

A POLLENDIAGRAM FROM WEICHSELIAN DEPOSITS NEAR APELDOORN, THE NETHERLANDS

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SUMMARY

Pollen analysis of a 20 m long core of peat, sand and silt deposits near Apeldoorn, the Netherlands shows that these sediments were laid down in the Late Eemian, the Early Weichselian and the Middle Weichselian.

Only the most upper Eemian is present. In the Early Weichselian one zone with interstadial character and represented by a peat layer is particularly well developed, showing successive maxima in the pollen values of *Alnus*, *Picea* and *Pinus*. Pollen of *Betula* however remains dominant. The Middle Weichselian is strongly glacial in character. It includes an oscillation with *Salix*, *Potamogeton*, *Pediastrum* and *Selaginella selaginoides* pointing to more favourable conditions.

INTRODUCTION

In 1968 the municipality of Apeldoorn conducted a series of corings in the "Maten" area, east of the canal Apeldoorn-Dieren and South of the railroad Apeldoorn-Zutphen in connection with expansion of the city of Apeldoorn.

According to v.d. Hammen (1951) and v.d. Hammen and Maarelveld (1952), north-south and east-west cross-sections through the area show a sequence of Eemian clay, pleniglacial? silt, 2 series of silt or peat layers, early and late coversands - I and locally sediments of Allerød age.

Burck (1949) investigated geologically a cross section between Breukelen and Deventer and considered everything above 12 m below the surface as belonging to the Weichselian.

The aim of the present paper is:

1. Dating of the various beds, and determination of the Eemian-Weichselian boundary.
2. Reconstruction of the vegetation of the area from the late Eemian up to the Lateglacial.

MATERIALS AND METHODS

a. Field methods.

The coring was done by the Apeldoorn municipality

with the "Ackermann" corer. Effective length is 30 cm. Each cylinder was longitudinally halved, and one half of the cylinder was saved for pollen analysis. From each fresh surface of the 30 cm core lithologic data were labelled (table 1).

b. Laboratory methods.

Sampling of the cores was done in the laboratory. Samples were subjected to the acetolysis method as described in Faegri and Iversen (1964). All the samples were also pretreated with HF for 24 hours at 20°C. Slides were mounted in silicone oil (2000 CS.) after replacement of water by 96% aethanol, 100% aethanol and benzene. Entire slides were counted.

c. Pollen diagram (fig. 1).

The pollen diagram is a so called Iversen diagram. Iversen (1941) calculated, for lake sediments, the pollen values on the basis of a ΣP excluding aquatics, and v.d. Hammen (1951) and Zagwijn (1961) used this way also to present data for other sediment types of the Pleniglacial and the Lateglacial.

The percentages of total herbs reflect the regional density of forest vegetation. A Similar ΣP is used for the Maten diagram in order to ensure the comparability with other Weichselian pollen diagrams. Included in the ΣP are:

1. Tree pollen except *Myrica gale*.
2. Poaceae, Cyperaceae.
3. Ericaceae, *Empetrum*.
4. Pollen of species indicating dry and open vegetation types.
5. *Polypodium* sp., *Pteridium*, and *Selaginella* sp.

The diagram is divided into five subdiagrams, partly according to the ecology of the plants involved:

- A. Summary diagram, a composite diagram including the curves of *Pinus*, *Picea*, *Abies*, *Betula*, *Alnus*, *Corylus*, *Salix*, along with cumulative curves of Ericales (incl. *Empetrum*), Cyperaceae, Poaceae, and other herbs, all included in the pollen sum.
- B. Separate curves for upland trees and shrubs not clearly shown in part A
- C. Separate curves for upland herbs
- D. Separate curves for swamp herbs
- E. Separate curves for open-water plants
- F. Separate curves of ecologically indeterminate pollen types

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and morphologically indeterminable types caused by corrosion (Cushing, 1967; p 89)

Black silhouettes refer to percentages shown at the base of the diagram. The white diagrams have a scale 5-times exaggerated.

The diagram is divided into 9 assemblage zones (1-9) mainly on the basis of the fluctuations of the curves of the total upland herbs and apparent gaps in the pollen record. In zones 1 and 4 a subdivision can be made on the basis of variation in the proportion of some tree- and herb pollen types separately.

Symbols of the lithology include fine sand, coarse sand, clay, sandy clay, silt, Hypnaceae peat and humic sand or clay. (Zagwijn, 1961).

The core shows a great variation in sediment types. Within each main Weichselian period these sediment types show their own pollen assemblages superimposed on the main characteristics of that time. Because of this variation the number of samples must be necessarily large. I feel that in the present diagram the number of samples is not sufficient. Part of the gaps shown in the pollen stratigraphy can be explained in this way. Often pollen in these layers is badly preserved.

RESULTS

In the following part the pollen assemblage of each zone is characterized and the local vegetation is discussed. For a consideration of the regional vegetation compared with that of other regions, the reader is referred to chapter 4.

Zone 1 (1940 – 1420 cm)

Diagnosis: Gradual decline of the *Pinus* values and increase of *Betula* after a general decline. Zone 1 has been subdivided into 4 subzones.

Subzone 1a (1940 – 1877 cm)

Diagnosis: *Betula* and *Pinus* dominant with equal percentages. NAP less than 25% *Picea* 25 – 5%, and *Abies* regularly present, but in low percentages.

Remarks: The high (200-1000) percentages of *Pediastrum* and presence of *Nymphaea* and *Sparganium* pollen point to an eutrophic aquatic environment. Pollen of thermophilous trees is present, but only the curves of *Carpinus* and *Quercus* are continuous. The percentages of these types remain below 2%, however the sediment is mostly inorganic, so some of the pollen grains may have been redeposited from older sediments. The presence of *Carpinus*, *Quercus* and *Abies* pollen may be explained in this way.

Subzone 1b (1945 – 1610 cm)

Diagnosis: Values of *Betula*, *Pinus*, and *Calluna* as in subzone 1a. *Picea* not over 2,5%. Increase in the values of Cyperaceae and Poaceae.

Remarks: The assemblage of local pollen types much resembles that of zone 1a: *Sphagnum*, *Dryopteris* type, *Osmunda*, and *Filipendula* are present in low percentages and the values of *Pediastrum* are still fairly high. The sediment is silt, with thin sand layers. Almost no pollen of thermophilous trees. Only *Ulmus* is regularly present in very low percentages.

Subzone 1c (1610 – 1450 cm)

Diagnosis: Decrease of the pine values and increase of *Alnus*. Strong increase of Ericales pollen, mostly *Calluna*. Cyperaceae and Poaceae 25%.

Remarks: The values of *Pediastrum* and *Filipendula* reach a minimum, but those of *Sphagnum*, *Calluna*, and *Dryopteris* type increase. One grain of *Pteridium* is present. These features indicate that the environment is turning more acid. The sediment is still silty and sandy, and lake filling has had no appreciable effect. The values for *Carpinus*, *Quercus*, and *Ulmus* are regularly higher than in the preceding zone and may also represent redeposition. The grain of *Carya* at 1570 cm must have been redeposited, for *Carya* is present in Western Europe only in the early Pleistocene (Zagwijn 1960). *Armeria* (including one tetrad), cf. *Centaurea pratensis*, *Anemone alpina* type, *Saxifraga oppositifolia* type, cf. *Gypsophila* and *Ephedra distachya* are part of the assemblage.

Subzone 1d (1450 – 1420 cm)

Diagnosis: Like subzone 1c, but values for *Betula* increase, those of *Calluna* decrease.

Remarks: The presence of *Typha latifolia*, *Potamogeton*, and *Sparganium* pollen, the decrease of the values for *Calluna* and *Sphagnum*, and the increase in *Dryopteris* and *Filipendula* indicate a less acid environment than in the preceding zone. The pollen assemblage points to an aquatic environment.

Pediastrum colonies, however, are rare.

Zone 2 (1412 cm)

One spectrum only. About 90% of the pollen is from Cyperaceae. The assemblage, including *Thalictrum*, Asteraceae (liguliflorae), *Selaginella selaginoïdes*, *Betula* and *Pinus*, suggests a rather treeless environment.

Zone 3 (1400 – 1340 cm)

Two spectra. The assemblage, from a humic layer (1340 cm) in a fine sandy deposit, shows 70% *Betula* and 20% Cyperaceae. Both spectra show a rather high *Juniperus* value.

Zone 4 (1270 – 923 cm)

The dominant pollen type is mostly *Betula*. The zone can be subdivided on the basis of maxima of *Alnus*, *Picea*, *Pinus*, and *Salix*.

Subzone 4a (1270 – 1249 cm)

Diagnosis: Maximum of *Alnus* and *Betula* and decreasing values of Poaceae and Cyperaceae.

Remarks: The sediment type changes from fine sand into gyttja and fine textured peat, with a few pieces of charcoal.

The local assemblage includes *Sparganium* type and *Typha latifolia* and decreasing values of *Dryopteris* and *Filipendula*. Perhaps this indicates falling water levels. A few grains of *Quercus* are present, probably redeposited, because inorganic material is present in the peat.

Subzone 4b (1249 – 1231 cm)

Diagnosis: Maximum of *Picea*, increase of *Pinus* and Ericaceae, and minimum of Poaceae and Cyperaceae.

Remarks: The sediment is slightly sandy peat with charcoal.

There is a strong increase of *Sphagnum*, but this increase is not accompanied by an increase of the Ericales. The environment must have been rather wet (*Sphagnum*, *Pediastrum*, *Sparganium*) and also poor in nutrients (*Sphagnum*). This is supported by the high values of *Picea* pollen. *Picea* is a poor pollen disperser, so high values may mean local occurrence (Faegri and Iversen 1964). Today *Picea* is a component of ombrotrophic and mesotrophic bogs in continental North America (Curtis, 1957). *Quercus* and *Carpinus* are present in low percentages. A few grains of *Fraxinus* and *Tilia* were found.

Subzone 4c (1231 – 1202 cm)

Diagnosis: Maximum of *Pinus*, increase of NAP, and slight increase of *Salix*.

Remarks: The sediment type changes to silty peat. A more eutrophic environment is indicated by increase of *Pediastrum* and the presence of *Potamogeton*. The local flora included *Myrica*, *Comarum*, *Potentilla*, *Fragaria*, and *Filipendula*.

Subzone 4d (1202 – 903 cm)

Diagnosis: Maxima of *Calluna* and NAP and decrease of *Pinus*.

Remarks: The trend of the pollen curves below 1180 cm suggests gradation to zone 4c. Above 1180 cm, however, gaps between the spectra are present, with differences in the pine and birch values and a larger differentiation in the NAP. Also, the sediment type is different. It changes from silty peat below 1180 cm to clayey silt above. The pollen assemblages are included in one zone however, largely because of the general level of the components of the NAP. *Alnus* pollen remains at 10% above 1180 cm, but it may have been transported by water from trees that lingered on in valleys despite a worsening climate. Also, the presence of *Carpinus* (0,5 – 1,8%) and one grain of *Ilex* could have been the result of redeposition.

Zone 5 (777 – 767 cm)

Diagnosis: Values of Cyperaceae extremely high, and *Pinus*, *Betula*, and *Salix* low.

Remarks: The pollen assemblages of two spectra include *Artemisia*, Chenopodiaceae, *Rumex*, *Thalictrum*, *Selaginella selaginoides*, and *Saxifraga oppositifolia* type, indicating high arctic conditions. Recent surface samples from Spitzbergen (Srod on 1960) indicate that the presence of *Pinus* and *Betula* pollen under these conditions may result from long-distance transport.

Zone 6 (667 – 579 cm)

Diagnosis: NAP 70-90%, mostly Cyperaceae; *Salix* increasing. The zone can be subdivided into:

subzone 6a:

Selaginella selaginoides and *Potamogeton*, with regular occurrence of *Thalictrum*.

subzone 6b:

Maximum of *Salix*, increase of *Pediastrum*, and presence of Ericaceae, *Empetrum*, *Sphagnum*, and *Dryopteris* type. This sediment is less sandy than that of subzone 6a.

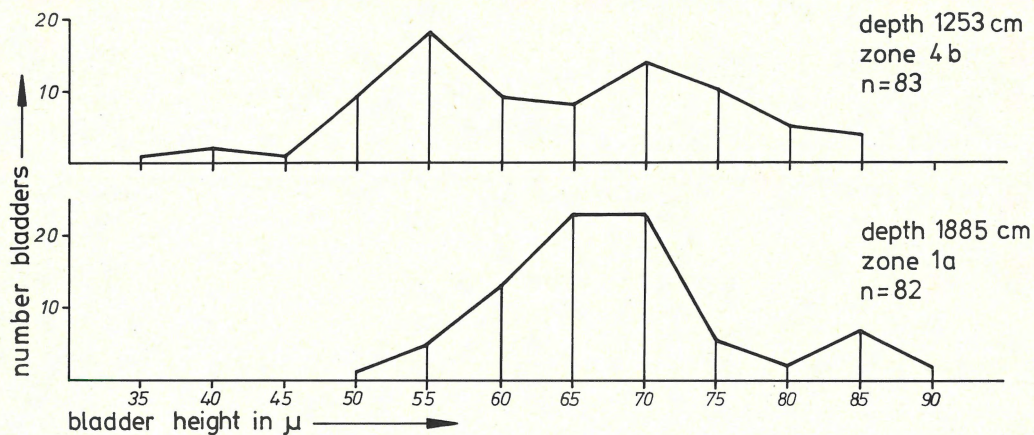


Fig. 2.
Frequency curves of bladder height for pollen of *Picea* at two levels.

Remarks: Zone 6 is separated from zone 5 by 1 m fine sand (cover sand and niveo-glacial deposits) with some pieces of gravel.

The occurrence of *Salix* may point to more favourable summer conditions. The species of dwarf *Salix* shrubs (*S. polaris*, *S. reticulata*, and *S. herbacea*) are underrepresented, according to S r o d o n (1960), even when locally present. In local surface samples a value as high as 20% is never reached. It is possible, however, that part of the *Salix* pollen comes from taller shrubs (*Salix glauca*) F r e d s k i l d 1967). Cf. *Verbascum* occurs in zone 6a and *Drosera* in zone 6b.

Zone 7, 8 and 9 are much alike. NAP is 90%, mostly Cyperaceae. Separated in three zones because of large sections in the core without pollen.

one 7 (518 – 510 cm)

One spectrum, much like zone 5. The sediment is clay-silt.

one 8 (359 – 342 cm)

The sediment is sandy Hypnaceae peat. Richer in pollen types, among which are *Selaginella helvetica* (photo 1, plate 1), *Botrychium*, *Armeria*, *Saxifraga oppositifolia*-type, *Saxifraga muscoïdes*-type, and *Gentianella* cf. *crossopetalum*-type.

Zone 9 (239 – 225 cm)

The sediment is silty with some humus. The assemblage is much like that from zone 8, but the values for *Selaginella selaginoides* are somewhat higher. *Botrychium simplex* (photo 2A, 2B, plate 1) and *Ribes* (alpinum?) (photo 3A, 3B, plate 1) are present.

DISCUSSION

There are several reasons to accept a Weichselian age of the sediments that were investigated.

1. The pollen assemblages show the character of glacial climatic conditions, especially from zone 5 on.
2. At a greater depth a grey clay is present that shows a pollen assemblage belonging to the *Carpinus* phase of the Eemian (v.d. H a m m e n, oral information).
3. According to B u r c k (1949), boulder clay of the Saalian is present at a depth of 70 m, thus at a much greater depth.

We therefore conclude that zones 1 through 4 represent the early Weichselian, and zone 5 – 9 part of the full Weichselian.

Deposits of early Weichselian were investigated in Jutland (A n d e r s e n 1961), in northern Germany (A v e r d i e c k, 1967), and the Netherlands (Z a g w i j n 1967). Zagwijn's Amersfoort sites are some (50 km) to the Maten, and correlation of the Maten zones therefore will concentrate on those of Zagwijn. The two sites however, are in different sedimentation basins, separated by the push moraines of the Veluwe.

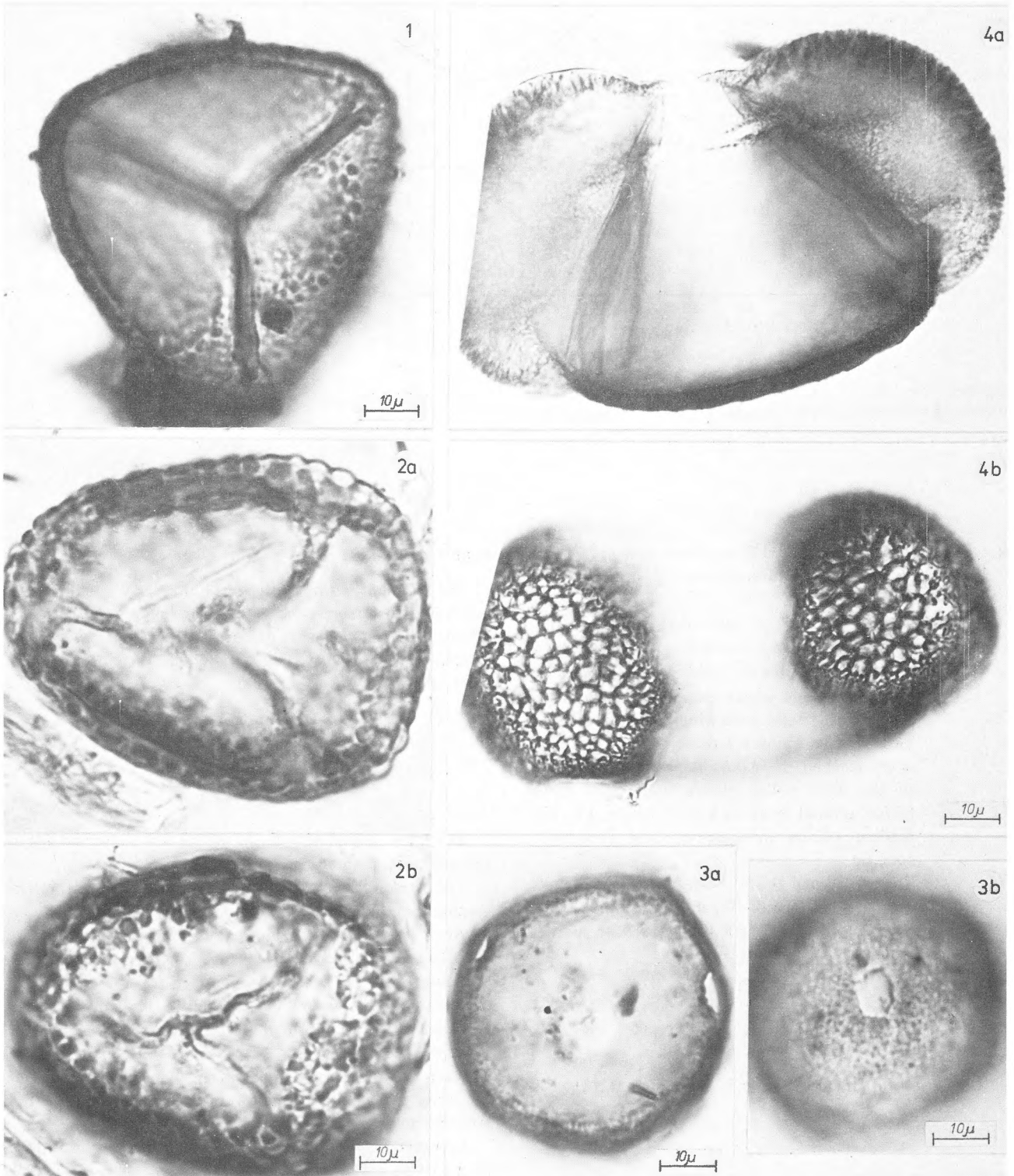


Plate 1:

photo 1.
Selaginella helvetica 342 cm

photo 2.
 cf. *Botrychium simplex* 234 cm

photo 3.
Ribes type 229 cm

photo 4.
Picea omorikoïdes 1244 cm

Table 1: Lithologic description of the De Maten core.

Depth in cm	Sediment type		
0 – 30	disturbed surface	1227 – 1238	peat with charcoal fragments
30 – 40	fine sand, occasionally silty	1238 – 1240	sand
40 – 129	fine sand with pieces of peat	1240 – 1258	peat with charcoal fragments
129 – 220	fine sand	1258 – 1260	fine sand
220 – 240	humous silt	1260 – 1339	coarse sand with piece of wood (1318)
240 – 338	coarse sand	1339 – 1341	very humous layer in sand
338 – 341	humous fine sand	1341 – 1386	sand
341 – 360	Hypnaceae peat	1386 – 1407	fine sand
360 – 450	fine sand with pieces of wood	1407 – 1409	silt
450 – 510	fine sand with gravel	1409 – 1412	peat
510 – 513	humous silt	1412 – 1470	sand
513 – 540	coarse sand with rounded gravel	1470 – 1486	humous silt
540 – 570	rather fine sand with gravel	1486 – 1500	sand
570 – 581	fine sand	1500 – 1507	very humous sand
581 – 603	humous silt	1507 – 1530	sand silt
603 – 606	sand and silt	1530 – 1533	silty sand
606 – 617	humous silt	1533 – 1534	silt
617 – 618	sand and gravel	1534 – 1540	sand
618 – 623	humous silt	1540 – 1560	sandy silt
623 – 640	silty peat	1560 – 1562	silt
640 – 660	silty sand	1562 – 1565	silt and sand
660 – 662	fine sand	1565 – 1572	silt
662 – 667	peaty sand	1572 – 1574	fine sand
667 – 690	coarse sand	1574 – 1587	sandy silt
690 – 720	fine sand with gravel	1587 – 1596	sand
720 – 767	fine sand	1596 – 1617	silt
767 – 777	peaty silt	1617 – 1618	sand
777 – 810	sand with gravel	1618 – 1621	silt
810 – 900	fine sand with gravel	1621 – 1623	sand
900 – 902	coarse sand	1623 – 1628	silt
902 – 904	silt	1628 – 1645	sand
904 – 930	coarse sand	1645 – 1648	silt
930 – 957	coarse sand with fine gravel	1648 – 1650	fine sand
957 – 964	silt	1650 – 1680	coarse sand
964 – 990	coarse sand with gravel	1680 – 1720	sand
990 – 1005	fine sand	1720 – 1728	sand and gravel
1005 – 1016	clay	1728 – 1875	sand
1016 – 1020	fine sand	1875 – 1898	very humous silt
1020 – 1178	coarse sand	1898 – 1902	sand
1178 – 1205	silty peat	1902 – 1920	peaty silt
1205 – 1208	sand	1920 – 1924	silt
1208 – 1216	peat	1924 – 1924,5	sand
1216 – 1220	sand	1924,5 – 2040	silt
1220 – 1222	silty peat	2040 – 2050	humous silt
1222 – 1227	very humous silt	2050 – 2070	peat

Zagwijn subdivided the Eemian as follows:

E 1	<i>Betula</i> zone	E 4	<i>Corylus</i> zone
E 2	<i>Ulmus</i> zone	E 5	<i>Carpinus</i> zone
	<i>Quercus</i> zone	E 6a	<i>Pinus-Picea</i> zone
E 3	<i>Alnus</i> zone	E 6b	<i>Betula-Pinus</i> zone

In the present diagram a *Carpinus* zone is absent. The Maten diagram thus represents a zone younger than zone E5.

Zone 1

Zone E6b is characterized by a dominance of *Betula* and *Pinus*, by *Picea* and *Alnus* values of 5 – 10%, and by low values of *Abies*.

Zone I of the Maten may be considered to belong to zone E6b, although the *Picea* values are too low. This view is supported by the regular presence of *Abies* and decreasing values of *Alnus*.

According to Zagwijn the Eemian/Weichselian boundary must be placed where there is a strong increase of the NAP. However, *Calluna* is included in the NAP, and when locally present an increase does not necessarily indicate the beginning of a glacial period. In the Maten diagram such an increase is present in zone 1c. Pollen analysis of the section between 1877 and 1645 cm is necessary to support the idea that the Weichselian/Eemian contact must be placed at the base of zone 1c. If so, zones 1a and 1b then will be correlative with zone E6b at Amersfoort. In that case the Weichselian/Eemian contact of Apeldoorn is present at a greater depth than suspected from the literature (somewhere between 1300 and 1400 cm, according to Burk, 1949 and Zagwijn, 1961).

Subzone 1c

Subzone 1c is considered to belong to Zagwijn's zone EW-I. If so, then almost all pollen from thermophilous trees must be redeposited. Especially the rise of the values of *Alnus* may be due to either transport by a river from the south or by long-distance transport. Zagwijn divides zone EW-Ia into a lower zone, characterized by a maximum of *Calluna*, and an upper zone EW-Ib characterized by a decrease of *Calluna* and maximum values of *Salix* and *Dryopteris thelypteris*. Subzone 1c of the Maten clearly belongs to zone EW-Ia. The stadial character of the zone is supported by the presence of pollen of *Ameria*, *Centaurea pratensis*, *Anemone alpina* type, *Saxifraga oppositifolia* type and *Ephedra distachya*.

Subzone 1d

Subzone 1d can be correlated with zone EW-Ib. There is an increase of the values of *Betula*, *Filipendula*, and *Dryopteris*.

But perhaps most of the zone belongs already to zone EW-IIa (Amersfoort interstadial), for *Betula* and *Filipendula* show rather high percentages.

Zone 2

The character of zone 2 is strongly stadial, even when overrepresentation is taken into account. If subzone 1d represents the beginning of the Amersfoort interstadial, then zone 2 is correlative with zone EW-III. However in none of Zagwijn's spectra from this zone does the NAP reach values as shown in zone 2 of the present diagram.

Zone 3

In this zone *Juniperus* and *Betula* show high values. According to v.d. Hammen (1951), this indicates the proximity of the arctic treeline. If so, then this zone represents the beginning of EW-IV (Brørup interstadial). Spectra with a similar pollen assemblage are also present in

Anderse'n's (1961) zone W-2 and W-3 that belong to the Brørup interstadial (*Betula*, *Juniperus*, and *Populus*). From this it follows that in regions towards the south such an assemblage might be characteristic for a time prior to the Brørup interstadial.

Spectrum 40 and 39 therefore may belong to the later part of zone EW-III.

Zone 4

The pollen assemblages of zone 4 resemble much those of zone EW-IV of Zagwijn (1961) at Amersfoort. However, the Maten diagram deviates from Amersfoort by a dominance of *Betula*. It is not possible here to trace the base of zone EW-IV, where *Pinus* becomes the dominant pollen type. But at any rate the base of zone 4 is considered to belong to zone EW-IV because of the low NAP.

Subzone 4a

Subzone 4a en 4b agree rather well with zone EW-IVb, for the sequence of a maximum of *Alnus* followed by a maximum of *Picea* is also present at Amersfoort-3. *Picea*, however, does not reach the high values shown at Amersfoort. Still the values of *Picea* in the Maten diagram indicate that *Picea* was present close-by.

Averdieck (1967) found wood of *Picea* at levels where the pollen percentages are rather low. This demonstrates the well-known underrepresentation of *Picea* (Faegri and Iversen, 1964). Two pollen types of *Picea* are present: *Picea abies* and *Picea omorikoïdes* (photo 4A, 4B plate 2). It is not clear which of the *Picea* pollen grains belong to *P. omorikoïdes*. Only part of the grains were suitable to measure the height of the sacci. Moreover, there is between the two species a large overlap in saccus-height, and a determination of a % of *P. omorikoïdes* in this way, such has been done by Averdieck, is highly inaccurate.

Fig. 2 shows for a number of spectra the frequency of distribution of the saccus height, indicating that *P. omorikoïdes* must have been present.

Subzone 4b

The assemblages of subzone 4b agree well with those of zone EW-IVb3. As in zone EW-IVb, *Quercus* and *Carpinus* are present, but show only a low percentage. The deposit is peat, and it is therefore possible that these trees were present around the basin in low quantities.

Subzone 4c

Characteristic is the maximum of *Pinus* and an increase of the NAP, also present in zone EW-IVc of Amersfoort 3.

At Amersfoort the increase of the NAP is caused by the local presence of Ericales, because the sediment changes into peat with the strong character of a raised bog. In the Maten

also *Myrica* is part of the local vegetation. It is not clear whether the increase of the NAP comes from open vegetation types in the sedimentary basin, in the valley of the Yssel, or on the push moraines.

Subzone 4d

Spectra 30-28 show clearly a continuation of the preceding zone, clearly belonging to zone EW-IVc.

However, a discontinuity is possible above spectrum 27.

According to Averdieck (1967), a third interstadial (Odderade) in the early Weichselian is present above the Brørup interstadial.

In his diagram Odderade 5 the Brørup interstadial is separated from a zone with a high and dominant *Betula* by a layer of sand, 1 m thick (FW 5). Above zone FW-5 *Pinus* becomes the dominant pollen type (FW-6). It is impossible to decide whether these single spectra belong to the Brørup or Odderade interstadial, because the latter is not characterized by a specific sequence of pollen curves. We consider the silt layers between 1180 and 923 cm at least to be of Odderade age. In a cross section of the Geological Survey, these strata are considered to be of Pleniglacial age (Layer III). The pollen assemblages thus suggest an early Weichselian age. This view is supported by the horizontal position of these layers in contrast to the strata of the Pleniglacial that constitute niveo-fluviatile fans deposited in the Pleniglacial on top of the early glacial deposits (oral information, Zagwijn; v.d. Hammen and Maarleveld 1953).

Zone 5 to 9

The character of these zones is pleniglacial. From the low values of *Artemisia* and trees (v.d. Hammen 1951), it is concluded that no sediments of the Lateglacial are present. Pollen of *Betula* and *Pinus* must have been transported over rather long distances (see Srodon, 1960). According to v.d. Hammen, Maarleveld, Vogel and Zagwijn (1967), no organic sediments have been found in the lower and upper Pleniglacial of The Netherlands. Consequently zones 5 to 9 of the Maten diagram must belong to the "Interpleniglacial".

The deposits in this period consist of coversands and niveo-fluviatile deposits.

In the interpleniglacial three interstadials have been recognized, all dated by 14C:

Denekamp	32.000 – 29.000 BP
Hengelo	39.000 – 37.000 BP
Moershoofd	50.000 – 45.000 BP

Both the Hengelo and Denekamp interstadial are characterized by a shrub tundra. In the pollen diagram a *Salix* maximum is followed by a *Betula* maximum and sometimes again by a *Salix* maximum. The Moershoofd interstadial shows a true tundra vegetation, but the differen-

ce from the other interstadials does not show up clearly in the pollen assemblages and it is therefore difficult to date the Maten zone pollenanalytically. Zone 5 differs from zones 6 to 9 by its high *Salix* values and the large variety of herb pollen types. The *Salix* percentages suggest the presence of a shrub tundra, indicating a Denekamp or Hengelo age. However, the low *Betula* values exclude such an age. It seems likely that in the Pleniglacial the local vegetation will determine strongly the character of the pollen assemblage, preventing a regional correlation of the various diagrams.

Only 14C datings may contribute to such a correlation. At any rate, zone 7 and zone 8 can be correlated pollenanalytically with the pleniglacial sediments near Apeldoorn analysed by v.d. Hammen in 1951 (Diagram XV). According to him (Vogel and v.d. Hammen 1967), these layers represent the Hengelo and Denekamp interstadials. Two samples of wood from Hypnaceae peat layers, which can be correlated geomorphologically with the zones 7 to 9 were 14C dated in Groningen by Dr. W.G. Mook:

APD IV	GrN-6258	34.040 ±	540 BP
APD V	GrN-6259	more than 42.700	BP

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