

LITHOLOGY, STRATIGRAPHY, AND PALYNOLOGY OF HOLOCENE DEPOSITS IN THE DRENTSCHE AA VALLEY SYSTEM¹

W. DE GANS²

ABSTRACT

De Gans, W. 1983 Lithology, stratigraphy, and palynology of Holocene deposits in the Drentsche Aa valley system – Geol. Mijnbouw 62: 285-295.

The brook deposits of the Singraven Formation in the Aa valley are described and dated by respectively six cross sections and seven pollen diagrams. Three lithozones are discriminated: a sand bed, a detritic gyttja bed and a peat bed. The influence of the Holocene sea level rise on the deposition of the detritic gyttja bed in the downstream part of the valley is discussed.

From the palynological data it is concluded that the Singraven Formation in the valley is confined to the Holocene. Two fluvial erosion phases causing headward erosion are distinguished: a Late Dryas phase, anticipating the deposition of the Singraven Formation, and a Late Boreal/Early Atlantic phase. Possible causes of these erosion phases are mentioned.

INTRODUCTION

Brook valleys are conspicuous features of the flat areas in the Pleistocene landscape of the Netherlands. Despite that, few studies have been made on their origin, geology and geomorphology. To gain insight in the development of these valleys as a function of the Late Quaternary climate, the Drentsche Aa valley was chosen for detailed investigations.

Four studies on this valley have been published so far. They concern the Eemian and Weichselian history of the Aa valley system (DE GANS, 1980; 1981; 1982; DE GANS & CLEVERINGA, 1981). In this paper the youngest fluvial or brook deposits are described and dated. These deposits are considered to belong to the Singraven Formation (ZAGWIJN & VAN STAALDUINEN, 1975; TER WEE, 1979).

THE AA VALLEY

The Drentsche Aa valley is located in the eastern part of the Drente plateau which is situated in the northern part of The Netherlands (Fig. 1). The valley system has been eroded into the Drente and Peelo Formations (DE GANS, 1980). The Drente Formation comprises a till, while the Peelo Formation

is composed of sand and clay (TER WEE, 1979; ZAGWIJN & VAN STAALDUINEN, 1975). The Weichselian and older fluvial deposits in the Aa valley are assigned to the Aa deposits (Table I) and have been described by DE GANS (1981) and DE

Table I
Lithology and stratigraphy of the Late Quaternary Aa valley deposits.

chronostratigraphy		lithology	lithostratigraphy	
Holocene	Subatlantic	clay	Westland Fm	
	Subboreal			
	Atlantic	detritic gyttja	Singraven Formation	
	Boreal	sand		
	Preboreal			
Weichselian	Late Glacial	Late Dryas	sand, pebble bands and humic loam	
		Allerød		
		Early Dryas		
		Bølling		
	Pleniglacial	gravel, sand, loam and organic layers		Aa deposits
	Early Glacial			
Eemian	till	Drente Fm		
Saalian				
Holsteinian				
Elsterian	sand and clay	Peelo Fm		

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² Instituut voor Aardwetenschappen, Vrije Universiteit, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands.

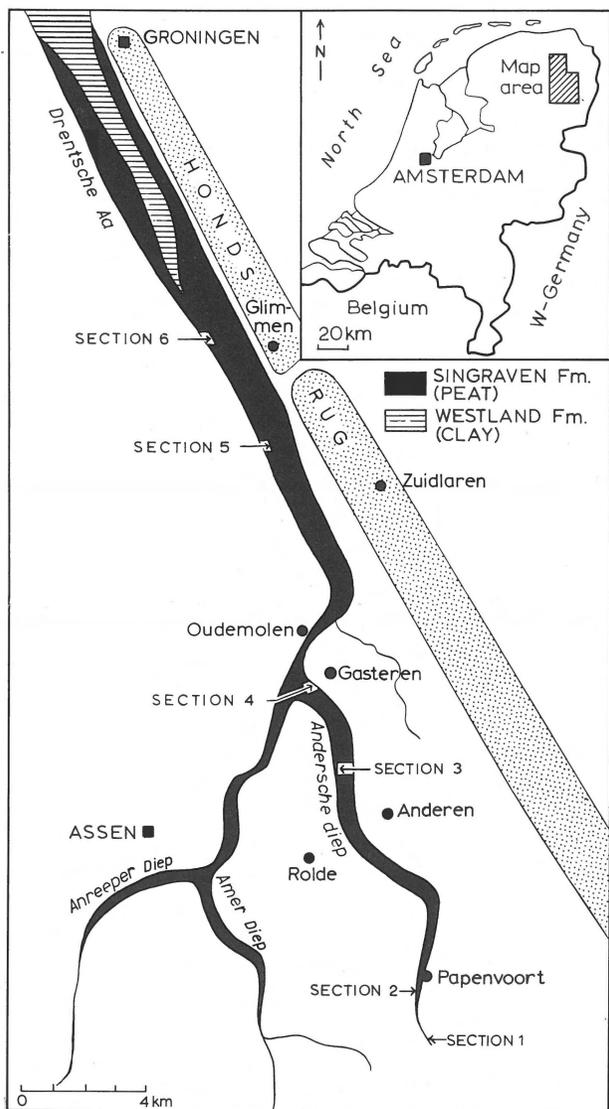


Fig. 1
The location of the Singraven and Westland Formations in the Aa valley system.

GANS & CLEVERINGA (1981). The top of the Aa deposits is marked by a pebble band or stone line overlying coarse sand. The pebble band is interpreted as a desert pavement (DE GANS & CLEVERINGA, 1981). This sequence of a coarse sand with a pebble band on top is correlated with the Beuningen Gravel Bed and dated Upper Pleniglacial (DE GANS & CLEVERINGA, 1981). After the deposition of the Beuningen Gravel Bed large parts of the Aa valley system were covered by aeolian sand and other sediments. The deposition of this aeolian sand continued locally until the early Holocene (CLEVERINGA ET AL., 1977) and these sediments are assigned to the Twente Formation. The fluvial valley sediments overlying the Twente Formation are assigned to the Singraven Formation and consist predominantly of organic material (VAN DER HAMMEN & WYMSTRA, 1971; ZAGWIJN & VAN STAALDUINEN, 1975; DE GANS, 1980).

THE SINGRAVEN FORMATION

The Singraven Formation was first described by VAN DER HAMMEN & WYMSTRA (1971) in the Dinkel area where it is composed of sand, sandy clay, clay and peat. Here, the thickness of the Formation does not exceed a few metres and is on palynological arguments dated as Holocene. DOPPERT ET AL. (1975) and TER WEE (1979) suggested that the basal part of the Formation may also have a Late Glacial age; for the Aa valley, however, this is questionable as the Formation overlies Younger Coversand deposits of the Twente Formation (DE GANS, 1980). VAN STAALDUINEN & VAN VEEN (1975) discriminate a clastic part of the Formation, which is composed of fine sand, clay and loam, and an organic part which is composed of peat, gyttja and dy. The Singraven Formation peat is mainly composed of eutrophic and mesotrophic peat. The discrimination between this peat and the peat being part of the Westland Formation as found in the downstream part of the valley is arbitrary (DE GANS, 1980; VAN STAALDUINEN & VAN VEEN, 1975). This also holds for the discrimination between peat of the Singraven and Griendtsveen Formations in the upstream part of the valley system, as the latter, mainly composed of oligotrophic peat, may contain some mesotrophic or eutrophic peat in its basal part (TER WEE, 1979).

THE CROSS SECTIONS

To facilitate the study of the lithology and to establish the extension of the Singraven Formation in the Aa and Andersche Diep valleys, six cross sections were constructed from data obtained by drilling, using soil-, Van der Staay-, and gouge-type augers. The location of the sections is indicated in Fig. 1.

Cross section 1 – Papenvoort IV

This section (Fig. 2) is located near the southern water divide of the Andersche Diep valley. In this section the Aa deposits are completely covered by aeolian sand and slope deposits which conceal the former Pleniglacial relief of the valley. In the western part of the section a shallow depression in the aeolian sand is filled with a thin layer of earthed peat. This peat may be assigned to the Griendtsveen Formation as well as to the Singraven Formation. The depression can be traced following the former valley as far as section 2.

Cross section 2 – Papenvoort III

This cross section (Fig. 3) is located 2 km north of section 1. In this section, the top of the Aa deposits is marked by a pebble band which is correlated with the upper part of the Beuningen Gravel Bed (DE GANS & CLEVERINGA, 1981). It is overlain by aeolian sand, intercalated by a humic loam layer from which a pollen diagram type LT5 has been derived. Consequently, the top of this layer has been dated Allerød Interstadial (DE GANS

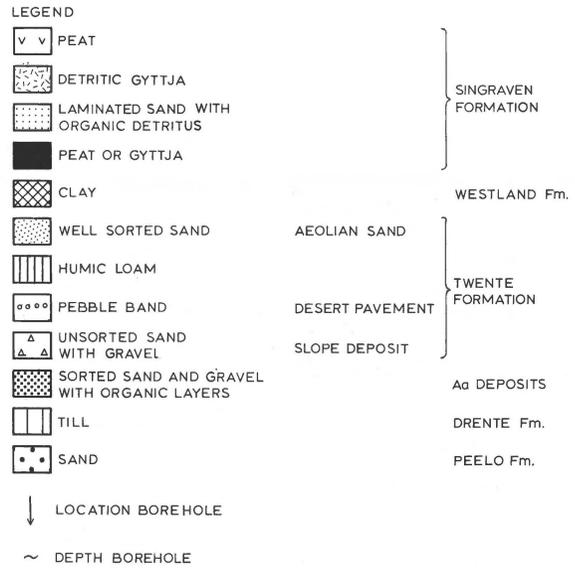
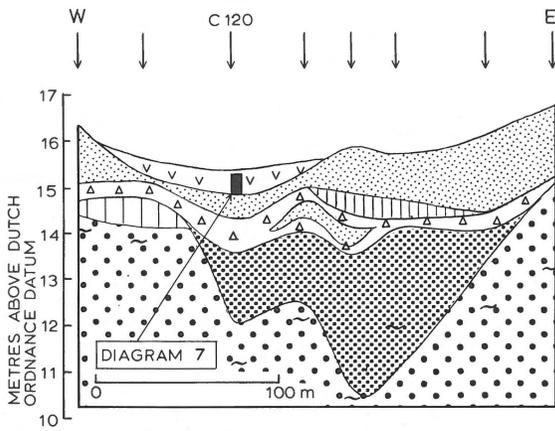


Fig. 2 Cross section 1 (Papenvoort IV; location Fig. 1). In this upstream section the basal part of the Singraven Formation has an Atlantic age. The Middle Weichselian Aa deposits are completely covered by Late Glacial Younger Coversand.

& CLEVERINGA, 1981). The aeolian sand is interpreted as Younger Cover sand. The peat layer which overlies the aeolian sand has a maximum thickness of 1 m and contains the wood fragments and other macro remains. This peat is assigned to the Singraven Formation. The interface between this peat layer and the underlying loam layer contains some gravel and is probably erosional.

Cross section 3 – Anderen

The Singraven Formation as found in this section (Fig. 4) is located in an erosional valley which is cut through the aeolian sand of the Twente Formation into the underlying Aa deposits. The Singraven Formation is composed of peaty gyttja and peat, and passes upwards into *Carex/Phragmites* peat. Locally within the Formation there are sand intercalations. The section shows that the recent Andersche Diep rivulet (*Andersche Diepje*) is located west of its original position because of human interference.

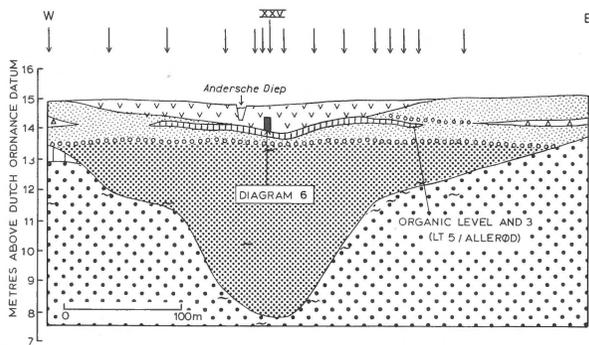


Fig. 3 Cross section 2 (Papenvoort III; location Fig. 1; legend Fig. 2). Upstream section with the basal Atlantic part of the Singraven Formation located in an erosive position upon the Late Glacial Coversand.

Cross section 4 – Gasteren

This section (Fig. 5), near the village of Gasteren, shows the Singraven Formation in a position at the eastern fringe of the former Pleniglacial valley. This erosional valley cuts through the aeolian sand of the Twente Formation and the Aa deposits into the sand of the Peelo Formation. The basal part of the Singraven Formation is composed of peat with wood fragments and intercalations of fine sand. The upper part of the Formation is composed of *Carex/Phragmites* peat.

Cross section 5 – De Punt

Schematic section De Punt (Fig. 6) shows only a part of the Singraven Formation. In the Formation three lithozones are distinguished. The lowermost lithozone is composed of stratified sand, in places with organic detritus, gyttja, and peat

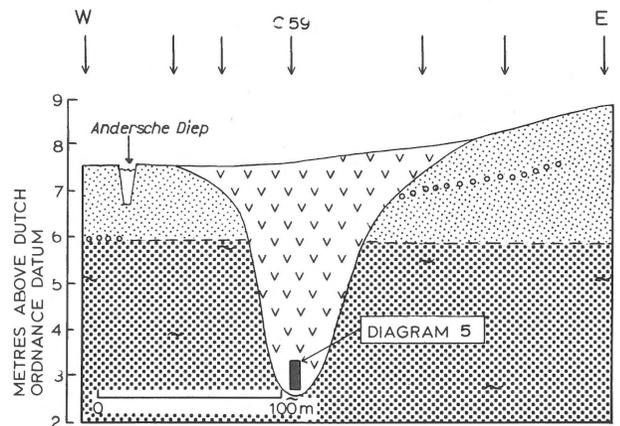


Fig. 4 Cross section 3 (Anderen; location Fig. 1; legend Fig. 2). Mid valley section in which the valley cuts through Younger Coversand into the Middle Weichselian Aa deposits. The basal part of the Singraven Formation is dated Boreal.

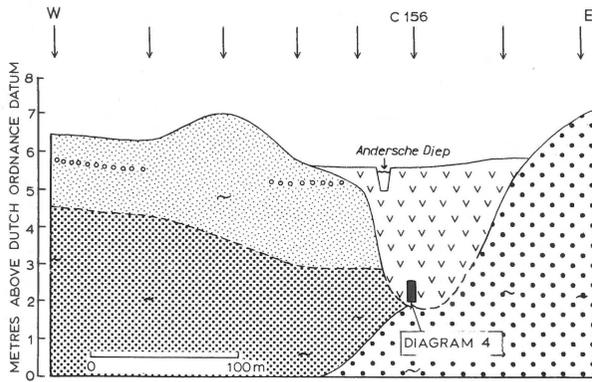


Fig. 5
Cross section 4 (Gasteren; location Fig. 1; legend Fig. 2). In this section the basal part of the Singraven Formation has an early Boreal age.

intercalations. The middle zone comprises detritic gyttja with clay, loam and sand intercalations. This bed also contains wood fragments and vivianite concretions. The upper lithozone of the Formation is composed predominantly of *Carex/Phragmites* peat.

Cross section 6 – Glimmen

In this Aa valley section (Fig. 7) the Singraven Formation is also located in an erosional valley which is cut through the aeolian sand of the Twente Formation into the underlying Aa deposits. Within the Singraven Formation again three lithozones are discriminated. The lowermost zone is composed of

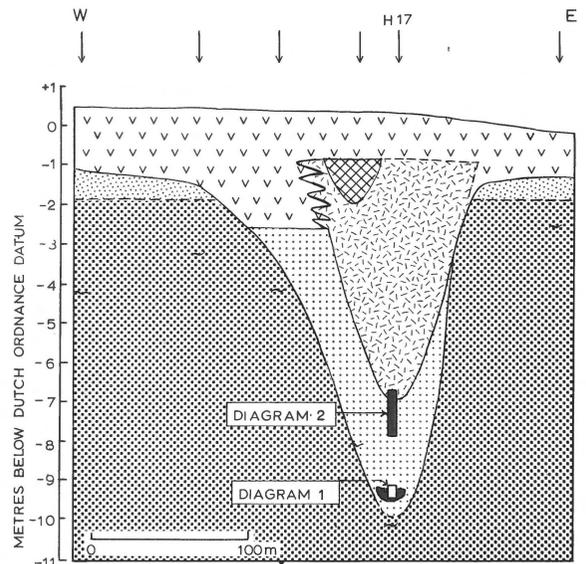


Fig. 7
Cross section 6 (Glimmen, location Fig. 1, legend Fig. 2). Down valley section with all three lithozones of the Singraven Formation and an intercalation of the marine Westland Formation clay. The basal part of the sand bed is dated Preboreal. The transition from the sand bed to the detritic gyttja bed is dated late Boreal/early Atlantic. The peat bed expands lateral over the Late Glacial Coversands.

stratified sand with organic detritus, gyttja, and peat intercalations. Overlying this bed in an erosive position there is a layer of detritic gyttja. This layer contains wood and other plant fragments, concretions, and clastic intercalations. On top of this detritic gyttja bed there is a thin clay layer. It has a marine facies and is assigned to the Westland Formation. The upper lithozone of the Singraven Formation is again predominantly composed of *Carex/Phragmites* peat and overlies the clay layer and detritic gyttja bed.

POLLEN ANALYSES

Method

To establish the chronostratigraphic position of the Singraven Formation sediments in the Aa valley, samples were collected with a gouge type sampling auger (\varnothing 50 mm and 30 mm) for pollen analytical treatment. All pollen samples were treated with KOH and subsequently subjected to bromoform separation. In general pollen slides were prepared from each centimetre of each core, although in a few cases the sampling interval was 2 cm or 5 cm. In the pollen diagrams the percentages are calculated on the basis of the sum of the AP (arboreal) pollen with the exception of diagram 5. In this diagram the sum of the AP and NAP (non arboreal pollen) has been used. Generally the pollen sum amounted to 300. The zonation of the Holocene in the pollen diagrams is according to ZAGWIJN (1975), while the classification of the Late Glacial pollen association is according to DE GANS & CLEVERINGA (1981).

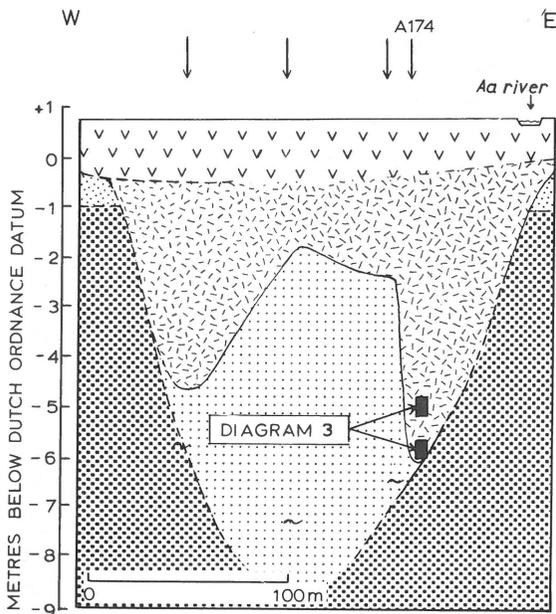


Fig. 6
Cross section 5 (De Punt, location Fig. 1, legend Fig. 2). Down valley section. The detritic gyttja bed is situated in an erosive position upon the underlying sand bed. This erosion phase is dated Boreal/early Atlantic.

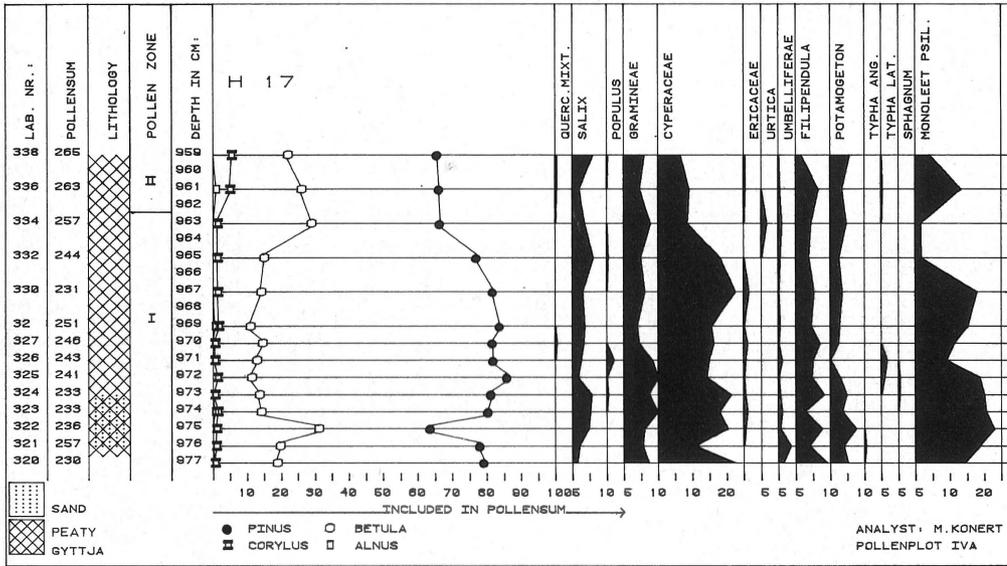


Fig. 8
Pollen diagram 1

Pollen diagram 1

This pollen diagram (Fig. 8) has been derived from a peaty gyttja deposit at the bottom of the Singraven Formation in section 6 (Fig. 7). Pollen zone I shows percentages of *Pinus* varying between 62%-85% and of *Betula* between 10%-32%, while *Quercetum mixtum* is absent or shows very low percentages. In pollen zone II the *Corylus* percentage increases slightly to 5%. On the basis of this information the bottom part of the deposit is dated as Preboreal, the upper part as Boreal.

Pollen diagram 2

This pollen diagram (Fig. 9) is also derived from section 6 (Fig. 7). It represents the transition from the stratified sand bed to the overlying detritic gyttja bed. The diagram is subdivided into two pollen zones. Zone II (718-835 cm) represents the lowest bed of the Singraven Formation. In this deposit *Corylus* shows a slight increase to 20%, *Betula* a decrease to 10%, whereas *Pinus* varies in value between 52% and 81%. The percentages of *Quercetum mixtum* are below 4%. This part of the diagram is thought to represent the early

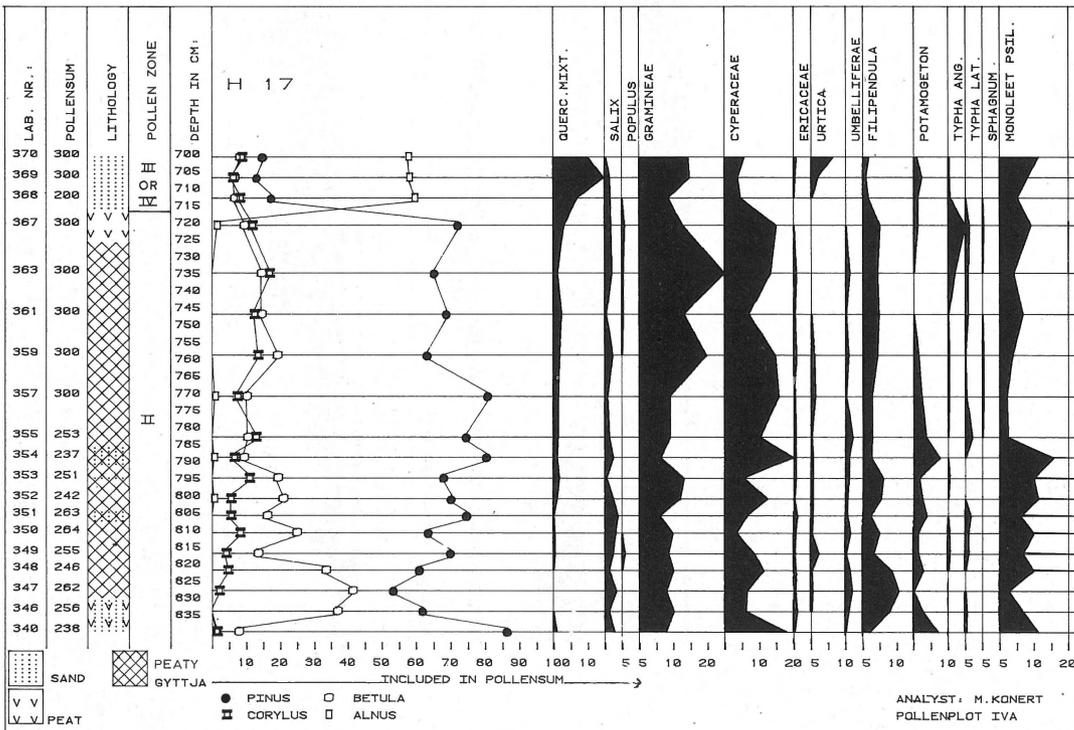


Fig. 9
Pollen diagram 2

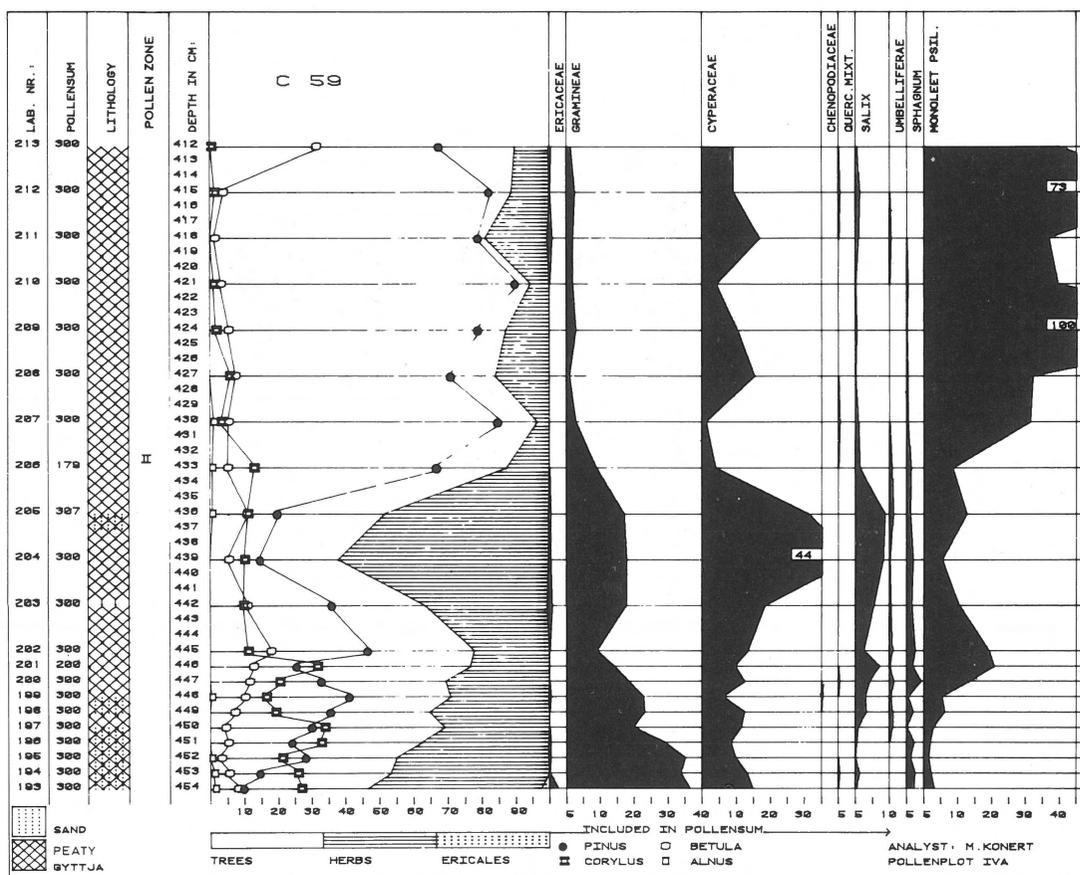


Fig. 12
Pollen diagram 5

Boreal. Zone III or IV (700-718 cm) represents the detritic gytjtja bed of the Singraven Formation which according to boring H 17 is located in an erosive position upon the sandy lithozone of this Formation. This zone shows percentages of *Quercetum mixtum* up to 15%, while *Pinus* decreases to 15% and *Alnus* increases to 57%. This zone of diagram 2 is attributed to the Atlantic or Subboreal.

Pollen diagram 3

Pollen diagram 3 (Fig. 10) is derived from cross section 5 (Fig. 6). The diagram represents two parts of core A 174 which are separated by a sandy deposit. The lower part of the diagram (666-674 cm) is derived from the sandy basal part of the detritic gytjtja bed of the Singraven Formation. It is characterised by percentages of *Quercetum mixtum* below 8%, *Corylus* percentages below 10%, and varying percentages of *Alnus* and *Betula*. This part of the diagram is thought to represent a mixture of Atlantic and Boreal pollen associations due to reworking. The upper part of the diagram (562-584 cm) represents also a part of the detritic gytjtja bed of the Singraven Formation. It is characterised by percentages of *Alnus* varying between 50%-100%, low percentages of *Pinus*, *Corylus* and *Betula* and higher percentages of *Quercetum mixtum* compared with the lower part of the diagram, and this indicates an Atlantic age.

Pollen diagram 4

This diagram (Fig. 11) is derived from section 4 (Fig. 5) and is characterised by two main pollen zones. Zone II (335-357 cm) is characterised by percentages of *Pinus* which increase from 70% to 93%, and low and decreasing percentages of *Corylus* (minimum 7%) and of *Betula* (minimum 4%). *Alnus* is present with percentages below 4% in the lowest part of this zone. Zone II represents the early part of the Boreal. Zone III (305-334 cm) shows a drastic increase of *Alnus* to over 50% and of *Quercetum mixtum* which reaches a maximum of 26%. This indicates an Atlantic age and this part of the diagram may be compared with diagrams 6 and 7. The sudden increase of *Alnus* and *Quercetum mixtum* in the spectrum of 333 cm may suggest an unconformity in the deposit, otherwise indiscernable in the lithologic sequence.

Pollen diagram 5

This diagram (Fig. 12) is derived from section 3 (Fig. 4) and represents the bottom part of the peat bed of the Singraven Formation. If the diagram is considered as a whole, the increasing percentage of *Pinus* is the dominant characteristic. Further, the absence of or the low percentages of the elements of *Quercetum mixtum* and *Alnus*, together with the decreasing percentages of *Corylus*, indicate that this deposit can be

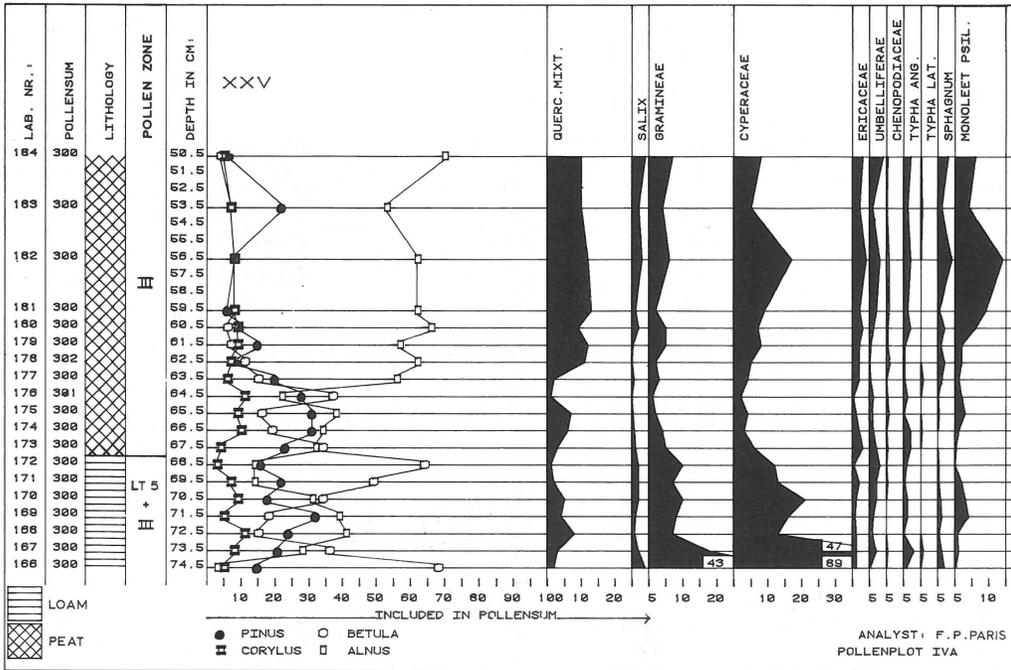


Fig. 13
Pollen diagram 6

dated as Boreal. The oscillation of *Pinus*, *Salix* and Cyperaceae percentages between 435-445 cm, is tentatively explained as a local phenomenon.

Pollen diagram 6

Core XXV, from which this diagram (Fig. 13) is derived, is located in cross section 2 (Fig. 3). The diagram has been subdivided into two zones. Zone LT 5 + III (68-74.5 cm) is characterised by percentages of *Corylus* that vary between

4% and 11%, two *Betula* maxima between 60% and 70%, a maximum percentage of *Alnus* of 42% and a *Pinus* maximum of 32%. This zone is interpreted to represent a mixture of Atlantic (zone III) and Late Glacial pollen associations (type LT 5 as described by DE GANS & CLEVERINGA, 1981), the result of infiltration. Zone III (50.5-68 cm) shows percentages of *Quercetum mixtum* up to 12%, relatively low percentages of *Pinus*, *Betula* and *Corylus*, but high percentages of *Alnus* up to 72%. Consequently this deposit is dated Atlantic.

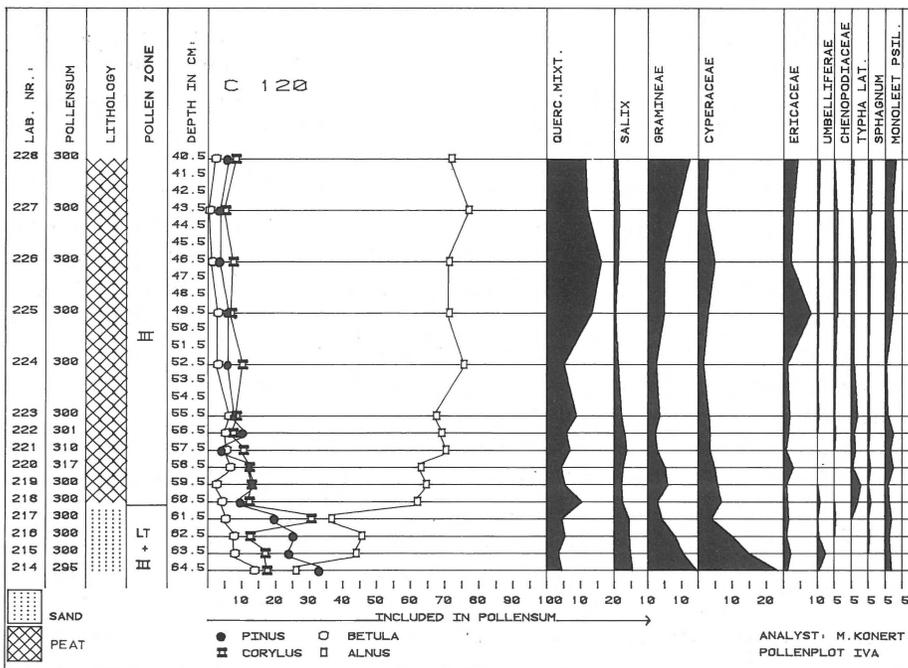


Fig. 14
Pollen diagram 7

Pollen diagram 7

This last diagram (Fig. 14) is derived from boring C120 in cross section 1 (Fig. 2). In this diagram two zones are distinguished which coincide with a difference in lithology. Zone III (40.5-61 cm) has high percentages of *Alnus* (up to 75%), *Quercetum mixtum* reaches 15%, and *Pinus*, *Corylus* and *Betula* have low values. This zone is dated Atlantic. Zone LT + III (61-64.5 cm) is derived from the upper part of the coversand and has a pollen association which again indicates infiltration of Atlantic pollen into a Late Glacial pollen association.

DISCUSSION

The deposits which make up the Singraven Formation in the Drentsche Aa valley system are subdivided into three lithozones: a sand bed, a detritic gyttja bed, and a peat bed. A lengthwise section of these beds in the Aa and Andersche Diep valleys is presented in figure 15. The sand bed is the lowest lithozone of the Singraven Formation in the Aa valley. It comprises stratified sand with organic detritus with thin layers of fine gravel in its basal part and in places intercalations of peat, peaty gyttja, or gyttja. The bed is estimated to be over 7 m thick in the downstream part of the Aa valley (Figs. 7 and 15). The palynological data from this bed (diagrams 1, 2 and 3) indicate a Preboreal and Boreal age. Consequently the incision of the valley, which preceded the deposition of this bed, is dated Late Dryas Stadial (Table I). This valley incision may have been caused by a climatic and

vegetational change during this period, as described by ZAGWIJN & VAN STAALDUINEN (1975), VAN DER HAMMEN (1951), GRAY & LOWE (1977) and COOPE (1977), amongst others. This climatic change possibly caused a local return of permafrost condition, as may be deduced from data of PISSART & JUVIGNE (1980) for the Hautes Fagnes area in Belgium. For The Netherlands, however, this is still questionable (MAARLEVELD, 1976). Late Glacial or early Holocene fluvial erosion is also described for the Helvoirt valley (BUURMAN, 1970) and for other valleys in Brabant (BISSCHOPS, 1973), in the Dinkel valley (VAN DER HAMMEN & WYMSTRA, 1971), the Gipping valley in England (ROSE ET AL., 1980); and in some Belgian valleys (VANDENBERGHE & DE SMEDT, 1979).

The detritic gyttja bed of the Singraven Formation is located in the downstream part of the Aa valley (Fig. 15) and reaches a maximum thickness of 5 m. This bed is composed of unconsolidated organic detritus with fragments of *Alnus* and *Betula* wood. Laminations and intercalations of clay, loam, and sand occur in places. In the basal part of this bed there may be some coarse sand or fine gravel. The detritic gyttja bed is palynologically dated Atlantic and Subboreal. On the basis of local abrupt lithologic changes (Fig. 7) and a hiatus in the pollen record (diagram 2), it is deduced that fluvial erosion occurred at the transition from the Boreal to the Atlantic. This erosion phase may have been caused by another climatic change and a consequent increase in precipitation and vegetation cover.

In the extreme north of the valley the detritic gyttja bed is overlain by a peaty clay which to the north passes into a

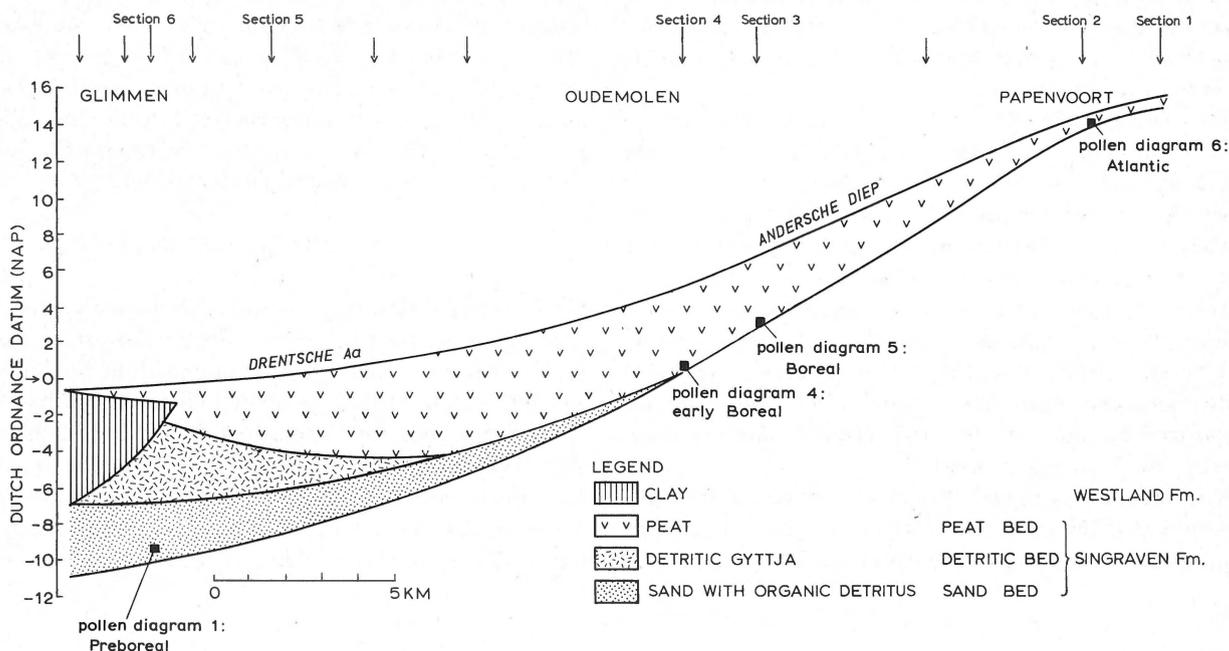


Fig. 15

Longitudinal section of the Singraven Formation lithozones in the Drentsche Aa and Andersche Diep valleys. The detritic gyttja bed is related to the Westland Formation clay, the deposition of which impeded the Aa valley discharge. The different dates of the basal part of the Singraven Formation indicate headward erosion.

gray-blue clay containing *Cardium edule* fragments (ELINK SCHUURMAN ET AL., in prep.). This clay is assigned to the Westland Formation and, because of its stratigraphic position, is dated Subboreal and Subatlantic. The extreme offshoot of this clay in the Aa valley (Fig. 7) is correlated with the Dunkerque I and II deposits (ROELEVELD, 1974). Although the offshoot of this clay has a marine facies, the palynological data of the over- and underlying organic deposits indicate deposition in a fresh water environment (ELINK SCHUURMAN ET AL., in prep.). It is suggested that the marine transgressions which caused the deposition of this clay, frustrated the discharge in the Aa river and gave rise to the deposition of the detritic gyttja bed in the downstream part of the Aa valley. Consequently, the detritic gyttja bed of the Singraven Formation can also be assigned to the perimarine deposits of the Westland Formation as described by ZAGWYN & VAN STAALDUINEN (1975). DE GANS (1980) suggested that before deposition of the clay some erosion may have taken place in the river channel.

The peat bed of the Singraven Formation varies in thickness from 0,5 m in the upper valley, to over 6 m in the central part (Fig. 15). In the north of the Aa valley the peat bed overlies the detritic gyttja bed. The peat bed is composed of peat or peaty gyttja and in its basal part may contain fragments of *Alnus* and *Betula* wood amongst other taxa. Vertically the peat bed changes into a *Carex/Phragmites* peat. This peat is also located outside the Late Dryas erosion valley, on top of the aeolian deposits which cover the former Pleniglacial floodplain. This lateral expansion of the peat in valleys on the plateau is dated Atlantic by TER WEE (1966), but in the Aa valley this probably occurred later. In the central part of the valley system the accumulation of the basal part of the peat bed started in the Boreal while it did not commence until the Atlantic in the upstream part of the valley.

These dates, compared to the Preboreal age of the sand bed in the downstream part of the valley system, show that the initial sedimentation of the Singraven Formation is not isochronous, but becomes increasingly younger in an upstream direction. This is explained as the result of headward erosion, which confirms the ideas of DE VRIES (1976).

The Late Dryas and late Boreal/early Atlantic fluvial erosion phases are explained as the result of climatic change, which caused an adjustment of the river channel to the altered hydrological and vegetational circumstances. These so called biogeomorphic adjustments of river channels due to climatic change, are discussed by KNOX (1975).

It is generally accepted that at the transition from the Weichselian to the Holocene the river patterns changed from braided into meandering ones (ROSE ET AL., 1980; ZONNEVELD,

1971; DE JONG, 1967). At that time the Aa river cut a narrow valley into the former wide Pleniglacial valley floor. The present Aa river is no longer confined to this narrow erosional valley, but located upon the peat bed of the Singraven Formation which covers most of the former wide Pleniglacial floodplain. Locally the Aa river has splendid meanders, which have been measured and described by KUENEN (1944). If the correlation between meandering of the Aa river and peat growth holds true, the meandering did not start before the Boreal. However, the Aa valley data do not as yet permit a firm conclusion on this subject.

CONCLUSIONS

The Singraven Formation of the Aa valley system is confined to the Holocene. The Formation is subdivided into three lithozones: a sand bed, a detritic gyttja bed and a peat bed. The sand bed comprises the oldest fluvial sediments of the Singraven Formation and was deposited in the Preboreal and Boreal in the downstream part of the valley system. Since the Atlantic the fluvial sedimentation was controlled by the Holocene sea level rise which impeded discharge of the Aa river. This resulted in the deposition of the detritic gyttja bed which is located also in the downstream part of the valley. In the Subboreal and Subatlantic the detritic gyttja bed was covered by a clay with a marine facies, which, however, may possibly have been deposited in a fresh water environment. In the middle and upstream part of the valley the peat bed developed since the Boreal. It is thought that only since the Subatlantic the peat of the Singraven covered all the older deposits on the former Pleniglacial floor of the Aa valley system. The fluvial incision of the valley which preceded the deposition of the Singraven Formation, is dated Late Dryas Stadial and it caused a headward erosion. A second erosion phase occurred at the transition from Boreal to the Atlantic. Both erosion phases were probably the result of an adjustment of the Aa river channel to climatic change.

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