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PALYNOLOGICAL INVESTIGATIONS OF EEMIAN DEPOSITS IN THE DRENTSCHE AA AREA (DRENTE, THE NETHERLANDS)

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ABSTRACT

Paris, F. P., P. Cleveringa & W. de Gans 1981 Palynological investigations of Eemian deposits in the Drentsche Aa area (Drente, The Netherlands). *In*: A. J. van Loon (ed.): Quaternary geology: a farewell to A. J. Wiggers – Geol. Mijnbouw 60: 409-416.

Two organic layers from the Upper Pleistocene of the northern Netherlands are investigated in detail for their pollen content. Comparison of the pollen diagrams with the standard Eemian biozones indicates that the continental peat growth and/or accumulation of organic material (mor) started during the E4/E5 phase.

A hiatus in the deposits with an Eemian age is discussed.

INTRODUCTION

Part of the current research of the Physical Geography and Quaternary Geology Department of the Institute of Earth Sciences concerns the Late Pleistocene geology and geomorphology of the Aa valley system. This paper is part of this study and deals with the palynology of organic Eemian deposits which were found in the upstream part of the valley system.

THE GEOLOGY OF THE DRENTSCHE AA AREA

The Drentsche Aa valley is situated in the north-eastern part of the Drente plateau (Fig. 1). The valley is eroded into Saalian till of the Drente Formation (Table I) and into underlying sand and clay deposits of the Eindhoven and Peelo Formations (DE GANS, 1980). The oldest fluvial valley sediments consist of sorted sand and gravel intercalated with mor-like organic layers and were dated to be of late Eemian and early Weichselian age (DE GANS, 1981-b). These are overlain by

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Table I
Lithology and stratigraphy of the Drentsche Aa area.

<table>
<tr><th colspan="2">CHRONO STRATIGRAPHY</th><th colspan="2">LITHO STRATIGRAPHY</th><th colspan="2">LITHOLOGY</th></tr>
<tr><td colspan="2">HOLOCENE</td><td colspan="2">SINGRAVEN FM</td><td colspan="2">PEAT</td></tr>
<tr><td rowspan="3">WEICHSELIAN</td><td>LATE</td><td colspan="2">TWENTE</td><td colspan="2">SAND, LOAM AND UNSORTED</td></tr>
<tr><td>MIDDLE</td><td rowspan="3">Aa DEPOSITS</td><td rowspan="2">FM</td><td rowspan="3">SORTED SAND AND GRAVEL WITH ORGANIC LEVELS</td><td rowspan="2">SAND WITH GRAVEL</td></tr>
<tr><td>EARLY</td></tr>
<tr><td colspan="2">EEMIAN</td><td>ASTEN FM</td><td>PEAT</td></tr>
<tr><td colspan="2" rowspan="2">SAALIAN</td><td colspan="2">DRENTE FM</td><td colspan="2">TILL</td></tr>
<tr><td colspan="2">EINDHOVEN FM</td><td colspan="2">FINE SAND</td></tr>
<tr><td colspan="2">HOLSTEINIAN</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">ELSTERIAN</td><td colspan="2">PEELO FORMATION</td><td colspan="2">FINE SAND AND CLAY (POTKLEI)</td></tr>
</table>

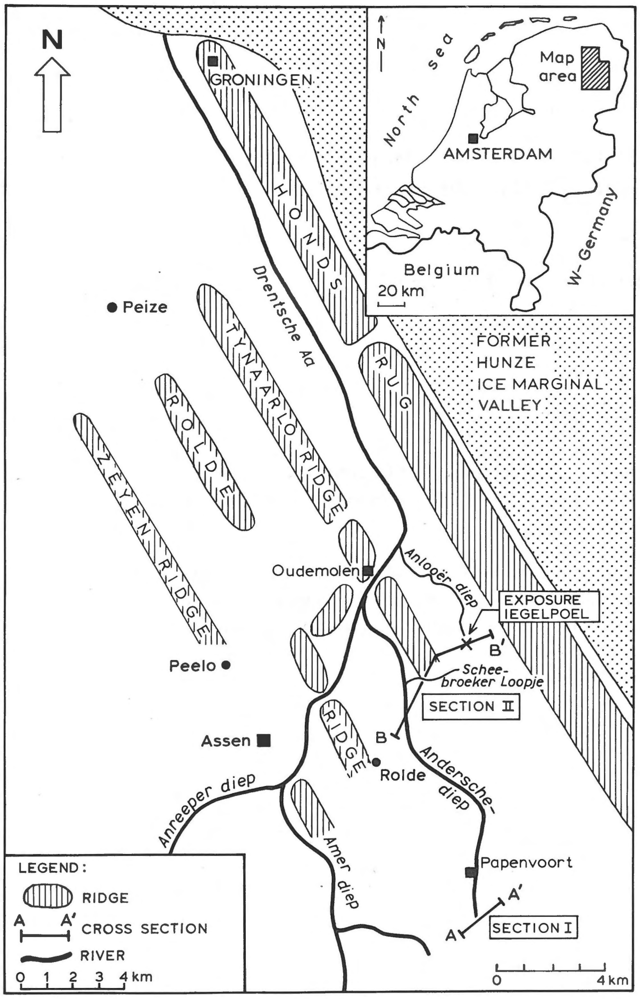


Fig. 1
The Drentsche Aa area and the locations of the sections and exposure.

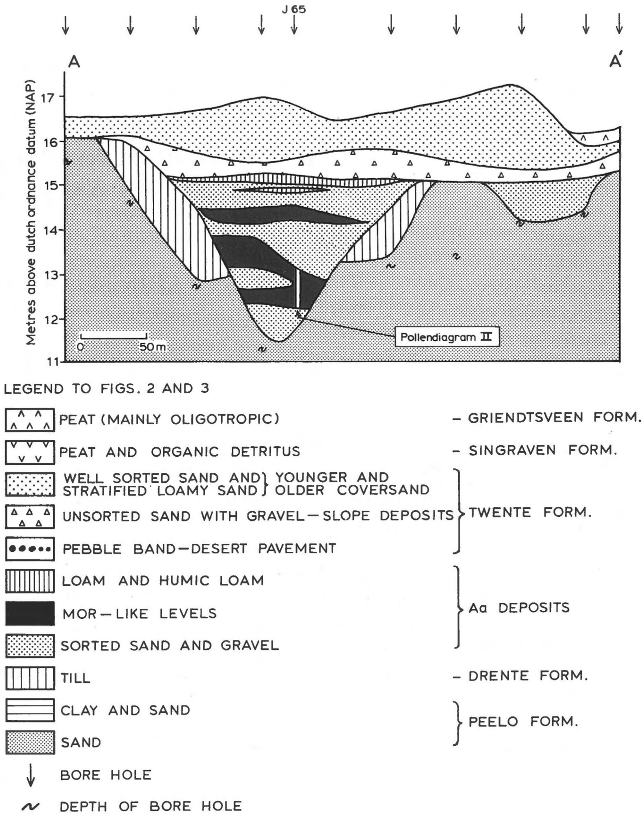


Fig. 2
Cross section I Papenvoort (after De Gans, 1981-b) For location see figure 1.

pleniglacial fluvial sand deposits with loam and humic loam layers. The pleniglacial and older fluvial sediments are assigned to the Aa deposits (DE GANS & CLEVERINGA, 1981). The fluvial deposits are superposed by unsorted sand mixed with gravel and wellsorted sand, and are interpreted as slope and aeolian sediments respectively. They are also present on the valley slopes and are included in the Twente Formation (DE GANS & CLEVERINGA, 1981; ZAGWIJN & VAN STAALDUINEN, 1975). After deposition of the Twente Formation sediments fluvial erosion and sedimentation occurred, resulting in deposition of a mainly organic deposit in the valley system which is assigned to the Singraven Formation (ZAGWIJN & VAN STAALDUINEN, 1975; DE GANS, 1980).

The cross sections

To establish the lithostratigraphic position of the palynologically investigated organic layers, two cross sections and one small exposure are described in detail. Data for the sections were obtained by means of hand drilling equipment.

Cross section I – Papenvoort

This cross section (Fig. 2) is located in the upstream part of the Andersche Diep valley (Fig. 1) which is eroded into till and sand of the Drente and Peelo Formations respectively. These upstream valley sediments are overlain by slope and aeolian deposits which completely cover the pre-existing relief. The Aa deposits are intercalated by mor-like organic and humic loam layers. The lowest mor-like organic layer is sampled in boring J 65 for pollen analysis. The basal part of this layer is composed of black to dark brown peaty material with a granular character and passes gradually into a sticky humic loam. Some minor sand intercalations occur in this layer, which has a thickness of about 1 m.

Cross section II - Rolde

The schematic cross section (Fig. 3) is located northeast of the village of Rolde and gives the topographic position of exposure I (Iegelpoel). The section shows that valleys of the Andersche Diep and Scheebroeker Loopje have asymmetric slopes as described by DE GANS (1980, 1981-a). In the eastern part of the section an outcrop of clay deposits from the Peelo Formation gives rise to relatively higher relief features.

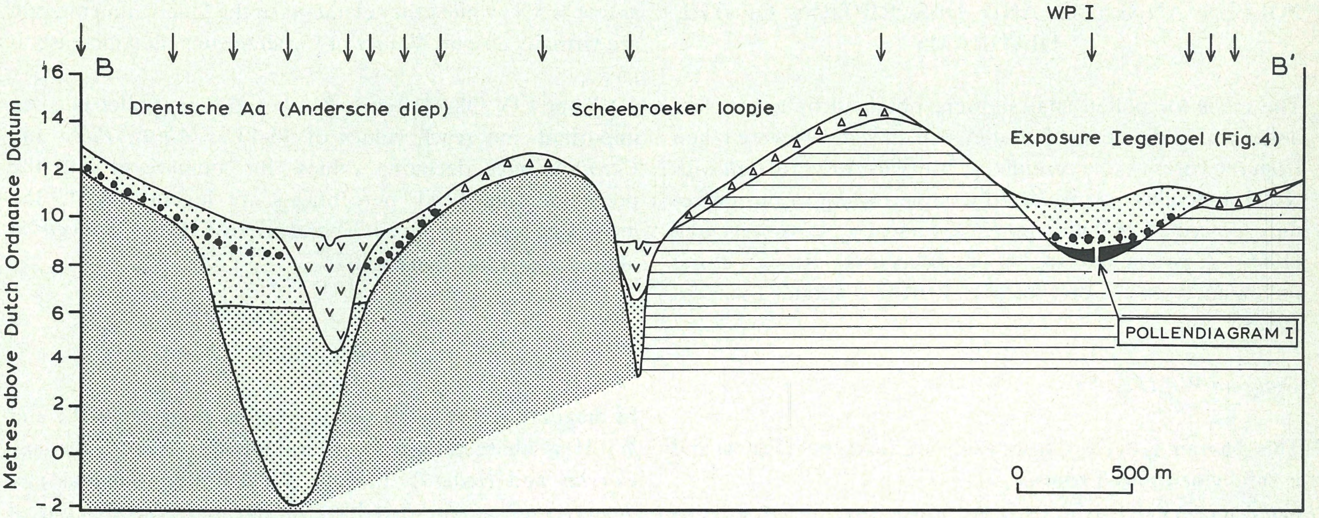


Fig. 3
Cross section II A: schematic section across Andersche Diep and the exposure Iegelpoel. For location see figure 1; for legend figure 2.

Exposure I – Iegelpoel (53°01'25"N, 6°42'30"E)

This exposure (Fig. 4) is located on the divide between the Anlooër Diepje and Scheebroeker Loopje (Fig. 1). In the upper parts of the exposure a layer of well-sorted sand is located which is thought to have an aeolian origin. Below this aeolian sand a pebble band is found. This band is in an erosive position overlying a 1 m thick cryoturbated zone composed of loam with fine sand intercalations of aeolian origin, another pebble band and a peat layer. These pebble bands are described by DE GANS & CLEVERINGA (1981). The peat layer contains a large concentration of acorns and wood fragments and overlies fine sand of the Peelo Formation. The position of pollen sample WP is indicated in the section.

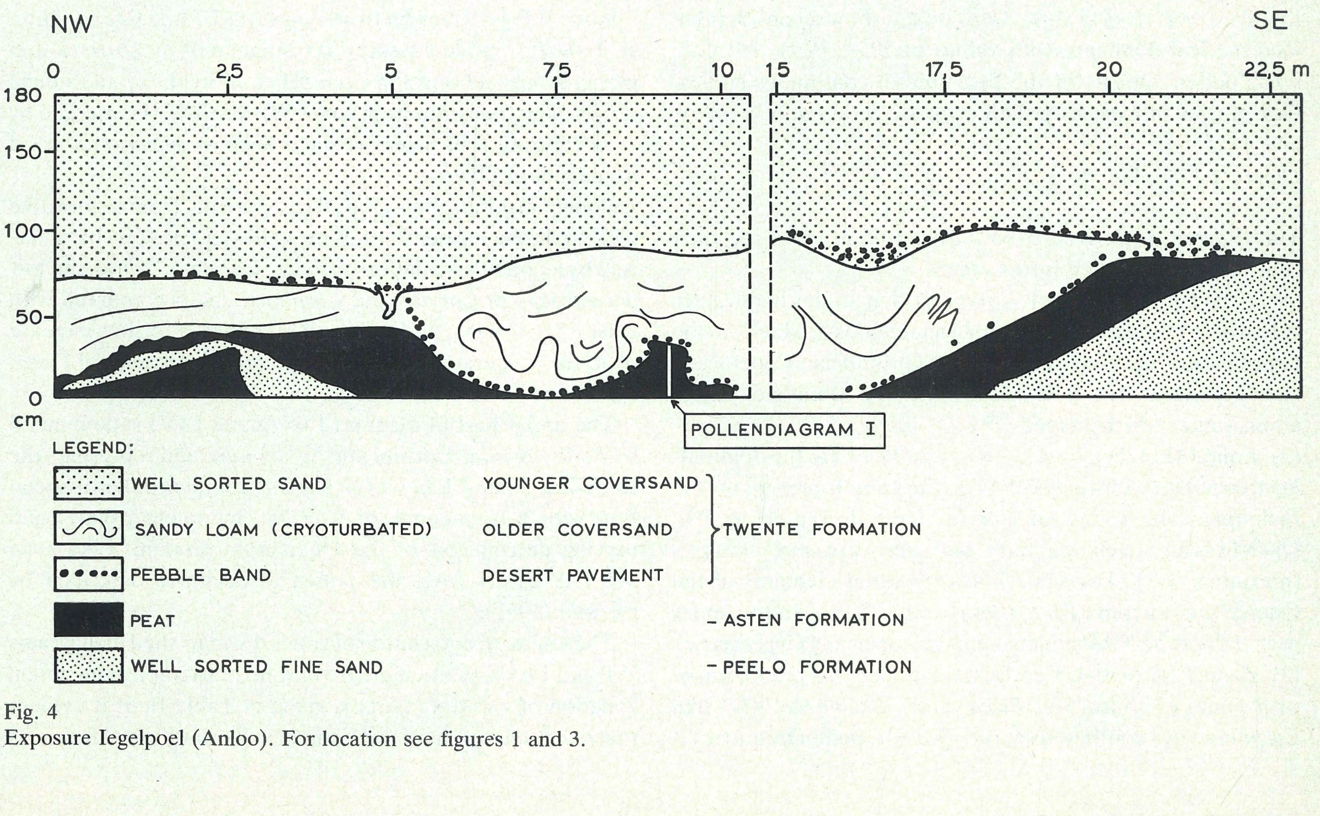


Fig. 4
Exposure Iegelpoel (Anloo). For location see figures 1 and 3.

POLLEN ANALYSIS AND DESCRIPTION OF THE DIAGRAMS

The cores for pollen analysis were obtained by a sampling auger with a diametre of 50 mm. Pollen samples were taken from the cores at one centimetre intervals, were treated with KOH and subsequently acetolysed according to the procedure described by ERDTMAN (1933) and by FAEGRI & IVERSEN (1966). A pollen sum of 300 has been used. Results of the pollen analyses are presented in Iversen diagrams (IVERSEN, 1942).

Diagram WP (Fig. 5)

This diagram is derived from exposure Iegelpoel (Fig. 4) and is subdivided into 3 zones.
(1) Zone WP I (81-87 cm): the lower part of this zone is characterised by high values for *Quercus* pollen (up to 65%). In the upper part of the zone these values decrease and increasing percentages of respectively Cyperaceae, *Pinus* and *Betula* pollen are found. The monolete psilate spores attain percentages of over 100%.
(2) Zone WP II (5-81 cm): *Corylus* and *Alnus* pollen dominate with values of 50-70%. *Quercus* has a lower value (± 20%). Other pollen elements of the Quercetum mixtum (*Ulmus* and *Hedera*) show low percentages but occur as continuous curves.

Zone WP II is subdivided into Subzone WP IIa (49-81) and WP IIb (5-49). The former shows relatively high percentages of *Quercus* and *Hedera* species. The latter shows an increasing percentage of *Pinus* pollen (to about 20%).
(3) Zone WP III (0-5 cm): *Alnus* pollen show a considerable increase and dominate with values of 70%. *Picea* and *Carpinus* pollen appear for the first time in continuous curves. Percentages of *Corylus* pollen decrease to about 5%.

Diagram J 65 (Fig. 6)

This diagram is derived from boring J 65 in cross section I (Fig. 2) and is divided into 4 zones.
(1) Zone J I (450-467 cm): *Corylus* pollen attains high values (up to 80%) though this percentage decreases gradually in the upper part of the zone. Pollen from Gramineae, Cyperaceae and Typhaceae reach values of 5-10%. Monolete psilate attain values which exceed 70%.
(2) Zone J II (425-450 cm): *Alnus* and *Picea* are the dominating tree pollen with values of 40%. *Carpinus* is present for the first time. The values of *Corylus* have decreased to 5%. *Quercus* is also declining, but is still present in small amounts (maximum 5%). The same holds for other elements of the Quercetum mixtum (*Tilia, Ulmus* and *Hedera*). In the upper part of the zone NAP pollen increase, especially Cyperaceae.
(3) Zone J III (410-425 cm): *Alnus* pollen are predominant with values of up to 75%. *Picea* values decline to 10% – like *Carpinus* – in a continuous curve. *Quercus* pollen frequency is as low as 5%, while other elements of the Quercetum mixtum are virtually absent. Values of Cyperaceae pollen increase to 25%.
(4) Zone J IV (384-410 cm): *Betula* and *Pinus* pollen become important and reach values of 30-40%. *Alnus, Picea* and *Carpinus* have declining values. By comparison with the preceding zone NAP percentages are higher, due to the increasing replacement of Cyperaceae by Ericales. *Sphagnum* attains high values up to 40%.

DISCUSSION

In diagram WP (Fig. 5) the vegetation of zones WP I and WP II is characterised by thermophilous trees (*Quercus, Corylus* and *Hedera*). In zone WP III thermophilous elements (*Quercus, Corylus*) decrease and are replaced by boreal trees such as *Picea* and *Carpinus.*

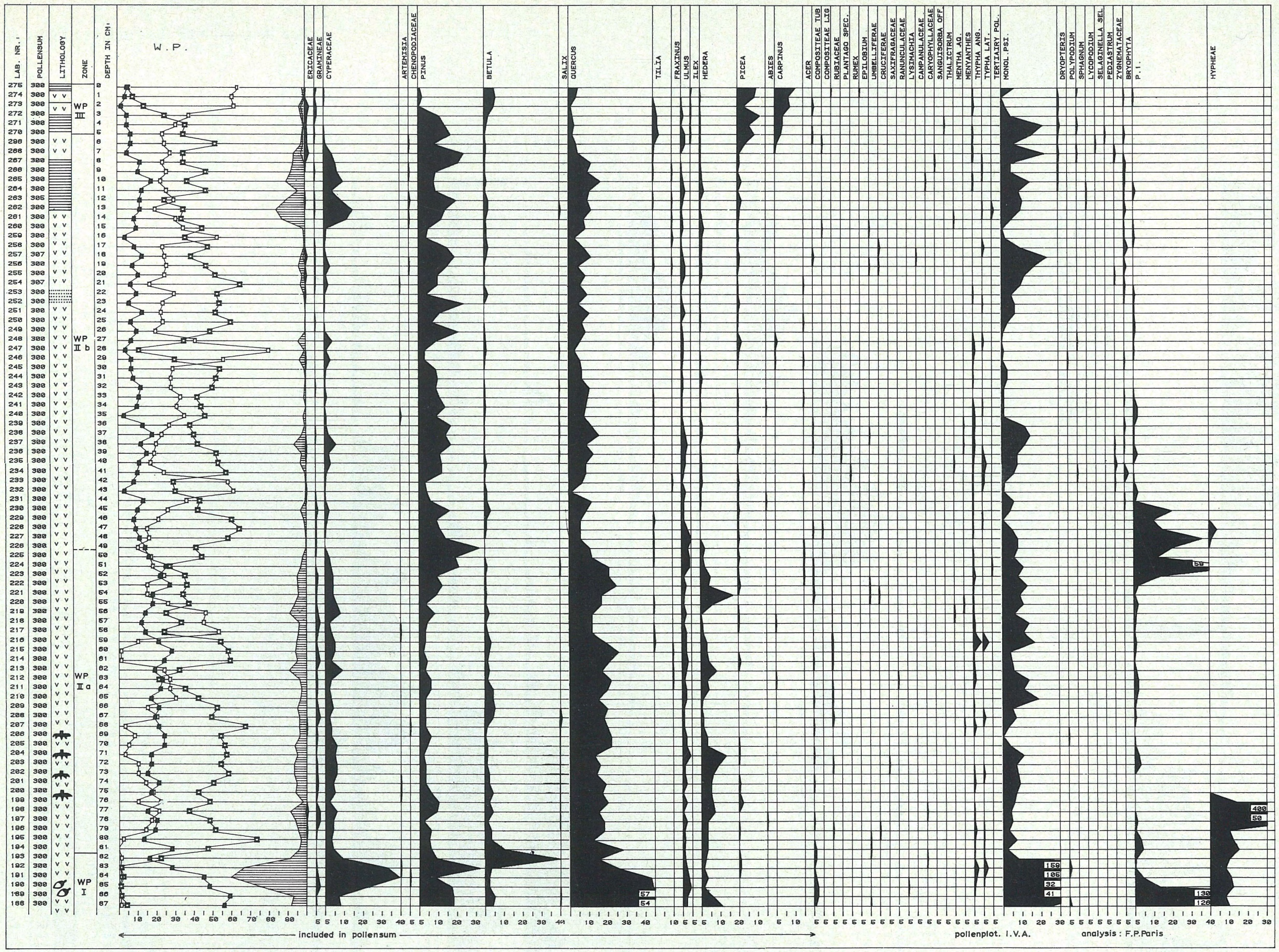
A similar replacement of thermophilous by boreal vegetation is shown in zones J II and J III of diagram J 65 (Fig. 6). The acidophilous vegetation of Ericales and *Sphagnum* in zone J IV indicates a more open character of the boreal vegetation. This characteristic vegetation development, derived from diagrams WP and J 65, is comparable with zones of the Eemian described by ZAGWIJN (1961). Pollen diagram WP is derived from a local peat layer on the valley divide. Zone WP II of this diagram is characterised by a pollen association of *Alnus, Corylus* and *Quercus*, and corresponds with zone E4a of ZAGWIJN (1961, 1975). The overlying zone WP III, with increasing values of *Picea* and *Carpinus*, indicates the transition to zone E4b.

Zone WP I is different from Zagwijn's E3 and E4a zonation as it shows a pollen association dominated by *Quercus* and monolete psilate and the occurrence of hypheae and fungal spores. The transition from zones WP I to WP II is marked by a concentration of macro-remains such as acorns and wood fragments of *Quercus*.

Pollen diagram J 65 (Fig. 6) is derived from a mor-like deposit on the former floor of the valley. Zone II is characterised by a pollen association of *Picea, Carpinus, Alnus* and low percentages of *Corylus* and *Carpinus,* and is compared with zone E5 (ZAGWIJN, 1961). Zone J III shows a further increase of *Alnus,* Cyperaceae, *Pinus* and *Betula*, a decrease of *Picea*, and is compared with zone E6a.

The upper part of diagram J 65 (Zone J IV) is dominated by *Pinus, Betula, Ericales* and *Sphagnum*, and represents the E6b zone. Zone J I, however, shows a complex pollen association with a dominance of *Corylus*, monolete psilate, and varying percentages of the Quercetum mixtum. Like zone WP I it differs from the pollen associations described by ZAGWIJN (1961).

The tentative correlation of zones distinguished in diagrams WP and J 65 with the standard chronostratigraphy and pollen zonation of ZAGWIJN (1961) is given in Table II. It is evident that commencement of the Eemian in its continental facies, as



LITHOLOGY

PEAT

ORGANIC MINERAL MIXTURE (MOR)

SAND

LOAM

FRAGMENT OF WOOD

ACORNS

SYMBOLS

QUERCETUM MIXTUM.

ALNUS

CORYLUS

HERBS

ERICALES

Fig. 5
Pollen diagram WP 1.

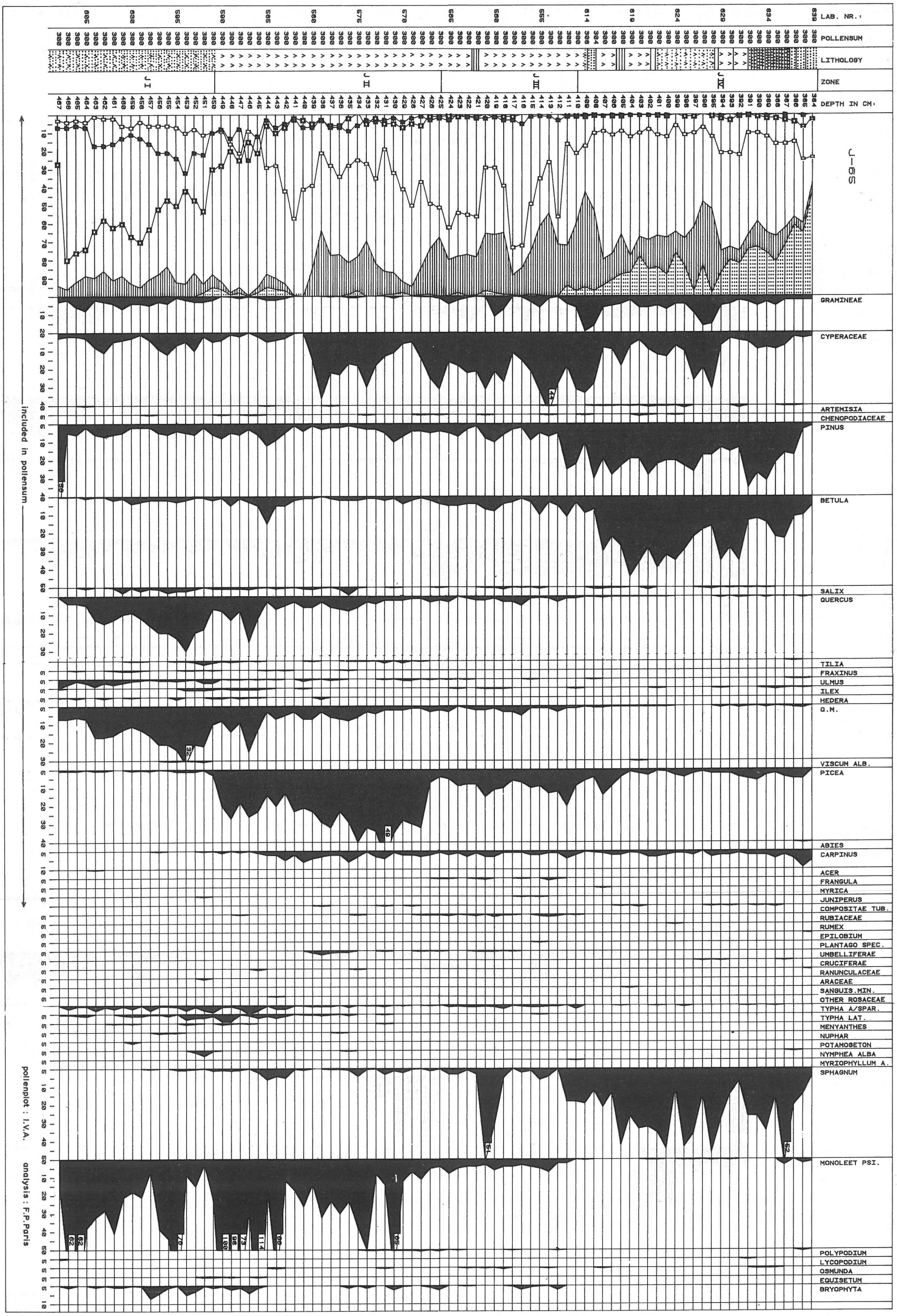


Fig. 6
Pollen diagram J 65. Legend: see figure 5.

found in the Aa area, occurs during the upper E4a or E5 phase. This is supported by data from DE GANS (1981-b) and TER WEE (1979). It should be noted, however, that in contrast with the Eemian diagrams of the Amersfoort area (ZAGWIJN, 1961), the diagrams of the Aa area show lower percentages of *Carpinus* in the E5 and E6a zones. These differences may be caused by different local edaphic as well as climatological factors.

Another striking factor is the absence of *Taxus* pollen in the described diagrams. In diagram WP this may be due to the fact that peat growth ended in the beginning of phase E4b (Table II), while in diagram J 65 this may be caused by soil forming processes giving rise to a discordance in the apparently continuous accumulation of organic material. The properties of soils as a medium for pollen accumulation are discussed by MUNAUT (1967), HAVINGA (1962), DIMBLEBY (1957, 1961), IVERSEN (1964), STOCKMARR (1975) and ANDERSEN (1979). However, uniform opinion about conservation and selective corrosion of pollen in soil horizons cannot be derived from these investigations.

As stated previously, the pollen associations of zone WP I and J I are complex and deviate from the pollen associations described by Zagwijn. In the case of diagrams described by ZAGWIJN (1961), the E4a/E4b zones represent the forest climax vegetation. Although zone J I is tentatively correlated with zone E4a it does not show the characteristic pollen association of an Eemian forest climax vegetation. As zone J I is correlated with E4a and zone J II with E5a, a hiatus is present between these zones. During this unrecorded period selective corrosion occurred which influenced the pollen content of lower parts of the investigated organic layer. This explains the relatively high percentages of *Corylus* and monolete psilate in zone J I. The occurrence of a hiatus between zones J I and J II also explains the absence of biozones with high percentages of *Carpinus* as described by ZAGWIJN (1961, 1975).

The growth of pine and spruce forest with an understorey of Ericales and *Sphagnum* in zones J III and J IV favoured the process of acidification, as a result of which an organic mineral mixture with a mor-like appearance was formed on the floors of the valley system. As these deposits are overlain by fluvial sediments which partly eroded the mor-like levels, it is difficult to derive complete Eemian pollen diagrams from these deposits. In pollen diagram WP the deviating pollen association of zone WP I may be similarly explained but occurred earlier (Table II).

If we compare our tentative results with investigations in the Federal Republic of Germany (AVERDIECK, 1962, 1967, 1979; DÜCKER & MENKE, 1970; STREMME & MENKE, 1980; SELLE, 1962), the German Democratic Republic (ERD, 1973) and in Denmark (ANDERSEN, 1961), the same deviations of pollen diagrams from Eemian deposits can be observed. The occurrence mechanism of pollen-bearing deposits in fluvial systems and its consequence for stratigraphic research will be discussed in a forthcoming paper by WESTERHOFF ET AL. (in prep.).

Table II
Chronostratigraphy and pollen zonation of the Eemian.

Aa AREA			AMERSFOORT LOCALITY (Zagwijn, 1975)	
Pollenzones of the pollen diagrams WP and J65			Pollenzones	Vegetation
	J IV		E6b	forest of Pinus, Betula and Picea
	J III		E6a	forest of Picea with Pinus, Abies, Alnus, Carpinus, Quercus
	J II		E5	forest of Carpinus with Alnus, Quercus, Corylus, Picea, Abies
WP III	J I		E4b	forest of Quercus, Corylus, Taxus, Fraxinus, Ulmus, Carpinus and Picea
WP II WP I ?			E4a	forest of Corylus with Quercus
			E3	forest of Quercus, Ulmus, Fraxinus, some Corylus and Pinus
			E2	Pinus forest with Quercus, Ulmus, Fraxinus and Alnus
			E1	Betula-Pinus forest

CONCLUSIONS

Continental Eemian deposits in two locations in the Drentsche Aa area are dated in the E4, E5 and E6 phases of ZAGWIJN (1961). In both locations there is a hiatus. This is reflected by the occurrence of a pollen association which differs from the climax vegetation due to selective corrosion during soil formation. In case of J 65 wet conditions on the Aa valley floor and a deterioration of the climate are responsible for accumulation of an organic-mineral mixture with mor characteristics on a fossil soil during the E4b, E5 and E6 phases of the Eemian.

In the Iegelpoel exposure (WP), peat growth started during the E4a phase. Outside the Aa area, in the Noordoostpolder, the so-called *Brasenia* peat described by VAN DER VLERK & FLÖRSCHÜTZ (1953) and WIGGERS (1955) developed during the E3/E4a phase of the Eemian.

Pollen conservation in the mor and peat deposits in valleys depended on local conditions, but became important during the E5 and E6 phases of the Eemian. Tentative results indicate an improvement of pollen-registration mechanism in continental Eemian deposits after the highest sea-level stand during the E5 phase (ZAGWIJN, 1978). In our view the topographic position, environment, mechanism and rate of accumulation are responsible for the varying types of Eemian pollen diagrams. Only by detailed geological and palynological investigations, supplemented by micro-morphological research, can differences in pollen diagrams of the Eemian be understood.

ACKNOWLEDGEMENTS

Mr. Konert and Mrs. Meyer prepared the pollen samples. Mr. Sion drafted the figures, and Mrs. Snijder typed the manuscript. Professor Simmers improved the English. Dr. Vandenberghe and Drs. Bohncke read the manuscript critically. Staatsbosbeheer gave permission for our research in areas under their administration.

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