STRATIGRAPHY, PALYNOLOGY AND RADIO CARBON DATA OF EEMIAN AND EARLY WEICHSELIAN FLUVIAL DEPOSITS IN THE DRENTSCHE AA VALLEY SYSTEM (DRENTE, THE NETHERLANDS)[1]

W. DE GANS[2]

ABSTRACT

De Gans, W. 1981 Stratigraphy, palynology and radiocarbon data of Eemian and early Weichselian fluvial deposits in the Drentsche Aa valley system (Drente, The Netherlands) – Geol. Mijnbouw 60: 193-202.

A survey is given of the Eemian and early Weichselian erosional and depositional fluvial history of the Drentsche Aa valley. In between these fluvial deposits four mor-like organic levels are dated on stratigraphical and palynological criteria. The lowest three levels are dated as late Eemian and the Brørup and Odderade Interstadials of the early Weichselian respectively. The fourth mor-like level is dated as middle Weichselian and tentatively called the Papenvoort pollen zone. The fluvial deposits intercalated with mor-like levels are reckoned to be the lower Aa deposits.

INTRODUCTION

In this paper the Eemian and early Weichselian fluvial deposits and stratigraphy of the Drentsche Aa valley are described. Emphasis is laid upon the investigation of the upstream part of the eastern branch of the valley system: the Andersche Diep (Fig. 1), as here most complete sequences were found within reach of hand-drilling equipment which were used for the investigation. The stratigraphy of the deposits is based on the superposition and pollen analysis of four organic levels.

THE AA-VALLEY SEDIMENTS

The Drentsche Aa valley is situated in the eastern part of the Drente plateau which is located in the northern part of The Netherlands (Fig. 1). The substratum of the valley consists of the Drente and Peelo Formations (Table I). The Drente Formation dates from the Saalian and consists predominantly of a till which is found on the interfluves of the valley system. The till overlies sand and clay of the Peelo Formation which has an Elsterian age (TER WEE, 1979).

In the Aa valley system four lithologic units are distinguished. Sorted sand and gravel with fining-upwards sequences

Table I
Stratigraphy and lithology of the Eemian and Early Weichselian Aa valley deposits.

CHRONOSTRATIGRAPHY	LITHOSTRATIGRAPHY	LITHOLOGY	VALLEY INCISION
HOLOCENE	WESTLAND FORMATION	CLAY AND PEAT	
HOLOCENE	SINGRAVEN AND GRIENDTSVEEN F.	PEAT AND GYTTJA	
WEICHSELIAN (TUBANTIAN) – LATE	TWENTE FORMATION	AEOLIAN SAND, AND SLOPE DEPOSITS	PHASE III
WEICHSELIAN (TUBANTIAN) – MIDDLE	Aa DEPOSITS – MIDDLE AND UPPER Aa DEP.	FLUVIAL SAND WITH LOAM LAYERS	PHASE II
WEICHSELIAN (TUBANTIAN) – MIDDLE – ET 3 PAPENVOORT	Aa DEPOSITS – LOWER Aa DEPOSITS – DrA4	FLUVIAL SAND WITH MOR-LIKE LAYERS	
WEICHSELIAN (TUBANTIAN) – EARLY – ET 2 ODDERADE	Aa DEPOSITS – LOWER Aa DEPOSITS – DrA3	FLUVIAL SAND WITH MOR-LIKE LAYERS	
WEICHSELIAN (TUBANTIAN) – EARLY – ET 1 BRØRUP	Aa DEPOSITS – LOWER Aa DEPOSITS – DrA2	FLUVIAL SAND WITH MOR-LIKE LAYERS	
EEMIAN – EM	Aa DEPOSITS – LOWER Aa DEPOSITS – DrA1	FLUVIAL SAND WITH MOR-LIKE LAYERS	PHASE IA?
			PHASE I
SUBSTRATUM	DRENTE FORMATION	TILL AND FLUVIOGLACIAL SAND	
SUBSTRATUM	PEELO FORMATION	FINE SAND AND CLAY (POTKLEI)	

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[2]Institute of Earth Sciences, Free University, De Boelelaan 1085, 1007 MC AMSTERDAM, The Netherlands.

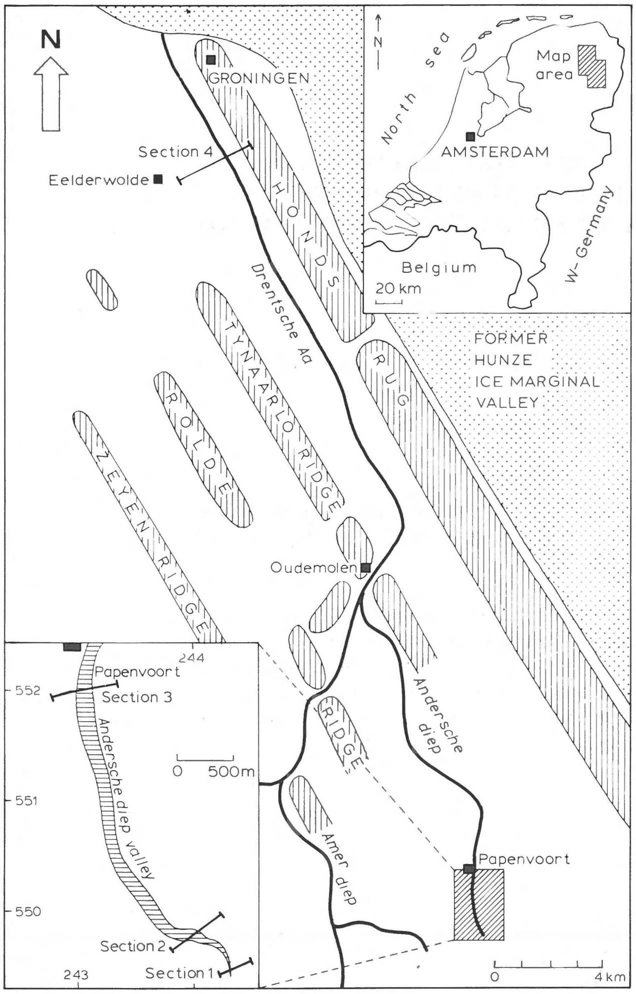
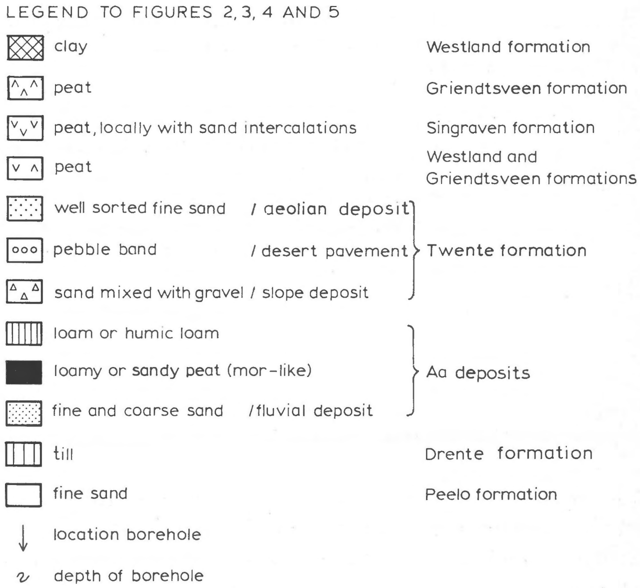


Fig. 1
The Drentsche Aa area and the location of the cross sections (Figs. 2-5).

and locally intercalated with loam, humic loam or peat layers is interpreted as a fluvial deposit. Unsorted sand with gravel and well-sorted sand with a grain-size median of 150-210 μm are considered as slope or aeolian deposits respectively. These deposits are all assigned to the Twente Formation (ZAGWIJN & VAN STAALDUINEN, 1975). Overlying the Twente Formation peat may be found which, owing to its facies and position, is reckoned to be in the Singraven, Griendtsveen or Westland Formation. The outlines of the valley sediments and morphology are described by DE GANS (1980).



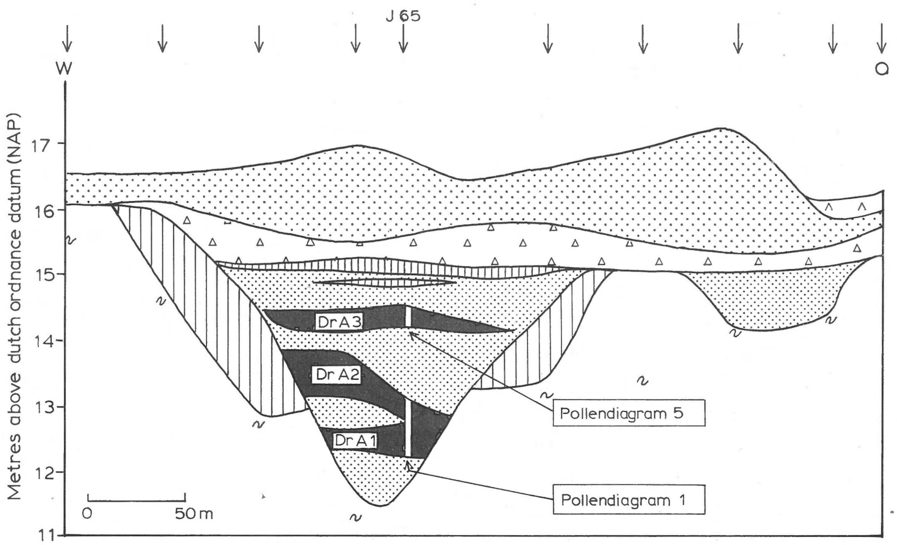


Fig. 2
Cross section 1 – Papenvoort I (Modified after Jagerman, 1979).

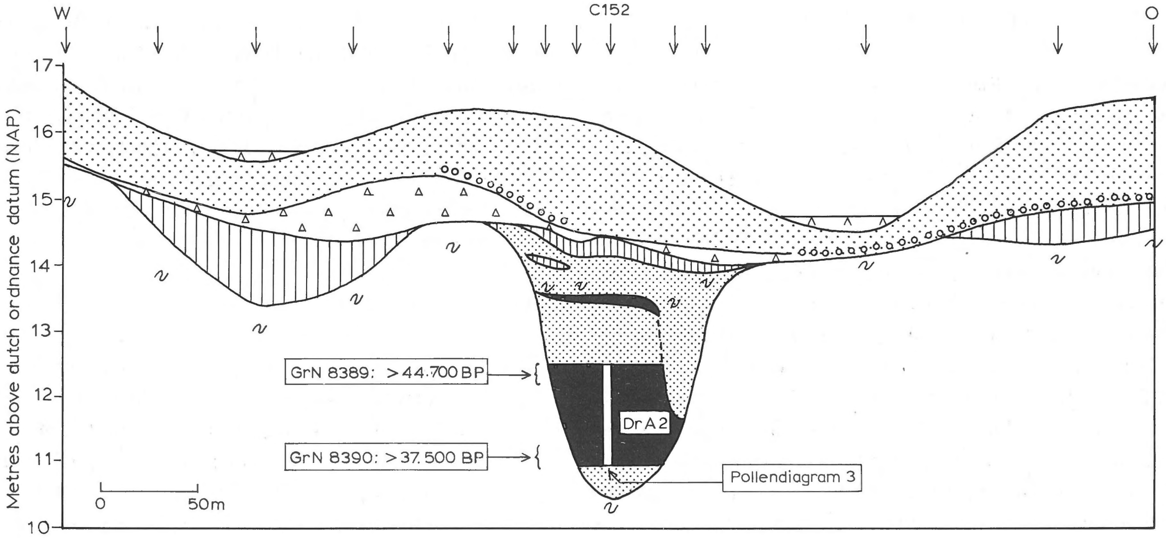


Fig. 3
Cross section 2 – Papenvoort II (Modified after Eschweiler & De Fretes, 1976; legend see Fig. 2).

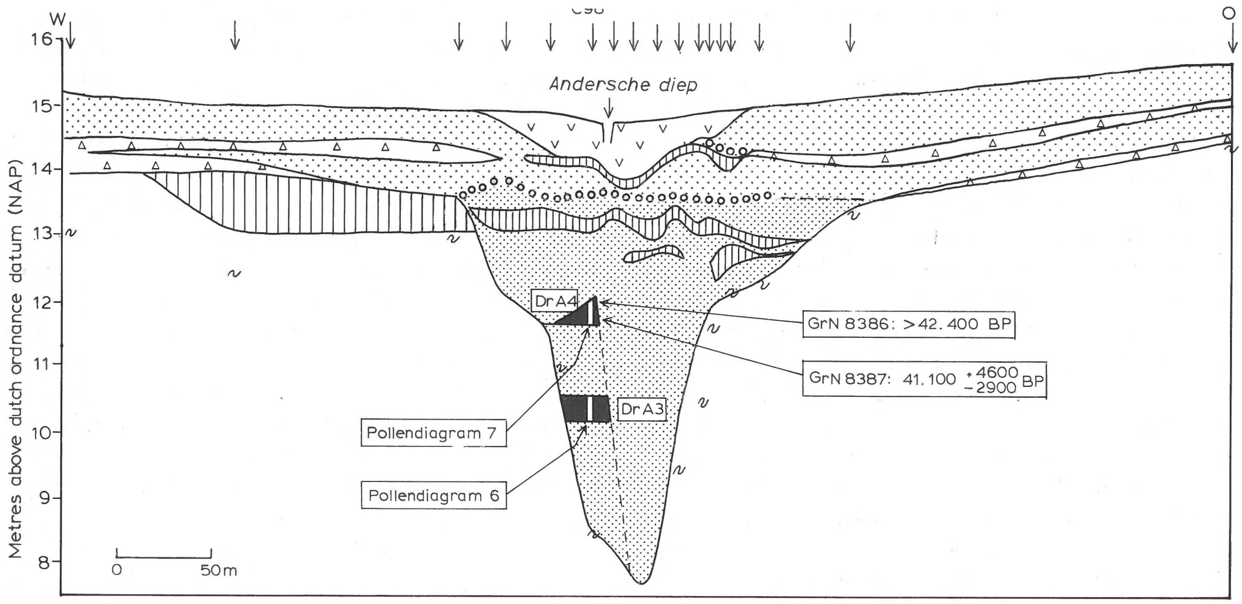


Fig. 4
Cross section 3 – Papenvoort III (Legend see Fig. 2).

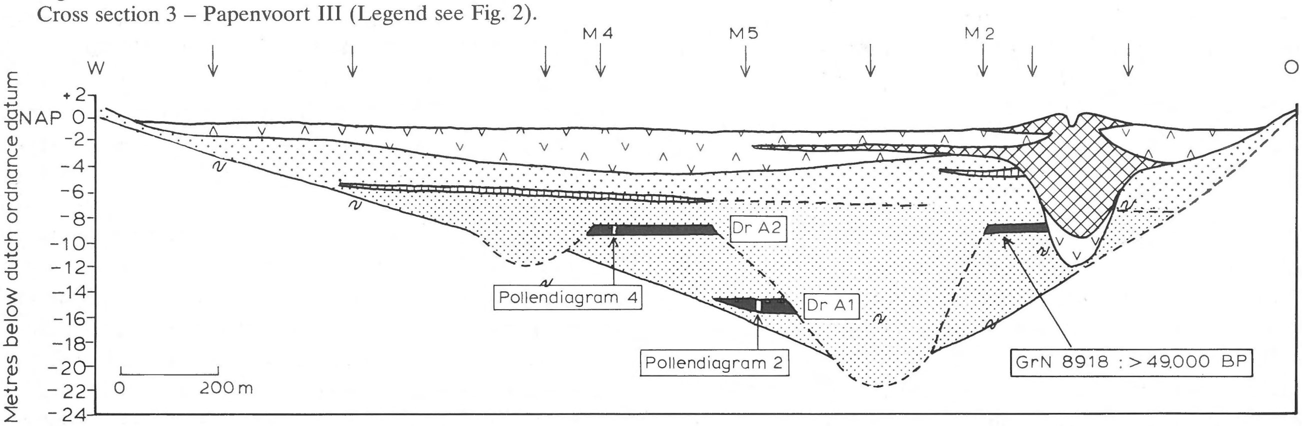


Fig. 5
Cross section 4 – Eelderwolde (Legend see Fig. 2).

THE CROSS SECTIONS

To study the oldest fluvial valley sediments three detailed cross sections from the upstream part of the Andersche Diep valley (Figs. 2, 3 and 4) and one section from the downstream part of the Aa valley (Fig. 5) have been constructed. The location of the sections is indicated in figure 1. The basal fluvial sediments in all sections consist of sorted gravel and sand and contain some organic debris in the Andersche Diep sections. These deposits have fining-upwards sequences on top of which organic layers may occur. The lowest four organic layers are anticipating the palynological data called DrA1, DrA2, DrA3 and DrA4 (Figs. 2, 3, 4 and 5) respectively. They have a black or dark brown colour and are composed of sandy or loamy organic material often with a peaty constitution. They are up to 1.5 m thick and have a sticky to platy structure in places, while their demarcation to the underlying fluvial deposits is sharp. The lowest levels may contain wood fragments. The partly decomposed organic matter in all four levels gives them a mor-like appearance as described by DUCHAUFOUR (1977) and VISSER (1980). The palynological data of these four mor-like levels will be discussed in this paper.

After deposition of level DrA4 a relatively narrow but deep fluvial incision took place (Fig. 4). The subsequent fluvial sediments contain loam or humic loam layers in their upper parts (Figs. 2, 3 and 4). These organic levels show in general a fine lamination and have a light brown colour due to dispersed organic material.

In the upstream part of the Andersche Diep valley the fluvial deposits are covered by a layer of unsorted sand with gravel up to 0.5 m in thickness which is interpreted as a slope deposit (Figs. 2 and 3). In cross section 3 (Fig. 4) the fluvial deposits are covered by a pebble band which is interpreted as a desert pavement (DE GANS, 1980; VAN DER HAMMEN & WYMSTRA, 1971; VAN DER HAMMEN ET AL., 1967).

In all sections well-sorted aeolian sand overlies the slope or fluvial deposits. They cover the pre-existing relief locally completely (Figs. 2 and 3). This aeolian sand is in places overlain by peat which is reckoned to belong to the Griendtsveen Formation (Fig. 3), Singraven Formation (Fig. 4) or Westland Formation (Fig. 5). The Westland Formation also contains marine clay in the downvalley area (Fig. 5).

POLLEN ANALYSES

From sections 1, 2 and 3 (Figs. 2, 3 and 4) cores were taken with a hand-sampling auger (∅ 50 mm) from the mor-like levels for pollen-analytical treatment. The cores from section 4 (Fig. 5) were obtained from the Rijkswegen Laboratory and sampled by the Geological Survey. Pollen slides were prepared from each centimetre of the cores. These pollen samples were treated with KOH and subsequently acetolysed and subjected to bromoform separation. In the diagrams the percentages are calculated on the basis of the sum of AP (arboreal pollen) and 'dry' NAP (non-arboreal pollen). Generally a sum of 300 AP+NAP has been used. The pollen diagrams are classified in four groups: type EM, type ET1, type ET2 and type ET3 which code indicates their Eemian (EM) or early Weichselian/Tubantian (ET) origin. They are successively derived from the mor-like organic levels DrA1, DrA2, DrA3 and DrA4 (Table I).

Pollen diagram type EM

This type is represented by diagrams 1 and 2 (Figs. 6 and 7), which are derived respectively from boring J65 (section 1, Fig. 2) and M5 (section 4, Fig. 5). In diagram 1 (Fig. 6), which is the most complete, three zones are distinguished, according to ZAGWIJN (1961): E5a, E5b and E6. Zone E5 is characterized by high percentages of *Corylus* and the presence of elements of Quercetum mixtum. Zone E5b demonstrated a maximum of *Alnus, Carpinus* and *Picea,* whereas zone E6 is characterized by decreasing percentages of *Alnus, Picea* and *Carpinus* and increasing percentages of *Pinus* and *Betula.* In this zone higher percentages of Ericaceae and *Sphagnum* are also found. Diagram 2 (Fig. 7) shows a detailed development of zones E5 and E6a in which the former is characterized by high percentages of *Alnus* (50%), *Picea* (30%) and *Carpinus* (6%), low percentages of thermophilous elements (especially Quercetum mixtum), and a maximum of monolete psilate spores in the middle part of this zone. The latter zone (E6a) shows a decrease of *Picea* and a slight increase of *Pinus* and *Betula.* If we compare these diagrams with the data of ZAGWIJN (1961) and ZAGWIJN & VAN STAALDUINEN (1975), type EM can be dated as late Eemian, although the upper part of diagram 1 may eventually correspond to type ET1. A detailed palynological investigation of the Eemian in the valley system will be discussed by PARIS ET AL. (in prep.).

Pollen diagram type ET1

From this type two diagrams are also presented: diagram 3 (Fig. 8) and diagram 4 (Fig. 9). They are derived respectively from boring C152 (section 2, Fig. 3) and M4 (section 4, Fig. 5). Diagram 4 is most complete and shows three distinct zones. The lowest one has a dominance of *Pinus* and *Picea.* The middle zone demonstrated a decrease of *Picea* and an increase of *Betula*, while the upper zone is characterized by higher percentages of *Pinus* and *Betula* and an increase of *Alnus.* This vegetational development corresponds with zone EW IV of ZAGWIJN (1961) and ZAGWIJN & VAN STAALDUINEN (1975) and with zone EW 4 of AVERDIECK (1967). This means that type ET1 can be correlated with the Brørup Interstadial. Measurements of the size of pollen grains of *Picea* in diagram 3 confirm the occurrence of *Picea omoricoides.* In diagram 3, the lowest zone as found in diagram 4, is absent. From organic level DrA2 three radiocarbon datings are available, which however do not add much further information. The

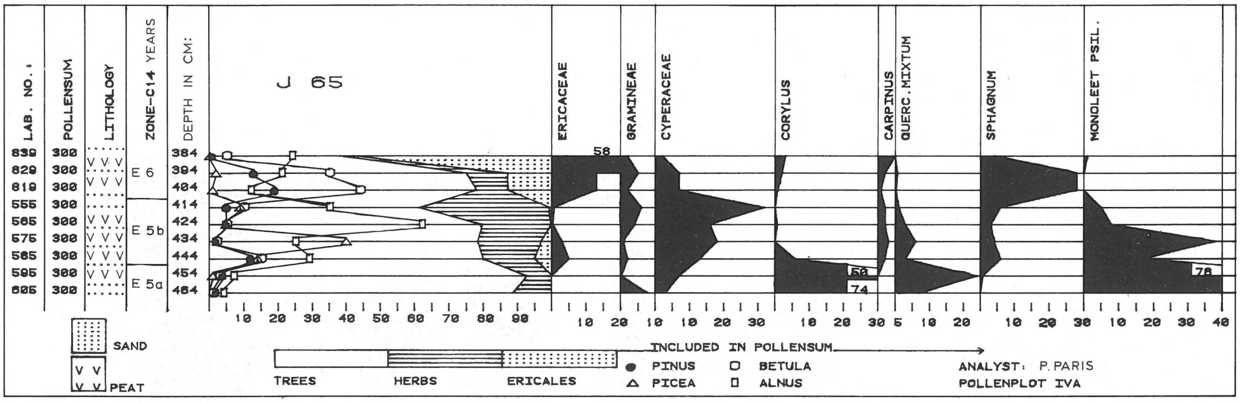


Fig. 6
Pollendiagram 1.

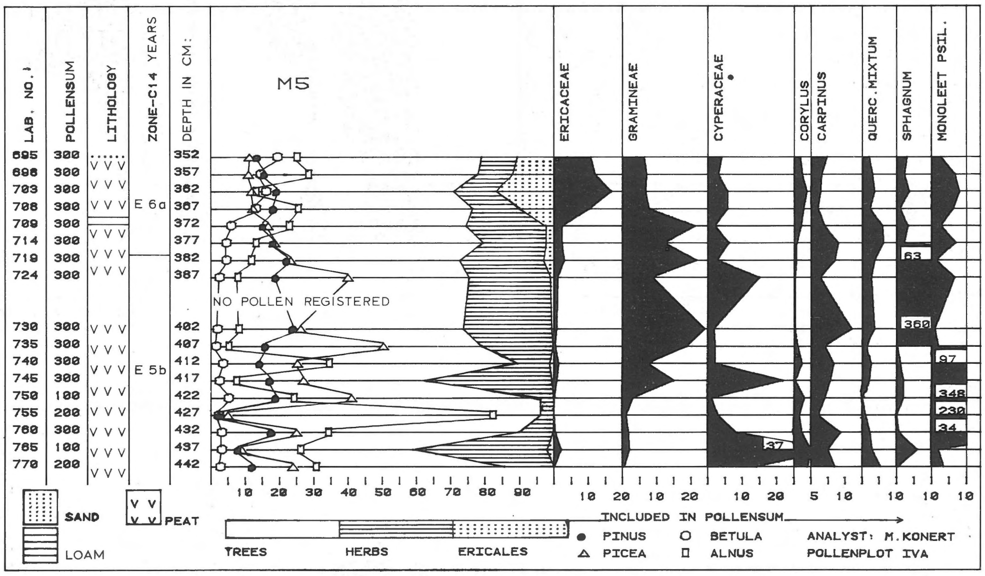


Fig. 7
Pollendiagram 2.

top of this level in boring C152 (section 2, Fig. 3) is dated > 44,700 BP (GrN 8389), the basal part of the level is dated > 37,500 (GrN 8390). A radiocarbon dating from this level in boring M2 (section 4, Fig. 5) gives > 49,000 (GrN 8918).

Pollen diagram type ET2

This type is represented by diagrams 5 (Fig. 10) and 6 (Fig. 11), which are derived from boring J65 (section 1, Fig. 2) and boring C98 (section 3, Fig. 4) respectively. Diagram 5 is derived from organic level DrA3, which is situated in a stratigraphic position above the organic levels DrA1 and DrA2 (Fig. 2). The diagram shows high percentages of *Betula* (60%) and percentages of *Pinus* up to 30%. *Corylus* and *Alnus* are present in low percentages. The predominance of *Betula* may be influenced by local factors (AVERDIECK, 1967) and is explained as a pioneer vegetation on the frequently eroded or flooded valley slopes and floors. Pollen diagram type ET2 is, because of its position and pollen data, correlated with the Odderade Interstadial diagrams as described by AVERDIECK (1967). Diagram 6, which is more complete than diagram 5, demonstrates that *Picea* was present in the first part of the Odderade Interstadial also. The striking similarity between the Brørup and Odderade Interstadial vegetation will be discussed in a forthcoming paper (WESTERHOF ET AL., in prep.).

Pollen diagram type ET3

This type is represented by diagram 7 (Fig. 12) which is derived from a mor-like level above DrA3 in boring C98 (section 3, Fig. 4). The diagram shows a decrease of arboreal

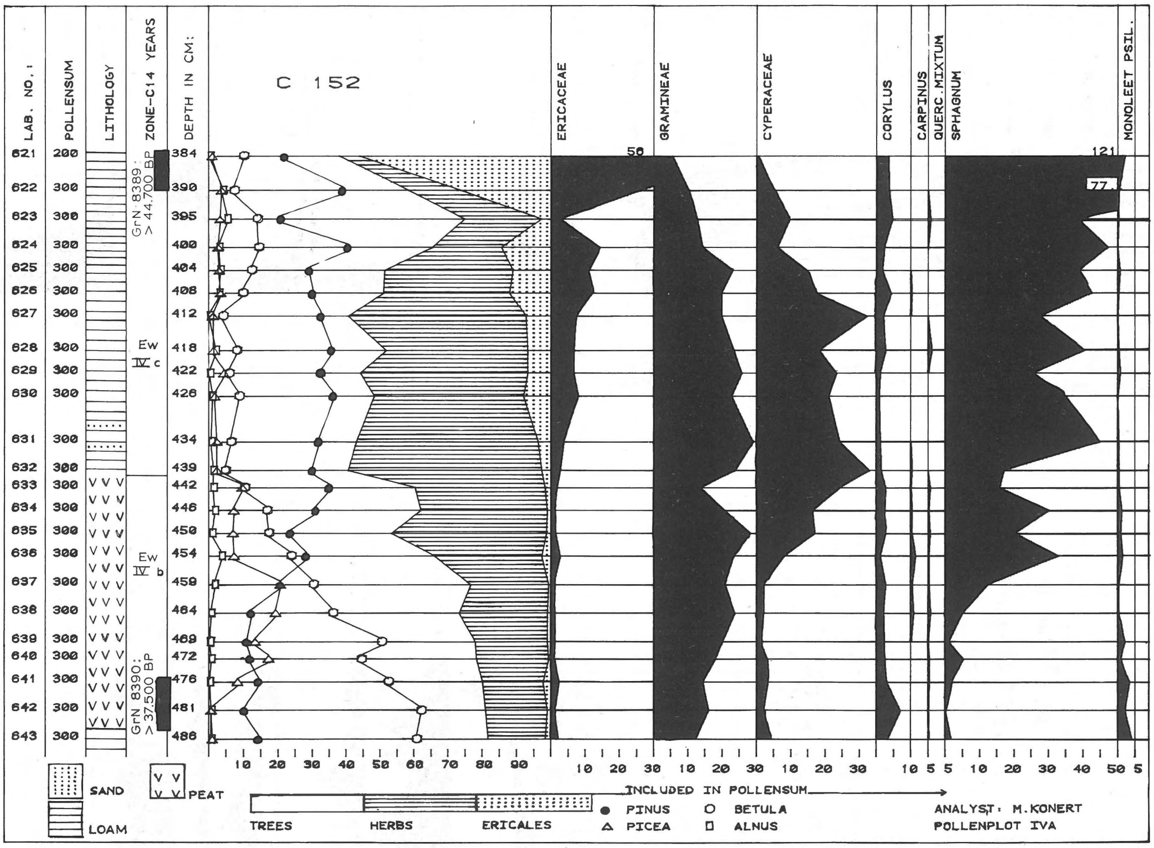


Fig. 8
Pollendiagram 3.

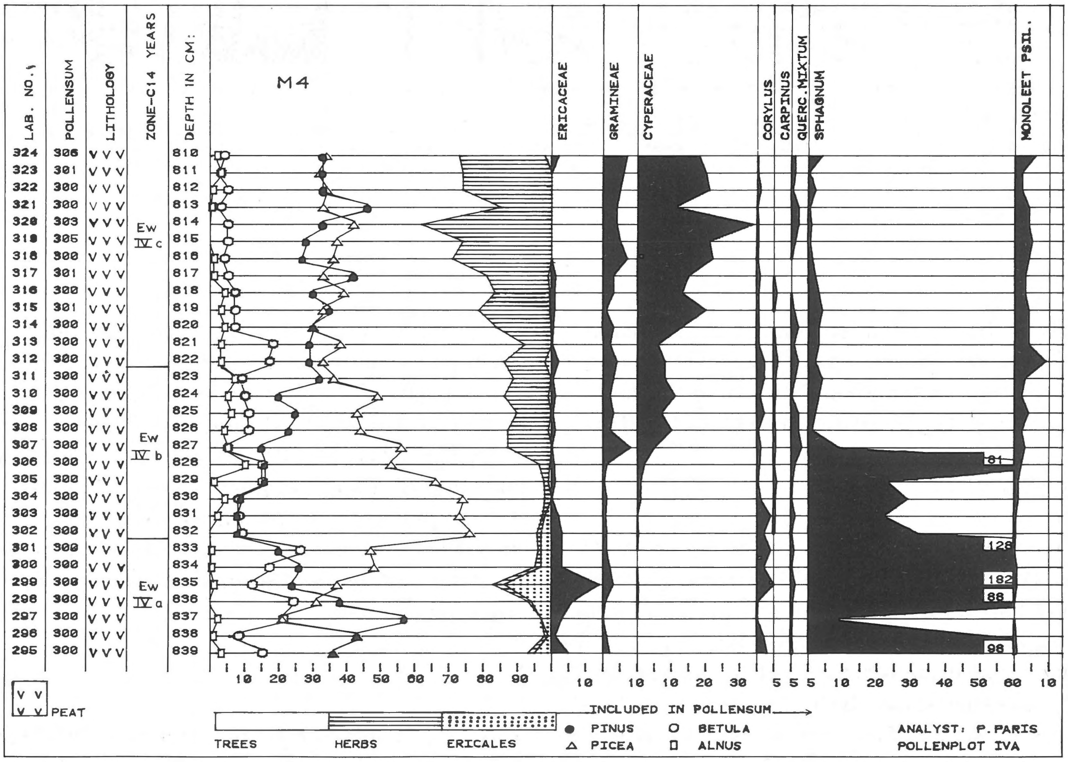


Fig. 9
Pollendiagram 4.

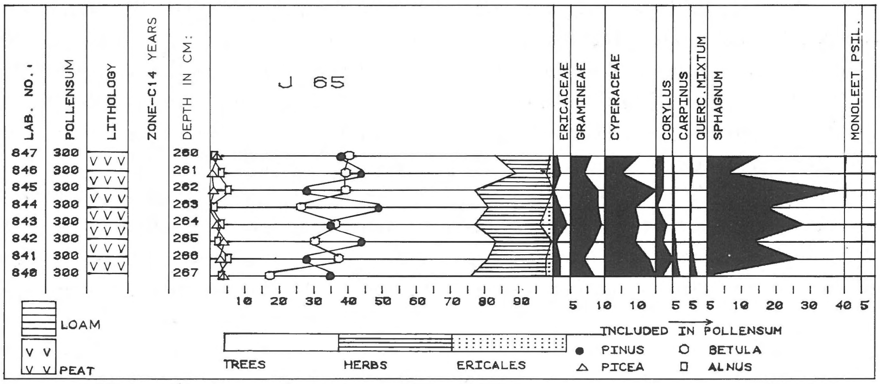


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Fig. 10
Pollendiagram 5.

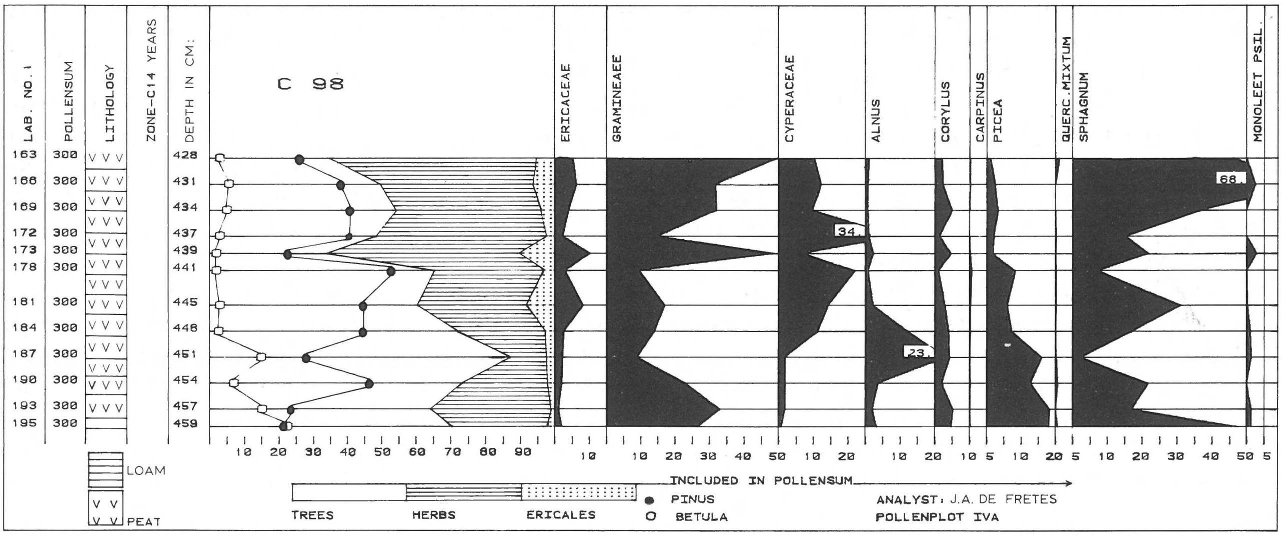

Fig. 12
Pollendiagram 7.

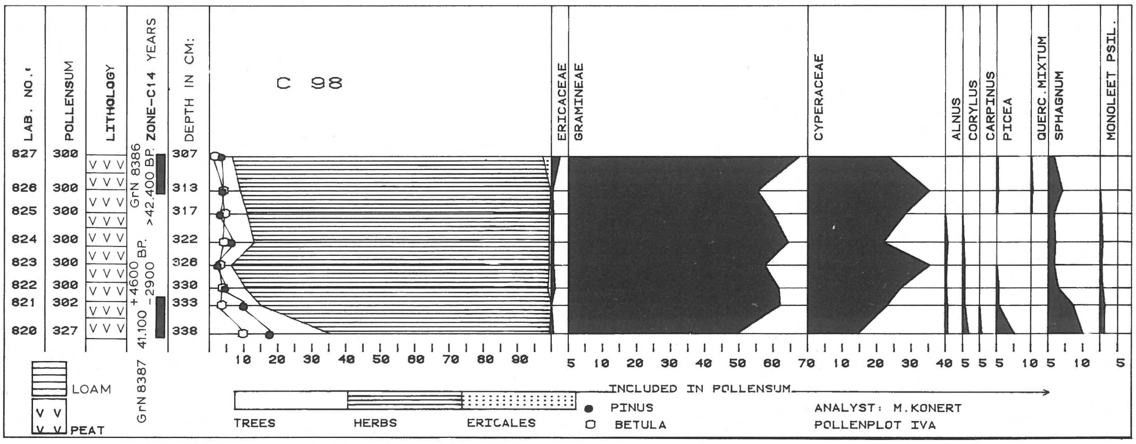

Fig. 11
Pollendiagram 6.

elements and a predominance of herbs. Notably Cyperaceae become important. The vegetation, as interpreted from the diagram, represents a wet tundra vegetation as described by WALTER & STRAKA (1970) and HULTÉN (1971). From organic level DrA4 in boring C98 the following radiocarbon dates were obtained: the top of the organic level > 42,200 BP (GrN 8386) and the basal part 41,100 $^{+4600}_{-2900}$ BP (GrN 8387). Because the diagram must be dated after the Odderade Interstadial and is slightly distinct from most other middle Weichselian diagrams it is tentatively called the Papenvoort pollen zone.

DISCUSSION

The pollen diagrams which are derived from four superposed but lithologically identical mor-like organic levels in between the oldest fluvial deposits in the Drentsche Aa valley are interpreted as Eemian (type EM, DrA1), Brørup (type ET1, DrA2) and Odderade diagrams (type ET2, DrA3) or classified as a Papenvoort zone (type ET3, DrA4) on he basis of their pollen content and stratigraphic position. The diagrams from the successive levels represent a type of vegetation in which the arboreal elements decrease and herbs (especially Cyperaceae) increase, indicating a lower temperature in each subsequent registered period. No indications were found for colder phases in between these levels during deposition of the fluvial deposits as recorded by BOWEN (1978), ZAGWIJN (1975) and VAN DER HAMMEN ET AL. (1967).

Organic level DrA1 and the related underlying fluvial deposits correspond in time and facies to the Asten Formation (ZAGWIJN & VAN STAALDUINEN, 1975). However, as these deposits cannot be discriminated on lithological criteria from the overlying Weichselian fluvial deposits, which correspond to the Twente Formation, the term Aa deposits is introduced to embrace all Weichselian and older fluvial deposits in the Drentsche Aa valley system (Table I). The fluvial sedimentary successions with mor-like organic levels will be called lower Aa deposits.

The organic levels DrA1-DrA4 represent fossil soil horizons formed upon fluvial deposits and therefore indicate approximately the position of the floodplain during the late Eemian and subsequent Weichselian interstadials when fluvial activity obviously decreased to a minimum. They are likely to have been formed all over the valley floor but may locally have been removed by fluvial erosion. The tentative positon of these subsequent floodplains is given in figure 13, which indicates that, starting in the Eemian, fluvial sedimentation continued in the early Weichselian. The downstream elevation of level DrA1 (Fig. 13) corresponds with the highest marine Eemian sea level (14 to 15 m below Dutch Ordnance Datum/NAP) as found in the former Hunze ice-marginal valley (DE GANS, 1980; TER WEE, 1979). There are no indications for an Eemian sea level 8 m below NAP in the Hunze area as recorded by ZAGWIJN (1961) in the Eem area. One explanation is that marine Eemian sediments were not deposited at this level in the Hunze ice-marginal valley or alternatively, they are located now in a lower position because of regional subsidence. It is concluded that the early fluvial sedimentation in the valley was stimulated by a rising Eemian sea level. This sedimentation continued in the early and middle Weichselian, notably in the upstream valley part, although sea level according to data of ZAGWIJN (1977) and MÖRNER (1974) was again low.

As fluvioglacial deposits are absent in the Aa valley (DE GANS, 1980) the initial fluvial incision of the valley (phase I,

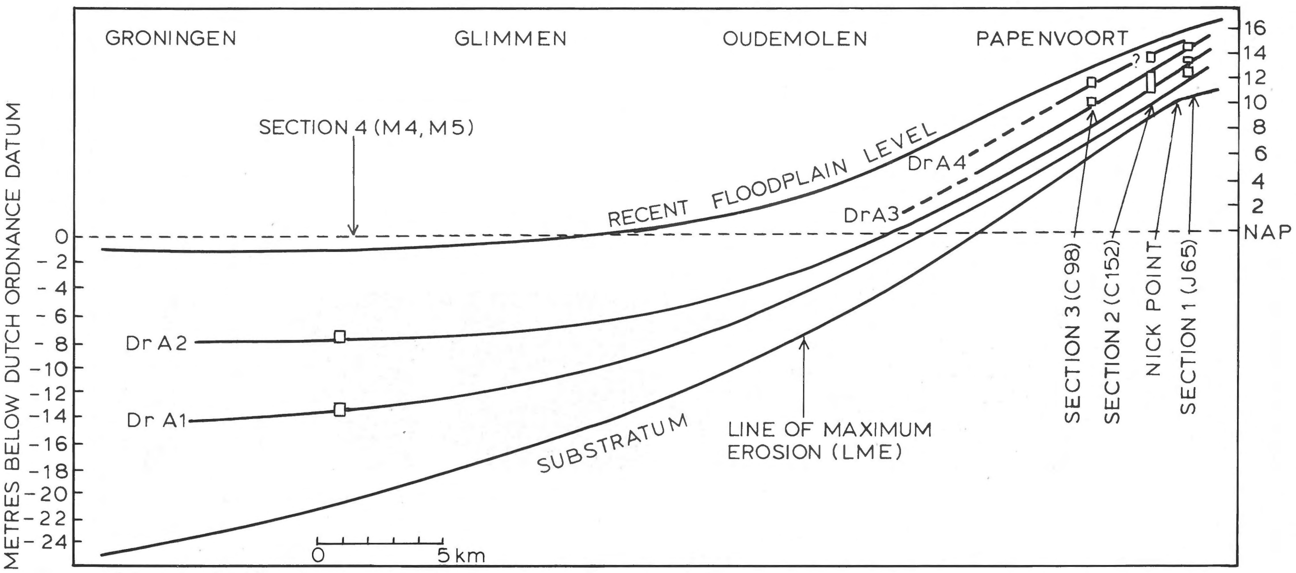

Fig. 13
Position of the mor-like organic levels in the Drentsche Aa and Andersche Diep valleys.

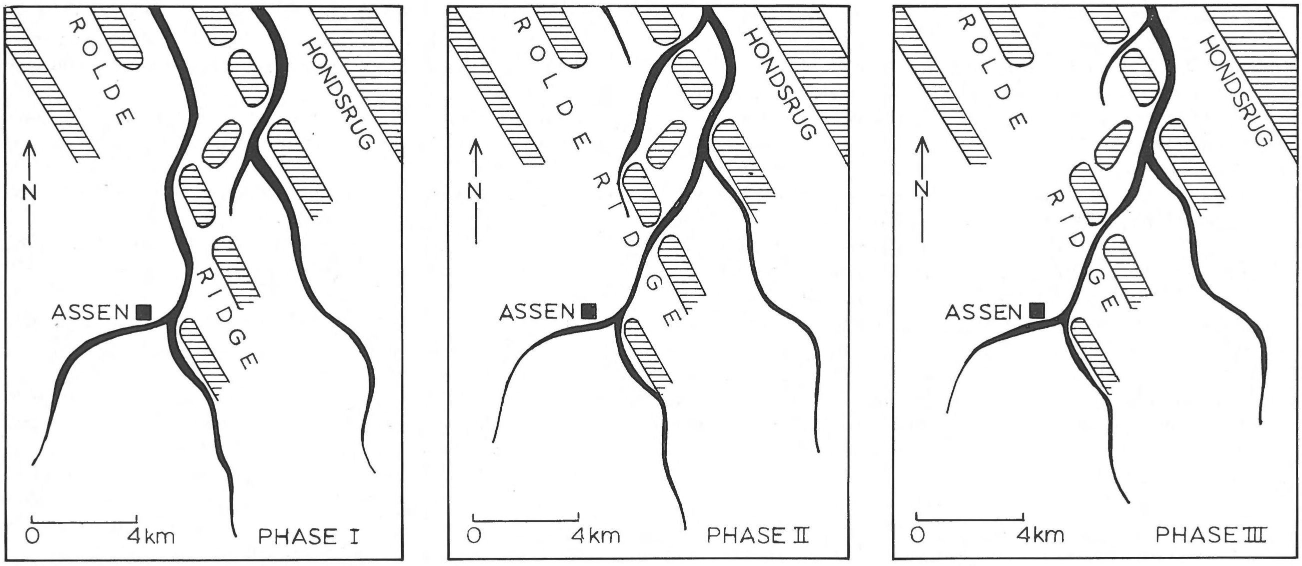

Fig. 14
Tentative Drentsche Aa drainage patterns after the subsequent erosion phases.

Table I) took place at the end of the Saalian or beginning of the Eemian. It was probably caused by the then low local base level of erosion which was located on top of the fluvioglacial deposits in the Hunze ice-marginal valley at approximately 20-30 m below NAP. Tentatively this first incision is correlated with phase V or phase E of the Saalian glaciation (JELGERSMA & BREEUWER, 1975; TER WEE, 1962).

Another fluvial incision is dated in the Eemian and correlated with the nickpoint on the line of maximum erosion (Fig. 6; DE GANS, 1980). The significance of this intermediate phase is not yet fully understood. The deepest incision in the valley (phase II) took place after the development of organic level DrA4 (Fig. 4). This fluvial incision is probably the result of the low middle Weichselian sea level as indicated by MÖRNER (1974), which caused a retarded fluvial erosion in the Drentsche Aa valley because of its remote position with respect to the then coastline. This incision caused a narrow erosional valley to develop (Fig. 4). The distribution of the Eemian and early Weichselian organic levels in the valley gives rise to a tentative reconstruction of the Drentsche Aa drainage system during the subsequent phases of valley development (Fig. 14; Table I).

CONCLUSIONS

The early history of the Drentsche Aa valley is characterized by fluvial processes which gradually filled up the valley system. This fluvial sedimentation is interrupted by the formation of mor-like organic layers. These are palynologically dated in the late Eemian and early and middle Weichselian, and correlated with former floodplain levels. A striking phenomenon is the absence of an organic level which may be correlated palynologically with the Amersfoort Interstadial. The deepest incision (phase II) in the valley took place in the middle Weichselian. The Eemian and Weichselian fluvial deposits in the valley system are reckoned to belong to the Aa deposits.

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