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EXCURSION GUIDE

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EXCURSION SITE 7

PLENIGLACIAL EOLIAN OR PERIGLACIAL LANDFORMS IN THE GROOTE PEEL

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Introduction

Excursion site the Groote Peel is located in the southern Netherlands (province of Noord-Brabant). The elevation is approximately 27 m above sea level. It is situated just west of the Peel Horst in the Central Graben (see fig. 6.2). The landscape is characterized by a nearly flat to weakly undulating coversand morphology. This Weichselian morphology was covered by peat during the Holocene, especially since the Atlanticum (Joosten & Bakker, 1987). From the late Middle Ages (c. 1400 AD) until 1984 this peat was excavated for fuel and soil improvement (Joosten, 1990) and the fossilized and undisturbed Pleniglacial morphology came to the surface again. Aerial photographs of the area revealed several closed, circular depressions marked by differences in vegetation type (Fig. 7.1).

According to Joosten & Bakker (1987), Van den Munckhof (1988) and Joosten (1988) these depressions are possibly pingo remnants. The presence of pingos is important since they give paleoclimatological information. There formation is restricted to permafrost areas. The temperature under which pingos grow depends on whether the pingo is an open or closed system pingo (Mackay, 1987). The closed system pingos occur where the mean annual ground surface temperature is about -5 °C or colder, and the mean annual air temperature about -8 °C or colder. The climatic conditions for the development of open system pingos can be much warmer with higher air and ground temperatures, because they can develop in discontinuous permafrost regions (Karte, 1981).

In contrast to the northern and central Netherlands (De Gans, 1981; Bohncke et al., 1988), pingo remnants are scarce and often shallow in the southern Netherlands (Bisschops et al., 1985). Therefore, it was decided to investigate some of these circular depressions. Morphologically two types are present: depressions with and depressions without a rampart. Since the presence of a rampart and the depth of the depression (larger than 2 m) are used as criteria for pingo recognition (De Gans, 1981), two depressions were selected for detailed lithological, sedimentological and palynological study. Depression A has a rampart, but appeared to be shallow; depression B does not have a rampart, but revealed a rather thick (c. 3 m) organic fill.

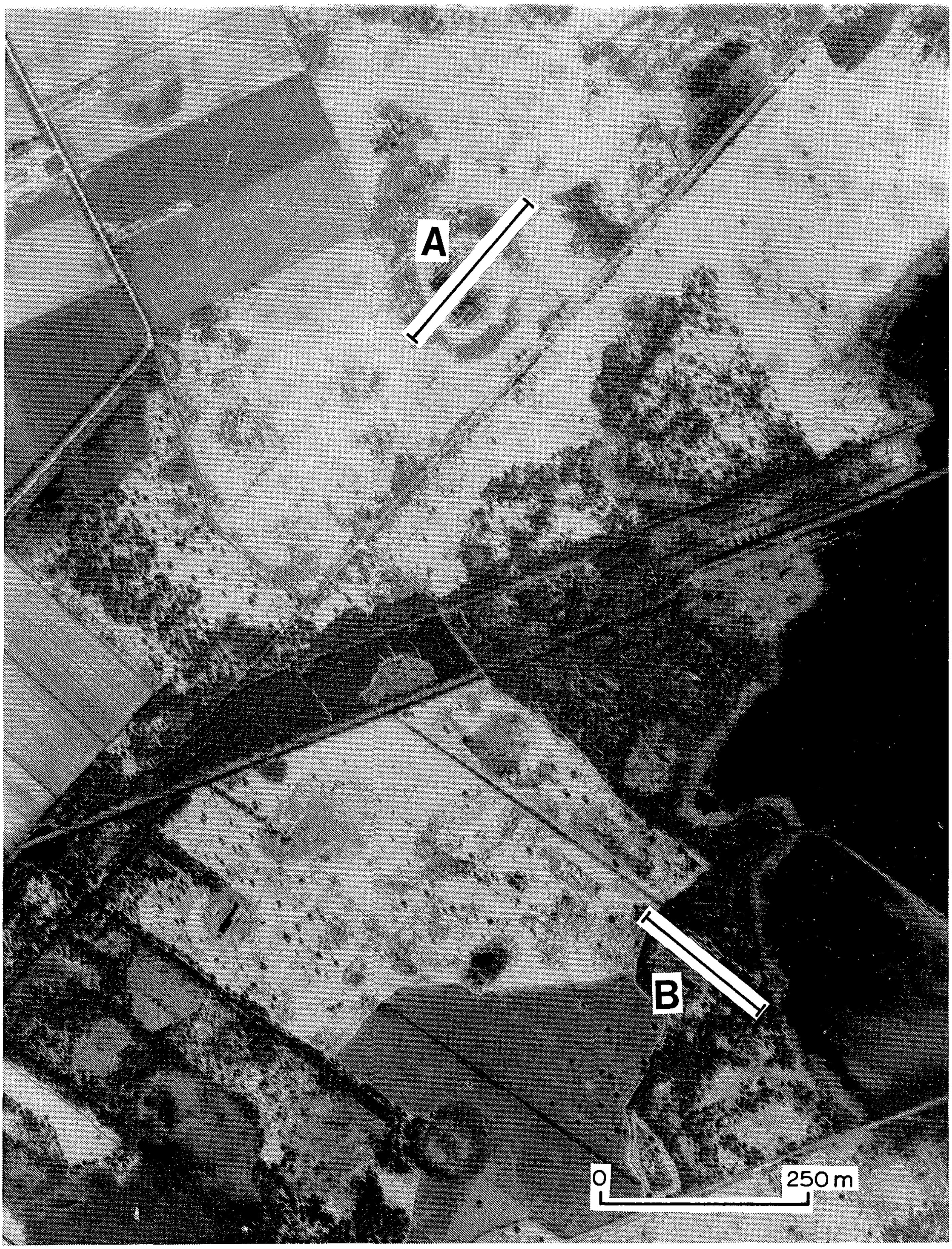

Fig. 7.1 Aerial photograph of excursion site 7: Groote Peel showing several circular depressions (see also fig. 6.2. for location).

Lithostratigraphy of the depressions

The depressions A and B have been investigated by hand-drillings. The cross-sections are represented in fig. 7.2. The results are summarized in fig. 7.3.

Unit 1 consists of moderately sorted, fine to medium sand (150-300 μm), with intercalated grenish gray, sandy silt-beds (up to 25 cm thick). Small fining-upward sequences are regularly found.
The unit is interpreted as a fluvial deposit, formed by shallow streams and superficial run-off. The silt-beds developed in stagnant pools or abandoned channels.

The stratigraphical position below unit 2 (Asten Formation of Eemian age) places unit 1 within the Eindhoven Formation of Saalian age (Zagwijn & Van Staalduinen, 1975) (fig. 7.3).

Unit 2 is a humic sand or amorphous peat-layer, which developed in or on top of unit 1. This unit is interpreted as a paleosol, because of the characteristic soil horizons. The humic to peaty Ah horizon overlies a gray brown eluviation horizon (Ae) and a black to bright brown humus illuviation horizon (B2h and B3). The complete soil profile is 0.95-1.35 m thick. The horizonation indicates that podzolization was the dominant soil forming process. The thickness of the B2h/B3 horizon (40-60 cm) and the local peaty character of the A horizon point to a hydromorphic podzol with periodic water saturation of the soil.

The pollen assemblage of the peaty soil is characterized by Pinus, Alnus, Corylus, Carpinus and Quercus, which is probably equivalent with pollen zone E5 of the Eemian (Zagwijn, 1983). Because of its lithostratigraphic position and age unit 2 is correlated with the Asten Formation which type locality is defined only 4 km northwest of the excursion site (Zagwijn & Van Staalduinen).

Unit 3 consists of moderately sorted, fine sand (150-210 μm). Thin silt-beds and fining-upward sequences were found locally. Towards the top fine gravel is present and the boundary to unit 4 is often developed as a thin, fine gravel-bed.

Like unit 1 this unit was probably formed by shallow fluvial systems (f-up) and surficial runoff from the Peel Horst in the east. The more homogeneous fine sand-beds can be of eolian origin. The gravel-bed on top of unit 3 is equivalent with the Beuningen deflation lag of the Weichselian Upper-Pleniglacial (Van der Hammen & Wijmstra, 1971). Therefore, unit 3 must be formed between the Eemian and the Upper-Pleniglacial.

Unit 4 crops out, except where it is overlain by unit 5. The unit is characterized by alternating bedding of moderately sorted, fine sand (105-210 μm) and silt. Fine gravel-laminae are present in the lower part. The sedimentary structures in the upper part are destroyed by Holocene soil formation.

Because of its stratigraphic position, its vertical homogeneity and lateral continuity and its alternating fine sand-silt lamination this unit is interpreted as eolian. It can be correlated with the Older Coversand II unit of the Upper-Pleniglacial (Van der Hammen & Wijmstra, 1971).

Unit 5 is a 1 to 3 m thick organic layer, which is a remnant of the thick peat-layer which covered the landscape before excavation. The lower part consists of fine and coarse detrital gyttja, locally with moss-beds. Higher up in the sequence more coarse detrital gyttja and peat occur. The ecology of the deepest organic fill is described below.

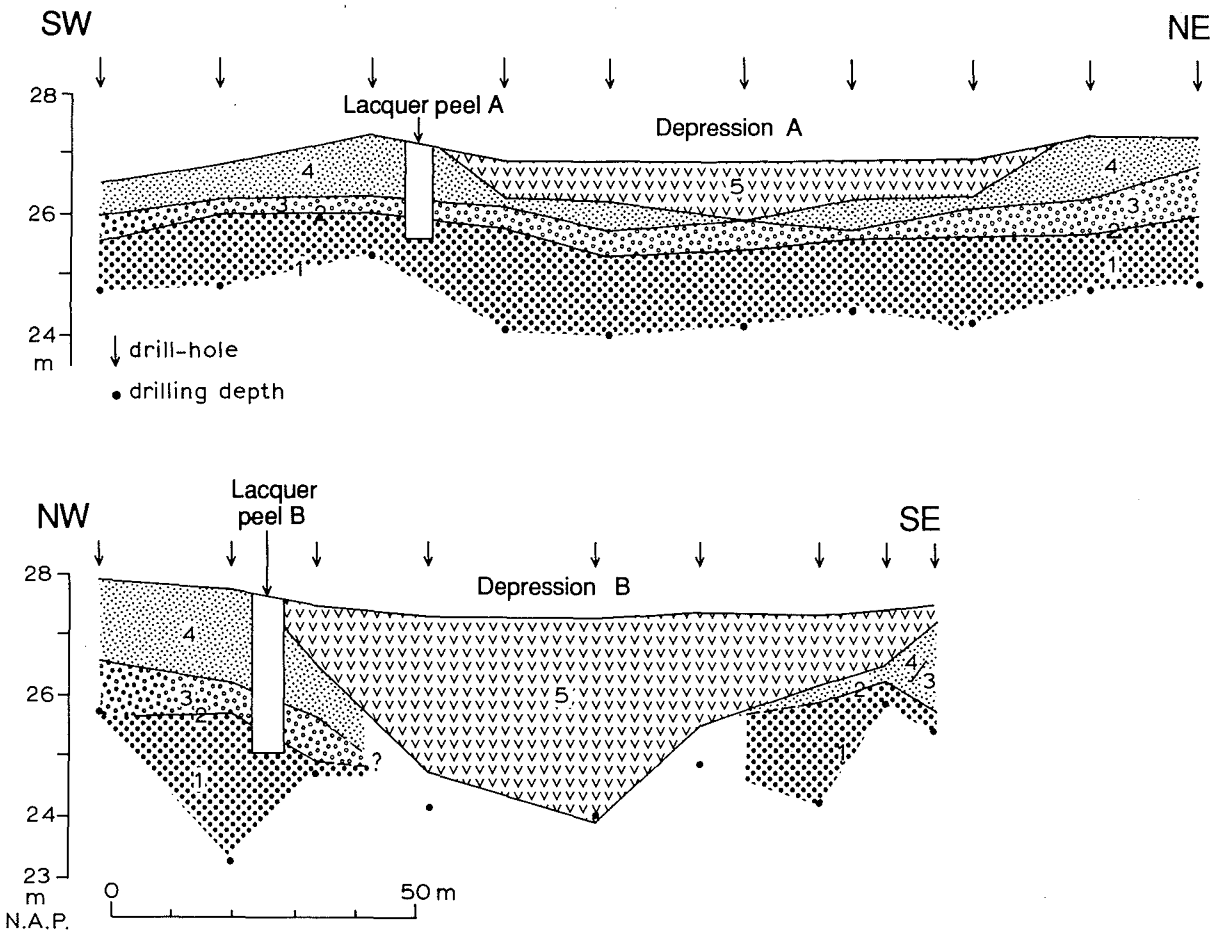

Fig. 7.2 Cross-sections over the depressions A and B in the Groote Peel (see Fig. 7.1. for location)

Local units	Regional Lithostratigraphy	Chronostratigraphy	Sedimentary and Periglacial processes
5	Griendtsveen Fm.	Holocene	Peat and soil formation
		Weichselian: Late - Glacial	Gyttja deposition Final pingo decay and lake formation
4	Twente Fm.: Older Coversand II	Weichselian: Upper Pleni-Glacial	Coversand deposition on ice-core remnant
	Twente Fm.: Beuningen Bed	Weichselian: Upper Pleni-Glacial	Cryoplanation of rampart
3	Twente Fm.	Weichselian: Upper Pleni-Glacial	Initial pingo decay and cryoturbation Pingo growth
	Twente Fm.	Weichselian	Superficial runoff
2	Asten Fm.	Eemian	Soil formation
1	Eindhoven Fm.	Saalian	Superficial runoff

Fig. 7.3 Lithostratigraphy, chronostratigraphy and genesis of the Groote Peel region.

Sedimentology and genesis of the depressions

As has been stated above, the presence of a rampart and depth larger than 2 m are used to differentiate pingo scars from eolian forms. Therefore, in addition to the corings, two pits were dug and lacquer peels were made from the walls, to study the sedimentary structures in the rampart and close to the depressions (fig. 7.4 and 7.5).

Lacquer peel A (fig. 7.4) was made in the rampart around depression A, at right angle to the ridge crest-line. Three units are distinguished, which are given the same numbers as in the cross-sections.

The deformed humic sand of unit 2 belongs to the top of the Eemian soil.

Fine sand with fine gravel-laminae is the dominant sediment in unit 3. The deformed, horizontal lamination in the sand-beds is interpreted either as eolian planebed lamination formed by tractional deposition at wind velocities too high for ripple existence (Schwan, 1988) or as low-angle climbing ripple cross-lamination by flat wind ripples (subcritically climbing translatent stratification of Hunter, 1977). The gravel-laminae represent deflation phases in which gravel was concentrated on the surface as a lag deposit.

The well developed gravel-bed separating the units 3 and 4 is interpreted as a deflation lag deposit (Beuningen gravel-bed). It discordantly overlies the deformations in units 2 and 3. The wedge-like structure, which is younger than the deformed strata of unit 3, is eroded also by the Beuningen gravel-bed. The wedge is probably a kind of sand-wedge. The sand-wedge developed during or shortly before the Beuningen deflation period in the dry arctic conditions of the Upper-Pleniglacial (Vandenberghe, 1983).

Horizontal and wavy parallel bedding are the dominant bedding types of unit 4. At the base fine sand-beds with horizontal laminations alternate with fine gravel-laminae. Like in unit 3, this alternation is interpreted as eolian planebed deposition alternated with deflation. Higher up in unit 4 gravel-laminae decrease in number and wavy parallel alternating bedding of fine sand and silt becomes more important. The alternation of fine sandy beds and finer grained silty laminae in the Older Coversand II (unit 4) is explained by cyclic sedimentation (Schwan, 1988; see also excursion sites 9 and 10). In fair weather periods (summer) silt settled from suspension and adhered to the moist, seasonally thawed, surface. In rough weather periods (winter) sand was transported by stronger winds and deposited in thin sheets with planebed lamination or low-angle climbing ripple cross-lamination.

The sedimentary structures in unit 4 clearly show that the rampart round depression A (fig. 7.1 and 7.2) is an eolian depositional form. The rampart does not reveal any signs of mass movement which can be associated with pingo decay (see e.g. Pissart, 1983). Because of the eolian rampart, the shallow depth, the near absence of eolian sand in the depression and the undisturbed nature of the subsoil, it is most likely that depression A is a blow out structure from which the deflated sand accumulated in the surrounding rampart. However, it is difficult to understand how an almost closed ridge could develop round the depression by eolian activity. More prominent accumulation at the downwind side and elongation of the deflation hollow would be expected. Although the eolian genesis of depression A is not completely understood it is favoured here, also because arguments supporting a pingo origin are lacking.

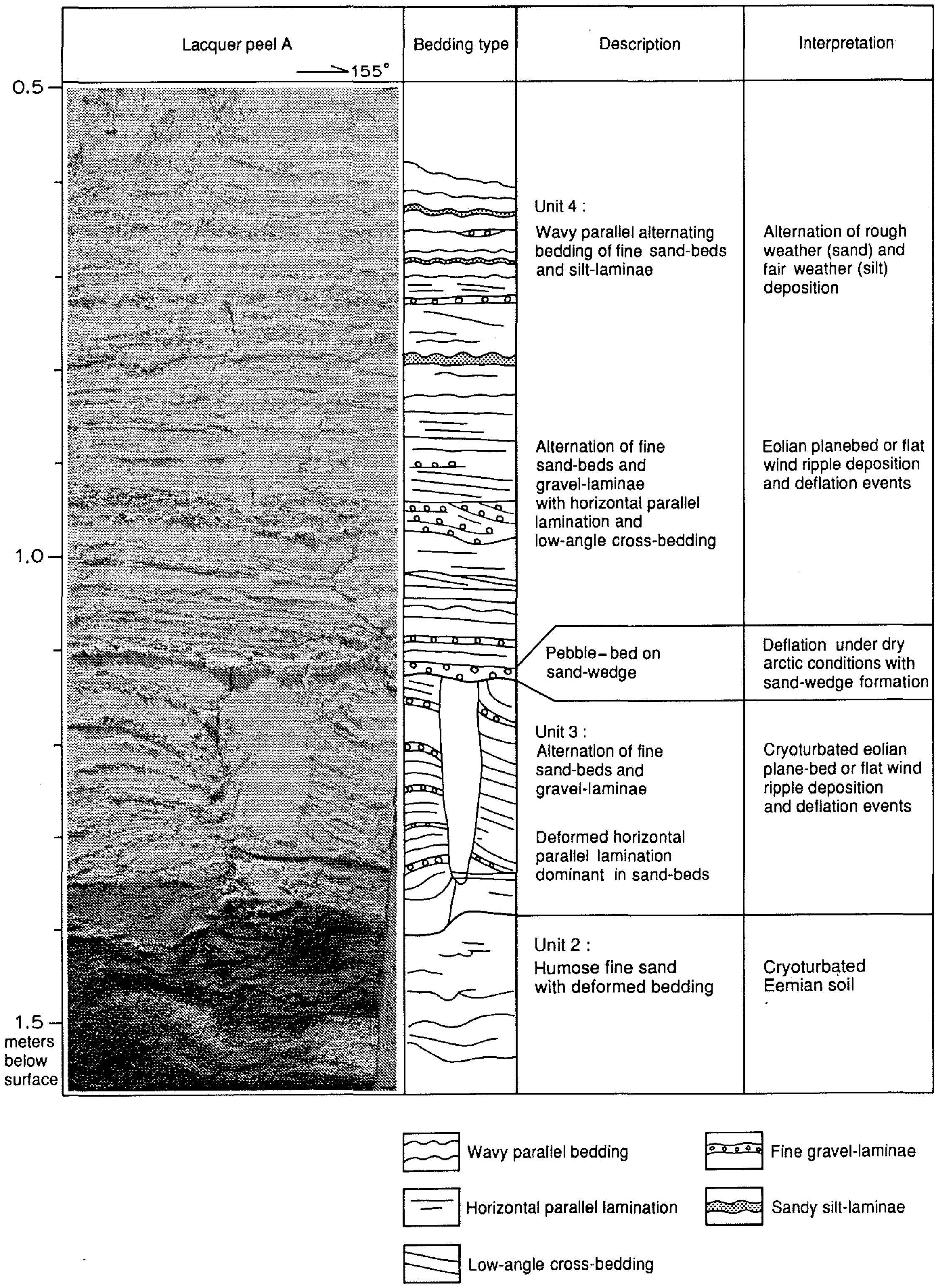

Fig. 7.4 Lacquer peel A from the rampart surrounding depression A (see fig. 7.2 for location).

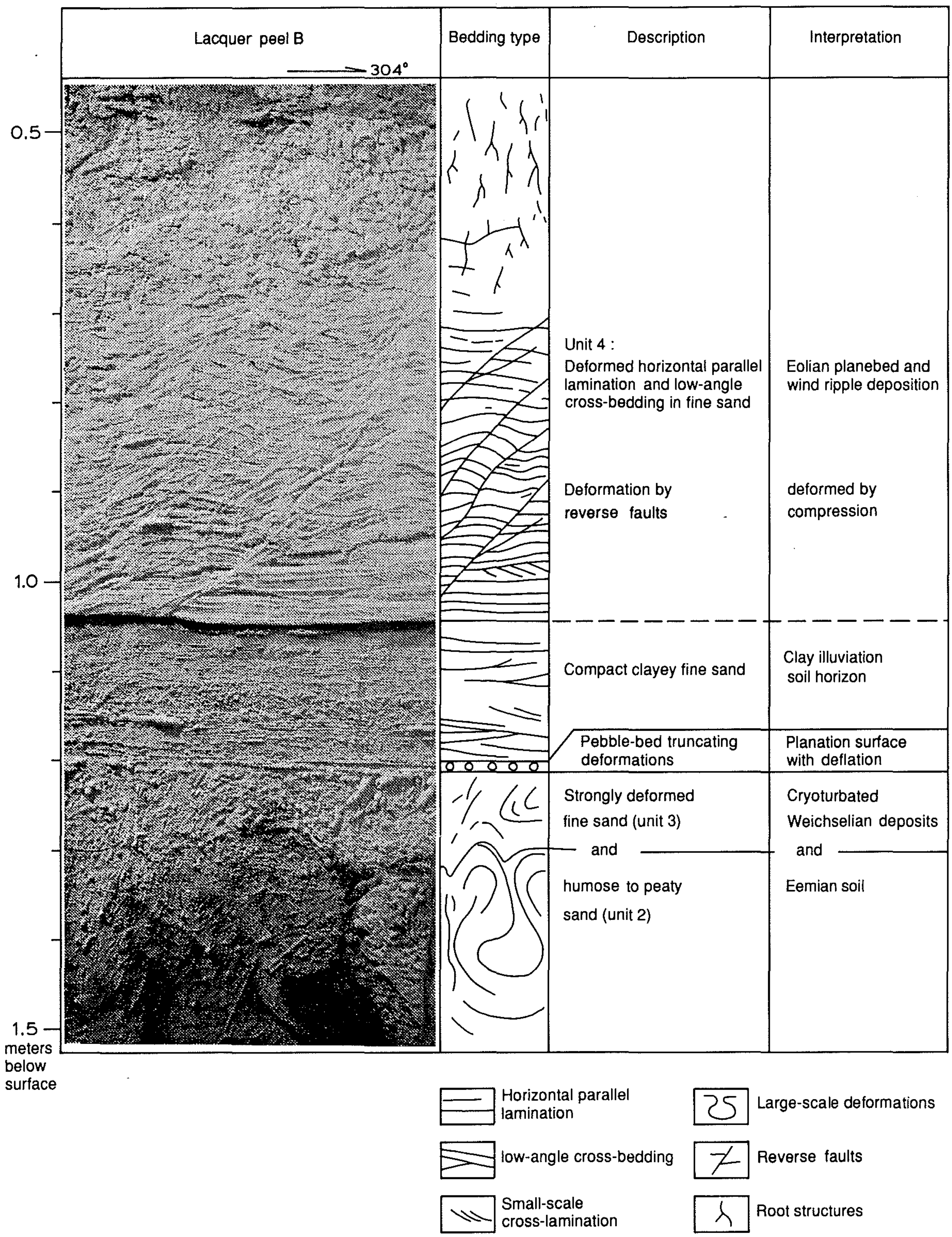

Fig. 7.5 Lacquer peel B close to the deeper depression B (see fig. 7.2 for location).

Lacquer peel B (fig. 7.5) was made on the western flank of depression B (see fig. 7.2 for location). Depression B lacks a rampart, but the locally deep organic fill (3 m) may point to a pingo scar (De Gans, 1981, 1988).

Like in peel A three units are present and the sedimentary sequence is almost comparable with peel A. The top of the Eemian soil (unit 2) and the overlying unit 3 are more intensively cryoturbated than in peel A. These deformations generated during the degradation of the permafrost after the maximum cold of the Upper Pleniglacial. The cryoturbation is truncated by the Beuningen gravel-bed.

Deformed horizontal lamination and low-angle cross-bedding in fine sand are the dominant bedding types in unit 4. These bedding types were formed by eolian planebed deposition. The local presence of small-scale cross-lamination indicates that wind ripple deposition occurred as well. The lower silt content in comparison with peel A points to a dry depositional surface.

The compact clayey sand-bed at the base of unit 4 is a post-depositional phenomenon. A thin section showed the presence of oriented clay in the pores between the sand grains, which is attributed to clay illuviation on top of the lithological contact between units 3 and 4. The clay illuviation process can be situated between the deposition of the Older Coversand II (unit 4) and the start of the peat formation in the Atlanticum.

In contrast to peel A, unit 4 in peel B contains a dense pattern of reverse faults, dipping towards the centre of the depression. The genesis of this faulting is still puzzling. Normal faulting would be expected, when the faults were caused by pingo collapse. If the reverse faulting was caused by pingo growth, then the pingo developed after the deposition of the Older Coversand II, this is during the Late-Glacial. In that case pingo formation during the Younger Dryas, being the coldest phase of the Late-Glacial, is the most likely (cf. Pissart, 1983).

The palynological study of the infill of the supposed pingo remnant at site B was hoped to provide a terminus ante quem for the formation of this depression. The cross-section over the depression demonstrates that the shape of the depression cuts through the paleosol (local lithological unit 2) which has, on palynological grounds, been dated to the Eemian.

<u>The infill of the depression B "Maartensdobbe"</u> (figs. 7.6 & 7.7)

Local zone MDB-1 (312 - 278 cm).

It is not surprising that the basal layers of the infill contain a large amount of reworked pollen, derived from the Eemian palaeosol. *Picea, Alnus, Corylus, Carpinus, Quercus* and *Ulmus* in the bottom samples have all been interpreted as reworked species. Hence, except for *Corylus* which is supposed to form part of the regional vegetation in the upper samples of the analysed segment of the core, they are not included in the pollensum.

Their relatively high values is thought to be an effect of the very low pollen production of the vegetation surrouning the basin at the time of deposition. This vegetation can be characterised as a rather open heliophilous herb cover with Gramineae, *Artemisia, Helianthemum, Plantago* spp. intermingled with Cyperaceae on the wetter locations.

The upper boundary of this zone is formed by the rather abrupt decline in all the reworked species simultaneously with a change in the lithology fom a sandy peat to a slightly sandy *Drepanocladus* peat.

Local zone MDB-2 (278 - 245 cm).

At the transition to zone MDB-2 a major spread of Betula in the vegetation is registered accompanied in the initial phase by *Juniperus* and *Salix*. Elements of the herbaceous rich vegetation of the preceding zone decline although *Artemisia* stays firmly present indicating that the regional vegetation remained rather open. With the spread of the vegetation the slopes of the depresion became stabelised and the inwash of sand deminishes as demonstrated in the lithological column. From 260 cm a gradual rise in the *Pinus* is registered but it never reaches dominance over *Betula*. The vegetation cover becomes more dense as appears from the decline in the *Artemisia* and the absence of *Thalictrum*.

Local zone MDB-3 (245 - 227 cm).

Both *Betula* and *Pinus* show a drop in their relative as well as in their concentration curves. *Salix* becomes the dominant shrub and incidental *Juniperus* is encounted. At the lower boundary *Potamogeton* is present, probably indicating a temporary rise in the lake level. The relative values of the non arboreal pollen increases indicating the presence of a more open herbaceous vegetation during this zone.

Local zone MDB-4 (227 - 205 cm).

With the firm increase in the *Betula* (both relative and absolute) the herb values deminish and a more dense vegetation cover is concluded. A succession from a *Betula* via a *Pinus* to a *Corylus* forest is evident in the upper samples. *Salix* remains a dominant species surrounding the basin.

Biostratigraphy

Biostratigraphycally the vegetational development as registered in zone MDB-2 seems to reflect the *Betula*- and *Pinus*- phase of the Allerφd, although *Pinus* does not reach the high values as registered in the palaeochannels of the Meuse. Probably the substratum in the Peel area, with a relatively high local groundwater table makes it a weak competitor with *Betula* and *Salix*. Both latter species prefer a damp, water saturated, substratum.

The retrogressive development towards a more open herbaceous vegetation during zone MDB-3, is supposed to represent the Younger Dryas period. Remarkable is that the onset of this phase, like in excursion site 5 (Bosscherheide), represents a temporary wet phase with increased lake-levels.

Zone MDB-4 represents the early Holocene revegetation of the landscape with its characteristic succession of *Betula*, *Pinus* and *Corylus*.

Zone MDB-1 represents the pre-Allerφd period, and more specifically, in the absence of a distinct *Betula*-phase, the Older Dryas.

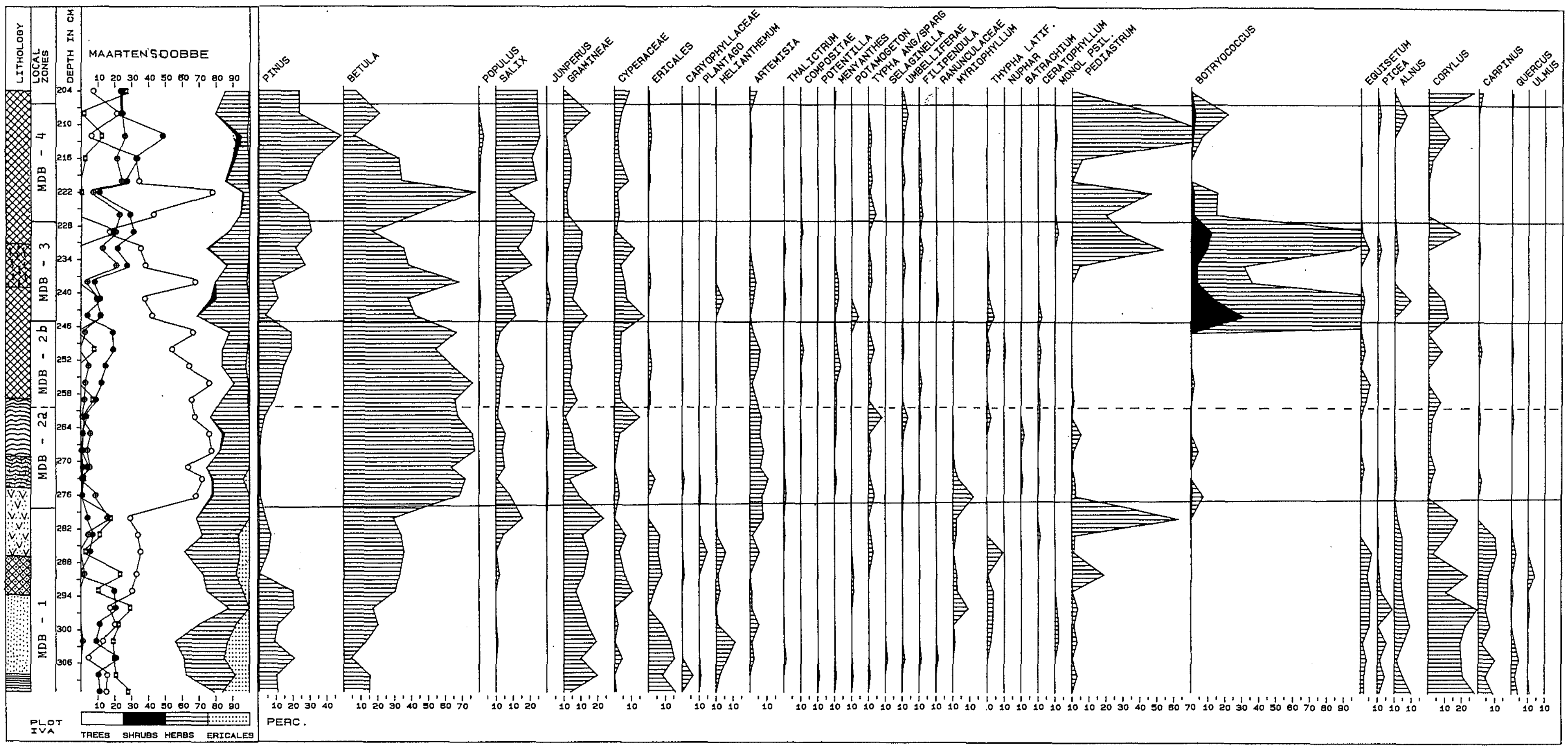

Fig. 7.6 Relative pollendiagram (selection of curves only) from the infill of Peel B, pingo remnant "Maartensdobbe".

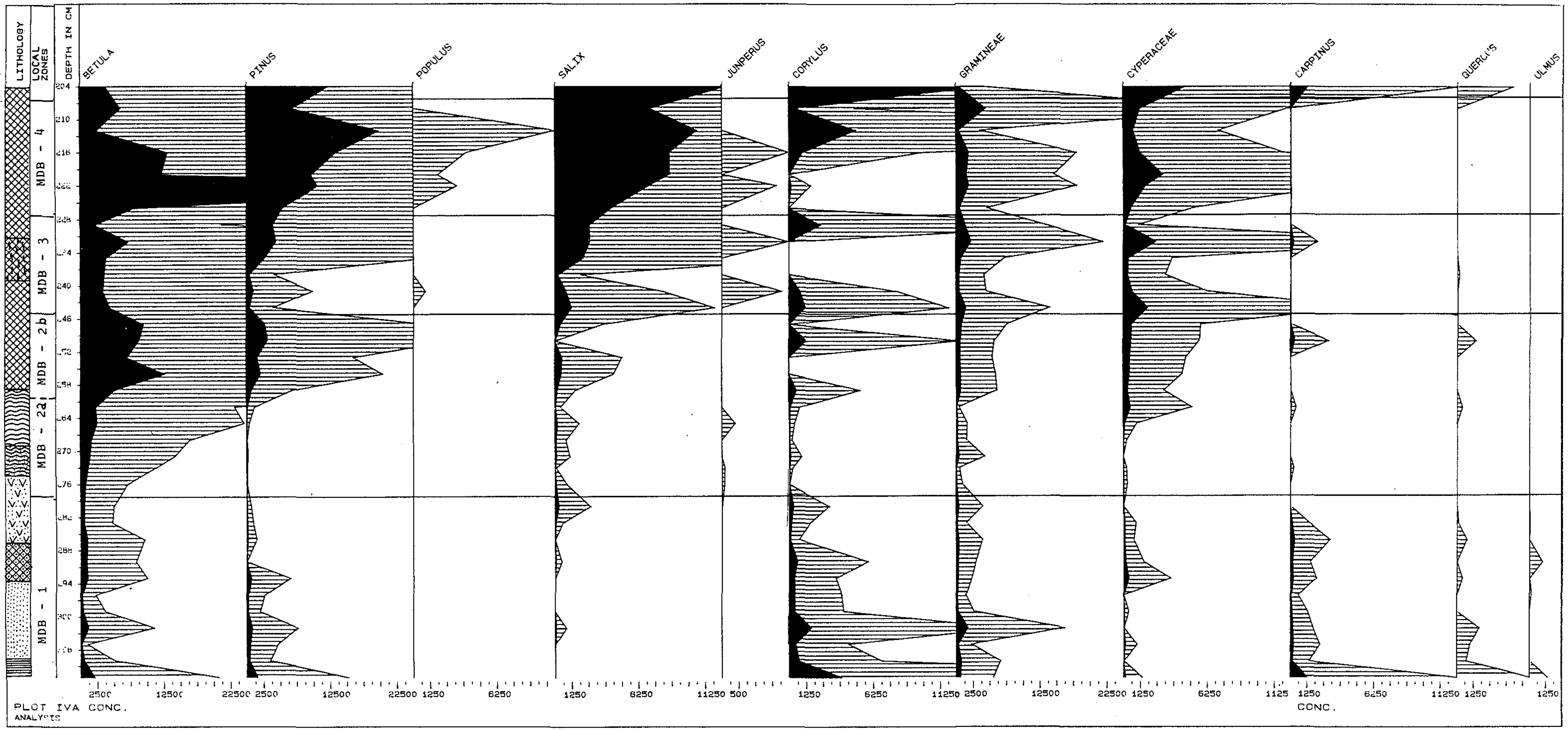

Fig. 7.7 Concentration diagram of a selection of species from the infill of Peel B.

With respect to the genesis of the depression at Peel B one may conclude that it was formed before 12.200 BP and that registration and final collapse of the pingo occurred at the termination of the Bϕlling, start of the Older Dryas period. This is in agreement with the infill of most of the dutch pingo remnants (Casparie & Van Zeist, 1960; Cleveringa et al., 1977; Paris et al., 1979; Bohncke et al., 1988).

Of course it cannot be excluded with certainty that the depression was formed by deflation during or shortly after the deposition of the Older Coversand II. However, this hypothesis is rejected, firstly because of the depth of more than 3 m and slope angles up to 13%, which is contradictory to the generally weakly undulating morphology of the top of the Older Coversand II unit. Secondly, it is unlikely that, during a period of widespread eolian accretion, locally deep erosion occurred into the Eemian soil and underlying Eindhoven Formation.

Based on these negative arguments, it is concluded that depression B was formed by pingo decay. The following evolution of pingo growth and decay is proposed (see Fig. 7.3):

Pingo growth probably occurred during the onset of the maximum cold in the Upper-Pleniglacial between 25.000 and 19.000 BP (De Gans, 1988).

The pingo started to decay after the maximum cold, because of a temperature rise. The cryoturbation in the top of unit 3 testifies to the melting of the ice-rich top of the permafrost, which caused inverse density gradients and loading of the soil. The melting of the top of the pingo will have led to rampart formation.

According to Mackay (1987) the ridges of recent, large pingo scars may exceed 10 m in height. However, from the cross-section and lacquer peel B it is clear that no rampart is present round depression B. The cryoturbated level is overlain by the Beuningen gravel-bed. The discordant nature of the gravel-bed points to intense deflation and planation of the surface. In our opinion this planation event has led to the destruction and removal of the rampart. It would also account for the near absence of ramparts round Pleniglacial scars, while Late-Glacial pingo scars, which were not subjected to severe periglacial erosion, often reveal well developed ramparts (e.g. round the Younger Dryas palsa scars in Belgium: Pissart, 1983 and the Late-Glacial pingo scars in Wales: Watson, 1971).

Because of the fact that a scar is visible today, we must assume that a remnant of the pingo ice-core remained present during the deflation phase. If the ice-core of the pingo had been molten already completely in the Upper-Pleniglacial, then the pingo scar would have been filled during the Beuningen deflation phase and afterwards by coversand deposition. Since this is not the case, the final melting of the buried remnant of the pingo ice-core took place after the Older Coversand II deposition (unit 4), probably due to the rapid climatic amelioration in the beginning of the Bølling. The Beuningen gravel-bed and the Older Coversand II, which were deposited on the buried ice-core, subsided by the final melting and formed the bottom of the pingo pond.

The presence of a buried ice-core, which remained unaltered between the initial and final melting, was previously postulated also by Bijlsma & De Lange (1983), who studied a pingo scar in the eastern Netherlands.

This supposed process of partial melting of the ice-core/permafrost is supported by observations along the western arctic coast of Canada (Mackay, 1987). In a region with a collapsed pingo permafrost is still 600 m deep. According to Mackay "any ice below the maximum thaw depth reached during pingo collapse will still be preserved". Drilling showed that at least 8 m of pingo ice still underlies the pingo ridge. "If permafrost were to degrade completely, all the ridges would likely be much more subdued". In our opinion the same argument holds true for ice-core remnants below an initial pond, which during final melting would lead to renewed pond formation or pond deepening.

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