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AN UPPER EEMIAN LAKE DEPOSIT FROM TWENTE, EASTERN NETHERLANDS

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ABSTRACT

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Study of micro- and macrofossils from a c. 80 cm thick organic deposit at Kamphuis (Twente, eastern Netherlands) provided information about vegetational succession in a lake and the surrounding marsh and forest. The deposit lies at the base of more than 20 m of predominantly sandy Weichselian sediments.

The pollen diagram indicates an Upper Eemian (last Interglacial) age: zones E4b, E5 and E6a. The most abundant dry forest pollen types of zone E4b are *Corylus, Taxus* and *Quercus.* Zone E5 is mainly characterized by a rise of the pollen curves of *Carpinus* and *Picea* and zone E6 shows a pronounced maximum of *Picea*. The recorded changes in forest composition may have been related to soil development, but there are no palaeoecological indications of an acidification concomitant with the final dominance of *Picea*. The presence of *Ilex* and *Hedera* pollen in zone E6a possibly indicates that this *Picea* dominance was not related to a decline in mean temperature. The expansion of the mildly parasitic fungus *Ustulina deusta* is apparently related to increasingly unfavourable conditions for the growth of deciduous forest elements. Macrofossils of local aquatic plants, marsh plants and invertebrates indicate a stagnant, eutrophic and base-rich aquatic environment. Some unknown and not generally known micro- and macrofossils are described and

illustrated.

INTRODUCTION

The upper Quaternary stratigraphy of the Dinkel Valley, in which Kamphuis is situated, was studied by Van der Hammen (1971). The hills bordering the valley are ice-pushed ridges which were formed during the Saalian. In these hill ridges disturbed sands, gravels and Tertiary clays are found. A cover of boulder clay was originally present on the surface of the hills. The presence of deposits of Eemian age in the valley was already mentioned by Van der Hammen (op. cit.) but up to the present no detailed studies were available.

In 1983 a research project was started at the Institute for Earth Sciences

of the Free University, Amsterdam, to study the fluvio-periglacial palaeoenvironment during the Weichselian in Twente in detail. The department of Palynology and Palaeo/Actuo-ecology of the Hugo de Vries-laboratory (University of Amsterdam) cooperates in this project, which comprises detailed palaeoecological studies of the more or less organic layers in the predominantly sandy Weichselian deposits. At several sites during the drilling programme for this project, a 0.8-2 m thick, predominantly organic deposit was encountered at the base of c. 20 m of mostly sandy (Weichselian) sediments.

In the Netherlands, a very restricted number of Eemian deposits have been studied (Zagwijn, 1961, 1983), which were all situated in the area of (temporary) marine influence; the data could be used for the determination of sea level changes in the Netherlands during this interglacial period. The fact that the Kamphuis site $(52^{\circ}20'42''N, 7^{\circ}2'26''E, \text{see Fig.1})$ was beyond the area of marine influence, even during the highest Eemian sea level, made this site to an object of interest to the present authors. Detailed data on the upper Eemian palaeoecology, generated by the study of a wide variety of micro- and macrofossils, would possibly provide information on the vegetational devel-



Fig.1. Simplified geomorphological map with location of the site.

Eem	nian	Pollen – zones	
E6	ь	Pinus	h
	a	Pinus – Picea	
E5	Ъ	Pinus – Carpinus	g
	a	Carpinus	
E4	Ь	Corylus –Taxus	
	a	Corylus	f
ЕЗ	Ь	Quercus – Ulmus – Corylus	
	a	Quercus – Ulmus	
E 2		Pinus	d
E 1		Betula	с

Fig.2. Pollen zonation of the Eemian in The Netherlands in relation to the zonation of Jessen and Milthers (1928). After Zagwijn (1983).

opment under the influence of soil degradation (Andersen, 1964, 1975) and the possible effects of climatic changes.

The interpretation of the results of the present analysis is hampered by the fact that at this moment no information is available concerning the horizontal extension of the deposit; this is caused by the scarcity of available machine corings, the depth of the deposit being prohibitive for hand coring. Although the nature of the deposit could not be unequivocally determined (lake, pool, oxbow-lake), the deposit from the Kamphuis site dealt with in the present paper will be referred to as a lake deposit.

A review of the Eemian pollen zonation in the Netherlands (after Zagwijn, 1983) is presented in Fig.2.

METHODS

Sampling was carried out by means of an engine-driven piston sampler PP350 (diameter of samples: 65 mm). To obtain subsamples of a known volume for the study of micro- and macrofossils, horizontal slices 1 cm thick were taken from the core. Subsamples of c. 12 ml were used for the analysis of macrofossils. These subsamples were boiled in a 5% KOH solution during 5 min and rinsed on a sieve with $140 \times 140 \,\mu$ m meshes. Diagrams (Figs.3 and 5–9) show the numbers of seeds, fruits and other macrofossils per sample.

A cork bore (diameter 10.9 mm) was used to take subsamples for microfossil analyses. One Lycopodium tablet containing 11,300 \pm 300 spores was added to each of the microfossil-subsamples (Stockmarr, 1971), which were subsequently processed according to Faegri and Iversen (1975). The counted numbers of Lycopodium spores were used to plot a pollen concentration diagram for the trees (Fig.4). The totals of tree pollen (Σ -pollen: 300 or more per sample) were used for percentage calculations. In Fig.3, the curves of tree pollen are presented in combination with histograms showing the absolute numbers of corresponding macrofossils. The vertical scale in the diagrams represents depth below the surface. Type numbers correspond with the palynomorphs described and illustrated by Van Geel (1978), Pals et al. (1980) and Van Geel et al. (1981, 1983 and in prep.), and with the descriptions and illustrations of the "new" Types in the present paper.

ZONATION

For the subdivision of the tree pollen diagram the zonation criteria of Zagwijn (1961, 1983) were used (see Fig.2). In combination with the stratigraphic position of the deposit studied, the tree pollen diagram (Fig.3) leaves no doubt that we are dealing with an Upper Eemian deposit. The forest elements are: *Abies, Acer, Alnus, Betula, Carpinus, Corylus, Fraxinus, Ilex, Picea, Pinus, Quercus, Salix, Taxus, Tilia* and *Ulmus*. It is obvious that zones E1, E2, E3 and E4 are not represented in the diagram. The trends of the tree pollen curves show that the deposit corresponds with zones E4b, E5 and E6a. Their main characteristics are:

Zone E4b (samples 21.10–20.85):

The curve of *Corylus* shows a decline, *Taxus* attains 5–10%, the percentages of *Carpinus* pollen increase.

Zone E5 (samples 20.80–20.45):

Carpinus rises to 30 or sometimes 50%, the percentages of *Picea* pollen also show a rise, whereas *Alnus* percentages show a maximum followed by a sharp decline. *Taxus* disappears in the upper part of the zone.

Zone E6a (samples 20.40-20.30):

Picea pollen attains a maximum, the percentages of *Abies* pollen rise somewhat, the *Alnus* percentages attain only low values and *Carpinus* declines.

REGIONAL AND LOCAL VEGETATIONAL HISTORY, DISCUSSION AND CONCLUSIONS

A. The forest development

The organic deposit at the Kamphuis site overlies a sandy layer. The sand immediately on top of the deposit did not contain any pollen. A Weichselian age of this sand and a hiatus at the gyttja—sand transition are probable. The pollen diagram shows the characteristics of an Upper Eemian forest development, the dominant taxa in the (dry) forest being *Corylus*, *Carpinus* and *Picea*, successively. The low representation of upland herbs suggests a closed stand of forest.

The *Picea* pollen percentages in zone E6a (34-48%) are relatively high as compared to other Eemian sites in the Netherlands (Zagwijn, 1961). Prentice (1978, 1983) presented surface isopoll maps and vegetational isofrequency maps (showing forest volume percentages) for lakes in eastern Fennoscandia and central and south Sweden. His maps summarize the major gradients and patterns of regional vegetation as sensed by the modern pollen spectra. From Prentice's data it appears that *Picea* percentages of forest of c. 40% correspond to pollen percentages of 20 or less. The ratio of pollen of *Picea abies* to the vegetational percentage in present-day Scandinavia may not be directly applicable to the Eemian interglacial, but the *Picea* percentages recorded at the Kamphuis site suggest the presence of a dense *Picea* forest in the area during the Upper Eemian (zone E6a). Firbas (1949, p.226) stated that for the development of *Picea abies*-dominated forest during the late Holocene period a mean January temperature of -2° C or lower is required. Zagwijn (1961, fig.11) supposed a slight decrease in July temperatures, favouring *Picea*, at the transition between zones E5 and E6a. In our and Zagwijn's present opinion (personal communication, 1984), however, the occurrence of pollen of *Hedera* and *Ilex* in the *Picea*-dominated zone E6a of the Kamphuis section is at variance with a temperature decline (cf. Iversen, 1944).

According to Andersen (1964), most of the changes in forest composition observed during interglacial phases of the Quaternary cycles can be primarily explained by gradual changes in the edaphic conditions; the increasing importance of *Picea* at the cost of *Carpinus* and other deciduous trees would be accounted for by the leaching and podzolization of sandy soils. The establishment of *Picea* with its acid humus would have accelerated this process. However, the fact that the Ericales pollen percentage does not show a rise means that acidification was not an important factor in the Kamphuis area. The ecological preferences of most mosses and the local water plants (neutral to basiphilous, see below) seem to corroborate this assumption. The conclusion must be that, for the Kamphuis area, the late Eemian forest succession, especially the expansion of *Picea* at the cost of other trees, cannot be satisfactorily explained in terms of temperature changes or soil development.

The pronounced changes in the forest succession are also reflected by a clearly marked rise in the curve of *Ustulina deusta* ascospores (see Fig.8 and Plate I). Although this fungus has a mildly parasitic character (with deciduous trees such as *Ulmus*, *Tilia* and *Acer* as its hosts; Butler and Jones, 1955), it can be ruled out as the primary cause of the degradation of the deciduous forest (see also page 54), although its expansion is apparently related to the recorded environmental changes. The analysis of fungal spores in other Eemian deposits in Europe may reveal the possible role of *Ustulina deusta* in the forest succession.

Macrofossils of Alnus, Betula, Carpinus and Picea reflect the occurrence of these taxa in the immediate surroundings of the lake, but at least some of these macrofossils may also have been washed into the lake by streams running into it. Most of the macrofossils were found in zone E4b and in the lower part of zone E5 (see also Fig.5). The maxima in the pollen percentages of Carpinus and Picea in the upper part of E5 and in E6 do not coincide with the maxima of macrofossils of these taxa. This phenomenon is possibly related with an increased distance between the sampling site and the lake margins (rise of the water table? — see Birks and Birks, 1980: chapter 5), which is also reflected in a change in the lithology: the sediment in the lower 55 cm of the section is very coarse with a relatively large quantity of plant remains in the sieve residue, whereas the sediment in the upper part of the section (20.55-20.30 m) consists of a fine gyttja yielding relatively small sieve residues with very few fruits and seeds. Relatively large amounts of

small animal remains were present here (see Fig.9). The macrofossil distribution is strongly influenced by a change in sedimentation, but this phenomenon apparently did not have an appreciable effect on the distribution of tree pollen: the tree pollen diagram shows the characteristic Upper Eemian fluctuations.

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Figure 4 shows the concentration of tree pollen in successive spectra. In contrast with the percentage diagram, the curves in Fig. 4 are not interdependent. Although the total tree pollen concentration shows considerable fluctuations, the successive maxima of Corylus, Taxus, Alnus, Carpinus and *Picea* shown in the percentage diagram can also be recognized in the concentration diagram. The tree pollen concentration diagram shows a mean value of about 8×10^4 grains per ml. From the 80 cm thick deposit only 15 samples were analyzed and, as a consequence, only a very rough estimate of accumulated tree pollen per cm² for the period of deposition can be made, viz., 64×10^5 . Using Dabrowski's (1971) method of analysis and recent data on pollen rain in the Bialowieza Park (average annual deposition of tree pollen about 15,000 grains per cm²), the duration of the period corresponding with the Kamphuis deposit is only about 425 "palynochrones" (the quotient of the accumulated pollen per cm² and the Bialowieza mean value of 15,000 grains/cm² \times annum). This would be such an unlikely brief time-span that the Dabrowski method apparently is not applicable in this case.

B. Local and regional environmental conditions

The pollen percentages of herbaceous plants and aquatics shown in Figs.5 and 7 are so low that it would have been impossible to get a detailed picture of the environmental conditions in situ and around the sample site on the basis of microfossils alone. The results of the macrofossil analysis (see below) appeared to be crucial for the reconstruction of former vegetation types and trophic conditions of the site.

The Bryophytes (Fig.6) can be divided into three main ecological groups: Amblystegium saxatile, Calliergon giganteum, Campylium elodes, Drepanocladus sendtneri, Homalothecium nitens, Scorpidium scorpioides and S. turgescens are hydrophytic species that might have grown in or close to the lake.

Antitrichia curtipendula, Isothecium myosuroides, Neckera complanata, N. crispa and N. pennata are commonly found as epiphytes.

Most of the remaining species may either be found epiphytic or as inhabiting the litter layer or fallen branches and boles in forests. *Sphagnum molle* does not fit into one of these groups by being a characteristic species of wet heath vegetation of moist sandy podzols or thin peat soils.

The majority of the Bryophytes are indicative of a basic to neutral, mesoto eutrophic environment. Antitrichia curtipendula, Isothecium myosuroides (both corticolous), Hylocomium brevirostre and Sphagnum molle prefer more oligotrophic and acidic conditions.

Landwehr (1966) presented detailed ecological characteristics for 24 of



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Fig.3. Diagram showing Σ -pollen elements (tree pollen, which was the base for percentage calculations of all microfossils) and corresponding macrofossils (number per sample of c. 12 ml). Identifications of microfossils made after the pollen total was attained are indicated with (+).

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TREE POLLEN CONCENTRATION DIAGRAM



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Fig.4. Tree pollen concentration diagram.



Fig.5. Non-arboreal taxa: pollen, spores and macrofossils. Percentage of microfossils are based on a tree pollen total (ΣAP). Macrofossils are indicated as number (n) per sample of c. 12 ml.

pp. 43-44





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Fig.6. Bryophytes. The volume percentages of the recorded mosses was always lower than one per cent. As a consequence the presence is indicated with (+).

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Fig.7. Aquatic plants. Percentages of microfossils are based on a tree pollen total (ΣAP). Macrofossils are indicated as number (n) per sample of c. 12 ml.

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Fig.8. Fungi and unknown microfossils. Percentages of the microfossils are based on a tree pollen total (ΣAP).

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the species in Fig.6. He listed 18 of them as more or less skiophytic. The richness in species capable of thriving under a closed woodland canopy points to the probability that locally the lake was directly bordered by the forest. The wealth of remains of obligate and facultative epiphytes may then have originated from overhanging branches and trees.

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From the distribution of the Bryophytes in the section, a vegetational succession in the stands surrounding the lake is not manifest. Only a slight increase in the number of litter-inhabiting species in the top half of the sequence is found.

Most of the bryophyte species from this section have also been recorded by Behre (1962, 1970), Averdieck (1967), Jung et al. (1972) and Averdieck et al. (1976) in Eemian deposits.

Of the species found in more than one sample, *Heterophyllium haldanianum*, *Neckera pennata*, *Orthothecium intricatum* and *Scorpidium turgescens* no longer belong to the recent Dutch bryoflora (Margadant and During 1982).

As is the case in the Bryophyta, the assemblage of local aquatic seed plants (Fig.7) is dominated by indicators of eutrophic, basic conditions: Batrachium, Ceratophyllum demersum, Najas marina, N. minor, Nymphaea alba, Nuphar lutea, Potamogeton friesii, P. natans, Aldrovanda vesiculosa and Stratiotes aloides. Brasenia purpurea nowadays prefers midly acidic lakes in North America; however, from recent and other studies of Interglacial European lake sediments it appears that this species favoured more alkaline waters during interglacial periods (Birks, 1980; p.40). The presence of seeds of the thermophilous Stratiotes aloides supports the assumption of the prevalence of relatively high temperatures during the Eemian period in Europe (see, e.g., Nilsson, 1983).

The marsh plants around the lake (macrofossil diagram, Fig.5) were likewise dominated by eutrophic taxa (*Cladium mariscus*, *Carex* cf. *pseudocyperus*, *C. riparia*, *Scirpus* cf. *lacustris*, *Lycopus europaeus*, *Lythrum* cf. *salicaria*, *Mentha*, *Rumex hydrolapathum*, *Typha* and *Alnus*), and even some strongly nitrophilous elements (*Rumex maritimus*, *Urtica dioica*), the latter possibly representing the undergrowth of an alder carr. Only a few taxa (*Carex rostrata*, *Potentilla palustris*) of more mesotrophic environments were present. *Scirpus sylvaticus*, a species indicative of horizontally flowing ground water, and characteristic of brooklet valley vegetation, and some upland herbs such as *Polygonum lapathifolium*, *Rumex acetosella* and *Ranunculus acris/repens* have probably been washed into the lake by a rivulet. The low representation of these upland herbs is apparently associated with the closed forest cover in the area.

The left part of Fig.9, the invertebrate macrofossil diagram, shows the fluctuations in the numbers of head capsules of chironomid larvae. In most samples, the identified taxa are indicative of stagnant water; only in the spectrum of 20.45 m five head capsules of various running-water taxa were present: Eusimulium, Prodiamesia olivacea, Rheocricotopus chalybeatus/fuscipes and Rheotanytarsus sp. Glyptotendipes gr. pallens is the dominant



Fig.9. Invertebrates, indicated as number (n) per sample of c. 12 ml.

taxon in the deposit. Higler (1977) found the genus *Glyptotendipes* as the predominant chironomid in a *Stratiotes* community in broads in the Netherlands, which agrees well with the occurrence of *Stratiotes* in the deposit (Fig.8). Larvae of *Stenochironomus* are obligate miners in living vegetation and decaying vegetable matter, including woody parts of plants. *Dicrotendipes nervosus*, *Endochironomus* spp. and *Glyptotendipes* gr. *pallens* are more or less confined to areas covered with coarse detritus. *Procladius*, *Chironomus* and *Polypedilum* cf. *nubeculosum* inhabit mud deposits (fine detritus), and *Cryptochironomus*, *Microtendipes* gr. *chloris* and *Microspectra* live in a mixture of sand and detritus.

Remains of *Sialis* (alder fly) larvae are of regular occurrence. These predatory larvae prefer a bottom rich in detritus and chironomid larvae would have been among their principal preys. Illustrations of fossil remains and relevant information about the life cycles and ecology of representatives of the genus *Sialis* will be presented by Van Geel et al. (in prep.).

After the plotting of the diagrams some additional identifications of Cladocera were made by Drs. E. Notenboom-Ram (Zeist). Remains of *Pseudochydorus globosus* were observed in samples 20.80 and 20.55. It is an infrequent species of eutrophic habitats feeding mainly on decaying small Crustaceae.

The abundance of bryozoic statoblasts corroborates the assumption of a stagnant aquatic habitat.

Summarizing the information provided by the local flora and fauna, the lake contained eutrophic, alkaline water, and its bottom was covered by detritus; it was fed by one or more rivulets, surrounded by a luxuriant marsh vegetation, and situated in an area covered by a closed stand of forest.

DESCRIPTIONS, ILLUSTRATIONS AND INTERPRETATIONS OF HITHERTO UNIDENTIFIED OR INCOMPLETELY KNOWN MICRO- AND MACROFOSSILS

Type 44: Ustulina deusta, ascospores (Plate I, 44)

Fossil ascospores resembling those of *U. deusta* were described and illustrated by Van Geel (1978). Pals et al. (1980) found similar spores in low fre-

PLATE I (p. 54)

- 44. Type 44: Ustulina deusta, ascospores (×850).
- 143a—f. Type 143: Diporotheca spec. of Eemian (143a) and Late Holocene (143b—f) age. a. Ascospore (×850) of Diporotheca spec. from sample Kamphuis 21.05 m.
- b. Fruit-body (×170) of *Diporotheca* spec. from the Late Holocene section "Suikerpot".
- c. Fragments of a squashed fruit-body (×170) of *Diporotheca* spec., showing ascospores (Late Holocene).
- d-f. Ascospores (×850) from a squashed fruit-body of *Diporotheca* spec. (Late Holocene).
- 501a, b. Type 501 fungal spores (×850).
- 502a-c. Type 502: Bactrodesmium-type, conidia (×850).

PLATE I (for explanation see p.53)



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quencies and, generally speaking, the ascospores of this mild parasite on deciduous trees such as *Ulmus*, *Tilia* and *Acer* are of regular occurrence in Holocene deposits in frequencies of less than 1%.

Ascospores of U. deusta turned up abundantly in the present study, especially in zones E5 and E6a. Although the short distance to the forest in the present case may also play a role in the dispersal of the ascospores, we consider the increasingly high representation of these spores (see diagram, Fig.6) as indicative of an appreciable number of infected trees. The decline of elements of the deciduous forest and the rise of *Picea* is probably related with the increasing importance of the fungus, but taking into consideration that at present U. deusta is only mildly parasitic, it is highly improbable that it could have played a primary role in the degradation process of the deciduous forest (W. Gams and H.A. van der Aa, Baarn, personal communication, 1984).

Type 143: Diporotheca spec. (Plate I, 143a-f)

Fruit-bodies (Plate I, 143b): ovoid, c. 180–300 μ m, blackish brown, with a coarsely verrucose wall, verrucae 15–20 μ m high.

Ascospores (Plate I, 143a and 143d—f): biseptate, $47-57 \times 17-25 \ \mu m$, fusiform, both ends truncate with a germ pore c. $3 \ \mu m$ in diameter. Surface often with dark brown anastomosing ribs.

Fossil spores of Diporotheca sp. (Meliolaceae) were described for the first time by Van der Wiel (1982) as the unidentified fungal spore "Type 143". It occurs regularly in Holocene deposits formed in eutrophic to mesotrophic conditions (see also Van der Woude, 1983). Mrs. A.E. Caseldine (personal communication, 1979) observed the spores in peat deposits of the Somerset Levels where they occurred throughout the profile, which varied from a woody peat to a Phragmites-Cladium peat. Diporotheca spores are rare in the Late Glacial deposits at Usselo (Van Geel et al., in prep.). Recently this spore type could be identified by Drs. J.A. von Arx and H.A. van der Aa (Baarn), when fruit-bodies still containing ascospores were found in a subrecent Thelypteris-peat deposit from the nature conservancy "Suikerpot" (West Netherlands). The concise description and illustrations of the fruitbodies in the present paper were made from this subrecent material. In order to show the morphological resemblance, an ascospore of Eemian age (Plate I, 143a) is placed next to Late-Holocene spores (Plate I, 143d-f). The size of the fossil spores indicates that they do not belong to the common rootparasitizing species D. rhizophila (mildly pathogenic on Solanaceae, see Gordon et al., 1961), which has smaller spores. We may expect a hostparasite relationship for this representative of the Meliolaceae. Curve matching (comparing frequency curves of the spores with curves of possible host plants) in the abovementioned subrecent deposit might point to *Thelypteris* as a host plant, but such a relationship is not mentioned in the mycological literature.

Type 501 (Plate I, 501a, b)

Three-lobate, flattened **fungal spore**, diameter c. 37 μ m. A pore, c. 2 μ m wide, with annulus, at one lobe. A second lobe with a c. 1- μ m wide pore and the third lobe without a pore. Only two observations in zone E5.

Type 502: Bactrodesmium-type (Plate I, 502a-c)

Conidia transversally 5-septate, c. 55 μ m long and 20–28 μ m wide. Basal cells paler (thinner-walled) than the other cells. Not constricted at septa or hardly so.

This Type is heterogeneous, with at least two taxa: Bactrodesmium cf. obovatum (Oudem.) M.B. Ellis and B. cf. moenitum Palm and Stewart. Ellis (1971) mentions B. obovatum on wood and bark of deciduous trees including Alnus, Fraxinus, Fagus, Betula, Ulmus and Quercus.

Type 503: cf. Drechslera state of Cochliobolus specifer Nelson (Plate II, 503a, b)

Conidia 3-pseudoseptate, c. $45 \times 15 \,\mu$ m, hilum 2–3 μ m wide. According to Ellis (1971) a very common cosmopolitan species. The conidia occur regulargly in the upper part of zone E5 and in E6a.

Type 504: wood fragments in pollen slides (Plate II, 504)

No attempts were made to identify the various fragments because pollen, fruits and seeds yielded adequate information about the taxa that played a role as forest elements.

Type 505: stomata of Coniferae (Plate II, 505)

These stomata occur in the upper part of zone E5 and in zone E6 (*Picea* phase) and are identical with the stomata observed in *Picea* needle fragments found as macrofossils in the same deposit.

Type 506 (Plate II, 506)

Thick-walled, originally globose spores, c. 50 μ m in diameter excluding the c. 15 μ m long and c. 1.5 μ m thick, bifurcating appendages. Only three records in zone E5.

Type 507 (*Plate II*, 507*a*–*c*)

Globose spores, mostly torn and folded, originally c. $57-72 \ \mu m$ in diameter. Wall c. $0.5 \ \mu m$ thick with a scabrate pattern of irregularly placed projections, $0.5-1.0 \ \mu m$ in diameter. Of regular occurrence in zone E4b.

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PLATE III



507a, b. Type 507 microfossil (×425). 507c. Detail of 507a (×850).

- 509. Type 509: armament of pupal tergit (\times 128) of *Glyptotendipes* gr. pallens. Type 510: epidermis showing paracytic stomata (\times 128).
- 510.
- 189D. Type 189D: ephippium of Leydigia-type (×128).
 Pc, Pb. Pediastrum clathratum and P. boryanum (×425).



503a, b. Type 503: cf. Drechslera state of Cochliobolus specifer, conidia (×850).

- 504. Type 504: wood fragment (\times 425).
- 505. Type 505: stoma (×425) of cf. Picea.
- 506. Type 506 microfossil (\times 425).
- 508a. Type 508 macrofossil (×28).
- 508b, c. Detail of Type 508 macrofossil (×128 and ×425, resp.).

Type 508 (Plate II, 508a-c)

Macrofossil, c. 4 mm long, proximal part consisting of several (partly detached) "stalks", covered at the distal end by a flat "scale". Cell walls between adjacent cells showing many thickenings. The "stalks" show a pattern of rows of parallel cells, alternating with areas showing intercrossing groups of cells. The "scale" shows a radial cell pattern. Type 508 is possibly part of an as yet unidentified inflorescence.

Type 509: armament of pupal tergit of Glyptotendipes gr. pallens (Plate III, 509)

In Fig.9 the frequency of larval head capsules of chironomids is shown. The most abundant are those of G. gr. pallens. Pupae of this taxon show a characteristic armament which also became fossilized in the deposit.

Type 510 (Plate III, 510)

Epidermis of a representative of the Dicotyledonae, showing irregularly placed paracytic stomata.

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