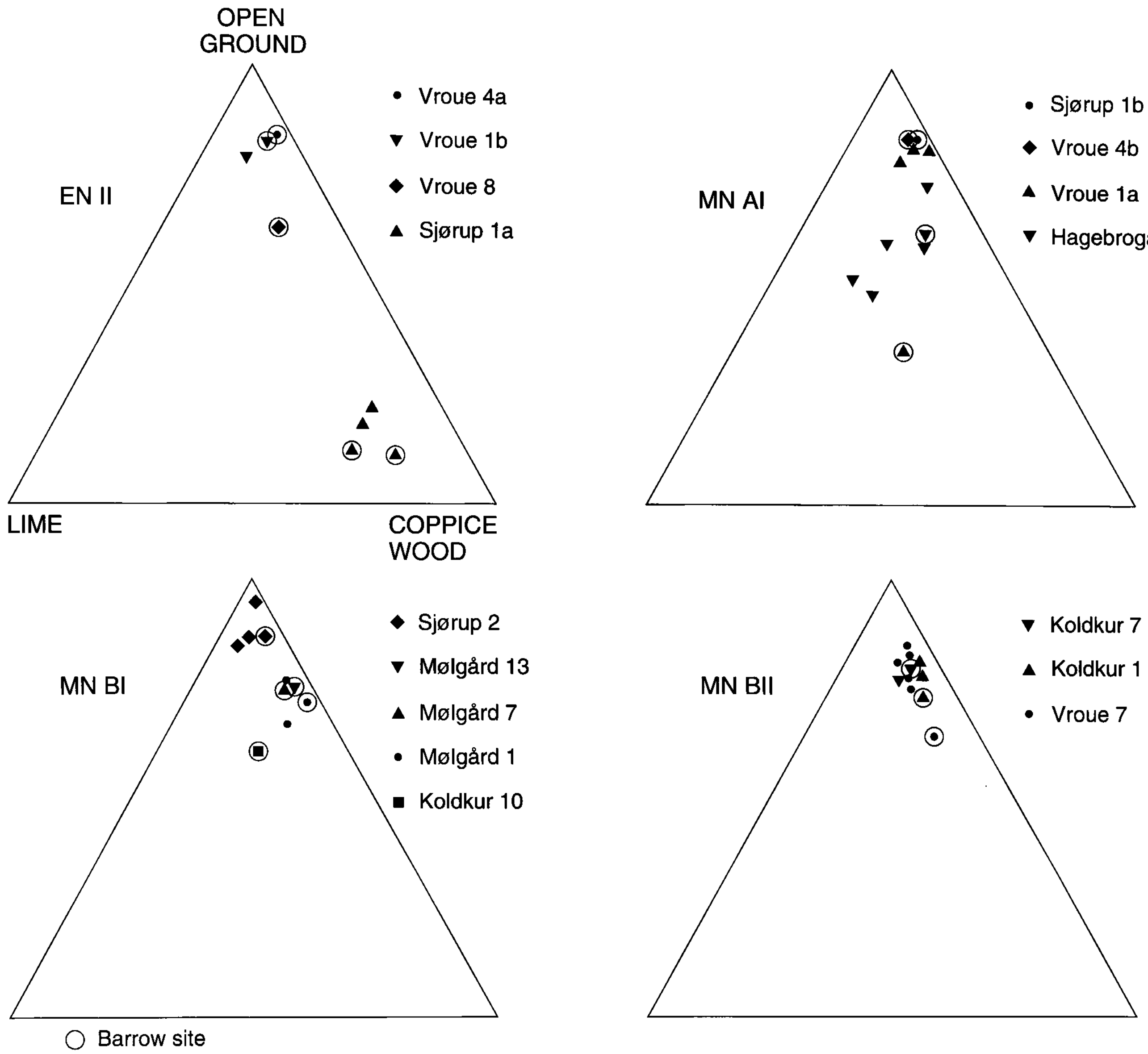

Fig. 8 Landscape diversity illustrated by pollen spectra from the topmost soil at the barrow sites (encircled) and from topsoil enclosed in the fill material, at barrows from the Early Neolithic (EN II), the early Middle Neolithic (MN AI), and from Single Grave barrows with undergraves (MN BI) and with ground graves (MN BII). The dots indicate pollen frequencies for lime trees (100% at the lower left-hand corner), for coppice trees (hazel, birch and alder, 100% at the right-hand corner), and for open ground (non-tree pollen, 100% at the uppermost corner).

Landscape variation

Lime was originally frequent within the woodland vegetation. High frequencies for birch, hazel and alder reflect secondary woodlands or coppice woods, and the frequencies for non-tree pollen reflect the extension of open areas. Landscape variation is therefore illustrated in triangular diagrams, where pollen spectra with high percentages for lime are indicated at the lower left-hand corner, high frequencies for coppice trees at the lower right hand corner, and high

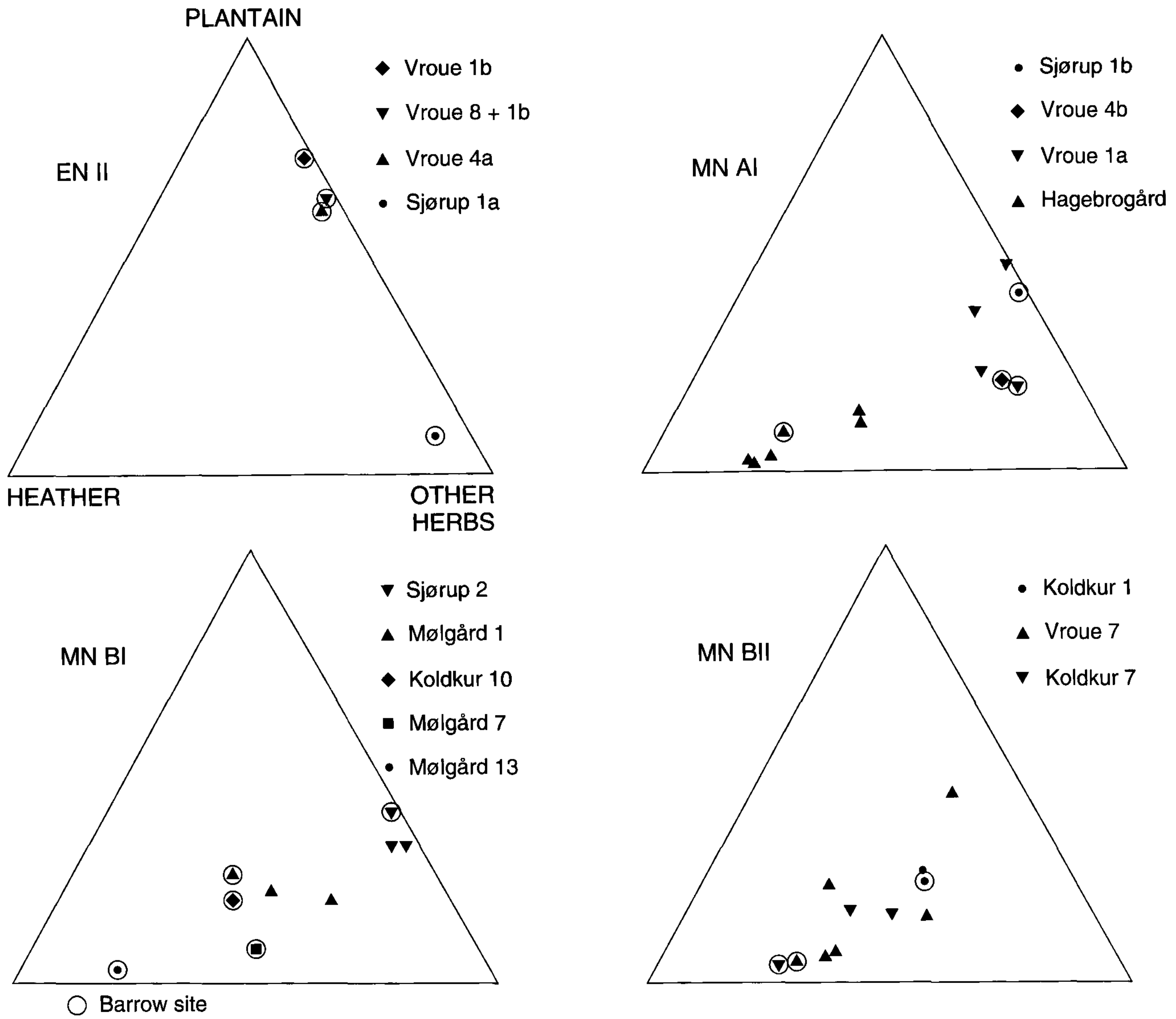

Fig. 9 Land-use illustrated by non-tree pollen spectra from the soil samples (see Fig. 8). The dots indicate pollen frequencies for heather (100% at the lower left-hand corner), for ribwort plantain (100% at the upper corner), and for other herbs (100% at the lower right-hand corner).

frequencies for non-tree plants at the upper corner. (Fig. 8).

The pollen spectra from the Early Neolithic barrows in the Vroue area are distributed along the right-hand side of the triangle. Coppice woods on the Sjørup Moraine are represented at the lower right-hand corner, and predominance of open areas on Vroue Heath is indicated by the dots in the uppermost corner. The tree vegetation had been strongly modified, and landscape exploitation varied widely.

Sites with relic lime-dominated woodlands at Vroue Heath 1a and at Hagebrogård are indicated by dots in the central part of the triangle for the early Middle Neolithic. There were areas poor in trees around these barrows. Trees were very scarce at the Vroue Heath 4b and Sjørup 1b sites. Landscape di-

	Vroue Heath 1a		Hagebrogård		Koldkur 7		Vroue 7	
	Depth cm	Plantain %	Depth cm	Plantain %	Depth cm	Plantain %	Depth cm	Plantain %
Fill			84	12,8			68	15,2
			94	10,9			110	23,2
	81	22,0	100	2,1			136	44,4
	99	46,0	104	3,4	35	17,0	162	7,3
	109	35,5	106	0,9	44	15,9	237	6,2
Soil	125	18,7	108	9,2	50	4,2	273	4,8

Table 3 Percentages frequencies for ribwort plantain in topsoil samples enclosed in fill material and in the topmost samples from the soils underneath the barrows. Increased plantain frequencies in the fill are indicated.

versity was, therefore high at and around the barrows from the early Middle Neolithic.

Tree vegetation was scarce at the time when the barrows with undergraves were built. Scattered populations of coppice trees occurred on Resen Heath. Lime was frequent at Koldkur10. Trees were very scarce on the Sjørup Moraine.

The diversity of the landscape was still more reduced at the time of the ground grave barrows. Vegetation poor in trees predominated on Resen Heath and Vroue Heath in response to increased exploitation. Trees were scarcer around the Vroue 7 barrow than at the barrow-site.

Land-use

The pollen diagrams from the soil sections indicate three main components in the non-tree vegetation, heather, ribwort plantain, and other herbs, mainly grasses. Heather was dominant in heath areas. Grass vegetation was promoted by felling and burning of trees, and plantain increased at the cost of the grasses at grazing. Variations in the composition of the non-tree vegetation at the time of mound building are illustrated in the triangular diagrams in Fig. 9. Pollen spectra with high frequencies for heather occur in the lower left-hand corner, high frequencies for plantain in the upper corner, and high frequencies for other herbs in the lower right-hand corner.

Heath was scarce in the pollen spectra from the late Early Neolithic (EN II). Plantain is low in a sample from birch woodland on the Sjørup Moraine, and is very high (60-75 %) in samples from barrows on Vroue Heath. The birch woodland on the Sjørup Moraine was unexploited, and grassland vegetation on Vroue Heath was grazed intensively.

Heather was dominant at and around the Hagebrogård barrow from the early Middle Neolithic (MN AI). Sites with heath and small areas with pasture occurred around the barrow. Heather was scarcer or absent at the barrows on Vroue Heath and on the Sjørup Moraine, and grazing was prominent. At Vroue 1a, grazing was more intensive around the barrow than at the mound. It is indicated that pasture was promoted with varying success probably dependant on differences in soil quality.

Heath occurred at one of the barrows with undergraves (MN BI) (Mølgård 13). Heath and patches of grazed grassland occurred at the other barrows on Resen Heath, and pasture dominated at the barrow on the Sjørup Moraine.

Two barrows with groundgraves (MN B II) were built in heath (Koldkur 7 and Vroue 7). Heath and patches of grazed grassland occurred in the vicinity of these barrows and at the Koldkur 1 barrow.

The land-use pattern in the Early Neolithic differed substantially from those of the early Middle Neolithic and the Single Grave Period. Sites with heath were avoided in the EN II. The land-use patterns from the MN AI, the MN BI and the MN BII are very similar. Areas with heath were used more or less intensively for grazing, and the best pasture was obtained at sites on the Sjørup Moraine. Hence, there were small-scale variations in the grazing activity.

Interestingly, there are indications that the barrows often were built at sites with less intensive land-use than around them. Trees were more common at the passage graves Hagebrogård and Vroue Heath

1a than in the area where the fill material was fetched. The plantain frequencies are higher around the barrow at Vroue Heath 1a, than at the barrow site, and these frequencies increase upwards in the fill at Hagebrogård, indicating that the uppermost fill was fetched in areas with pasture at increased distances (Table 3). Pasture had been abandoned or was reduced at barrows from the Single Grave Culture (Mølgård 1, Mølgård 13, Koldkur 7, Vroue Heath 7, Koldkur 1), and there are indications of continued grazing at increasing distance from the barrow sites at Koldkur 7 and Vroue 7 (Table 3). Hence, sites where grazing had been abandoned were selected, and the best pastures were avoided.

There are a few traces of arable farming from the Single Grave barrows in the Vroue area. The main agricultural economy was based on pastoral farming and the raising of husbandry. Pastoral farming was favoured by the burning of tree vegetation and at the cost of heath, but areas with heath were probably used for winter grazing. Grassland with grazing was scarce at the two ground grave barrows at Harreskov and Skarrild investigated by Odgaard and Rostholm (1989) and Odgaard (1990). Heath was favoured at these sites by burning of vegetation with the purpose to promote winter grazing. The soils at these sites were probably poorer than most of the soils in the Vroue area.

There are no finds of husbandry-bones from the Neolithic in West Jutland, and it is impossible to decide whether cattle or sheep was reared. Sheep may have been common in the heath areas, as they are less selective in their grazing habits than cattle (Buttenschøn 1995).

SOIL CONDITIONS AT THE TIME OF THE BARROWS IN THE VROUE AREA

The soil profiles have indicated that most of the soils found underneath the barrows in the Vroue area were oligotrophic brown earths (Ah-Bv-C profiles). Soils without a Bv-horizon occurred in a few cases, and podzols were seen at two barrows, both from the Early Neolithic.

Heath areas were present at barrows from the early Middle Neolithic and the Single Grave Period. A raw humus layer (Ao-horizon) had not developed at these sites, and there were no podzols. Hence, there are no traces of pronounced soil degradation. Sarauw (1898) found traces of podzols at 8 barrows from the Single Grave period. These barrows were situated just inside the Weichselian glaciation border or on Saalian tills just west of this limit. Odgaard and Rostholm (1989) also noticed a podzol underneath a Single Grave barrow on Saalian till. Hence, podzols underneath Neolithic barrows have been noticed outside the Vroue area.

REGIONAL VEGETATIONAL CHANGES IN NORTHWEST JUTLAND

Odgaard (1994) published pollen diagrams from three lakes, Kragsø on the southern part of the Karup heath plain 13 km south of the Vroue area, Skaansø on a late Weichselian heath plain 18 km northwest of Vroue, and Solsø on Saalian till 40 km to the southwest (Fig. 1). These pollen diagrams probably reflect vegetation within 5-10 km distance, contrasting the very local pollen spectra from the barrow soils.

The Early Neolithic activities in the Vroue area are reflected by low peaks for birch pollen at Solsø and Skaansø. The grasses increase slightly and ribwort plantain pollen is present with low frequencies at the lakes. Birch woodlands and pastures such as those occurring at Vroue are, therefore, weakly reflected regionally.

Utilization of heathland for pasture at Vroue during the early Middle Neolithic and the Single Grave Period is reflected by slightly increased frequencies for grasses and plantain in the three lake pollen diagrams. The percentages for heather pollen are rather low at Kragsø and Skaansø. The heather curve increases strongly at Solsø during the Single Grave Period. Odgaard and Rostholm (1989) and Odgaard (1994) surmised that heath was promoted and maintained by artificial burning in order to provide winter grazing. There are no indications of heath expansion in the Vroue area. The heath present there at the time of human settlement probably provided sufficient winter grazing.

Agricultural activities as those in the Vroue area can be traced in a wide region but their effect on vegetation was weak probably because of low population density. More widespread agricultural activity is recorded at Solsø during the Single Grave Period.

POLLEN ANALYSES FROM NEOLITHIC BARROWS IN NORTH AND EAST DENMARK, NORTH GERMANY AND THE NETHERLANDS

North and East Denmark

Lime woodlands were present at Early Neolithic barrows inside the Weichselian glaciation limit (Andersen 1992). Open areas were grazed intensively by husbandry, and birch coppice woods have been burned and were used for cereal growing.

The early Middle Neolithic landscape was highly diversified. There were relics of lime woodlands, coppice woods of birch, hazel and alder, and open areas, that were used for cereal growing and grazing in a swidden rotation system (Andersen 1992, in print a). Herbs from woods and coppices were common, and there were few traces of heath (Andersen in print a). A differing strategy was used in the Vroue area, where heaths were utilized for pasture.

Pollen spectra from barrows of the Single-Grave Culture in North and East Jutland were mentioned by Andersen and Rasmussen (1996). The pollen spectra indicate a radical change from the coppice management of the early Middle Neolithic to nearly treeless landscapes in the Single Grave Period. Increasing deforestation during the Single Grave Period is indicated. Pasture vegetation with plantain dominated the treeless areas and heath was scarce in contrast to the Vroue area, where heaths were used for pasture. Neolithic land use was, accordingly, highly adapted to the environment (cp. Casparie & Groenman-van Waateringe 1980).

North Germany

Averdieck (1980) found high frequencies for pastures (grasses and ribwort plantain) in pollen spectra from Neolithic barrows in Schleswig-Holstein. Heather was frequent at barrows outside the limit of the Weichselian glaciation. Mixed woodland and heather were frequent and grasses and ribwort plantain scarce at megalithic barrows on sandy till of Saalian age south of Hamburg (Groenman-van Waateringe 1979). The heathlands thus were utilized more or less intensively for pasture. Averdieck (1980) noticed dominant brown earth soils beneath the barrows, whereas podzols were scarce.

The Netherlands

A comprehensive survey of pollen spectra from soils underneath barrows in the Netherlands was shown by Casparie and Groenman-van Waateringe (1980). This survey includes pollen spectra from megalithic tombs of the Funnel Beaker Culture and barrows from the Single Grave Culture (Protruding Foot Beaker Culture). Heather pollen was common in the pollen spectra from both cultures. Grasses and ribwort plantain were generally low in the megalithic barrows. The grasses tend to be higher in the Single Grave barrows, and plantain varied considerably there. Casparie and Groenman-van Waateringe (1980) assumed that open spaces were used for cereal growing and pasture at the megalithic tombs, and that plantain was favoured by grazing at the Single Grave barrows. Bakker and Groenman-van Waateringe (1988) found lime-dominated woodlands around megalithic tombs on sandy soils. Lime was scarcer on loamy soils with traces of agriculture and grazing and was generally scarce at the time of the Single Grave Culture (Casparie and Groenman-van Waateringe 1980). Relic lime-woodland thus still occurred in the Netherlands during the early Middle Neolithic. The heathlands were utilized intensively for pasture in the Single Grave Period. Podzols were common underneath Neolithic barrows (Waterbolk 1964).

SUMMARY

Neolithic barrows in the investigation area at Vroue are situated on the Sjørup Moraine from the Weichselian glaciation and in the Vroue and Resen Heaths on an upper meltwater terrace of the original Karup valley. One passage grave occurs on a lower terrace.

Sections were excavated in sixteen barrows. Soils found beneath the barrows were oligotrophic brown earth. Pollen diagrams from the soils and pollen spectra from soil enclosed in fill material were worked out for four Early Neolithic barrows, four early Middle Neolithic barrows, five Single Grave barrows with undergraves and three barrows with ground graves.

The pollen diagrams from the soil sections indicate changes in vegetation up to the time when the barrows were constructed. In Early Neolithic time, natural woodland had been converted to birch woods, which were used for pasture in a swidden rotation system. Early Middle Neolithic barrows were built in areas where natural woodlands with heath patches became utilized for pasture or in pasture vegetation on the Sjørup Moraine. The MN BI Single Grave barrows were also built in areas where woodlands with heath patches were used for pasture. One barrow on the Sjørup Moraine, was built in an area that had been occupied in early Middle Neolithic time. Former birch woodland was converted into pasture at this site. MN BII barrows were built at sites, where pastures in heathland had been abandoned and was replaced by heath. There were slight traces of arable farming at the Single Grave barrows.

Landscape diversity was high at the time when the Early Neolithic barrows were built. There were birch coppice woods and open areas with intensive grazing were prominent. In early Middle Neolithic time, trees were scarcer, but relic lime-dominated woodlands still occurred. Pasture vegetation in heathland was more or less widespread. Trees became increasingly scarce during the Single Grave Period and there were areas with pasture vegetation in heathland. Pasture was more widespread around some of the barrows than at the barrow sites. The mounds were often built at sites that were less intensively exploited than areas in the vicinity of the barrows.

The land-use, that was traced at the barrows in the investigation area, is weakly reflected by regional pollen diagrams from lakes in North West Jutland. Coppice woods were much more common in East and North Denmark during the Funnel Beaker Period than in the Vroue area. Trees were scarce and heath was absent at Single Grave barrows in East and North Denmark. Heathland with pasture occurred around Neolithic barrows in North Germany and the Netherlands.

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