FORMER VEGETATION AND SEDIMENTATION IN THE VALLEY OF THE RIVER GEUL

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CONTENTS

1. AIM OF THE INVESTIGATION

A tentative investigation was made into the age of the loess deposits of fluvial or colluvial origin in the valley of the river Geul. Our aim was to establish whether these deposits could have been the indirect result of the deforestation which began with the introduction of agriculture in the hilly region of South Limburg. If so, they would be of relatively young date.

Being of a tentative kind, the investigation was kept simple and limited in scope. Only two profiles were subjected to pollen analysis, one consisting of fluvial loess on peat and the other of colluvial loess on peat. The peat part of the two profiles was analysed over its entire depth, the covering mineral part near the contact zone only.

2. THE PROFILES STUDIED

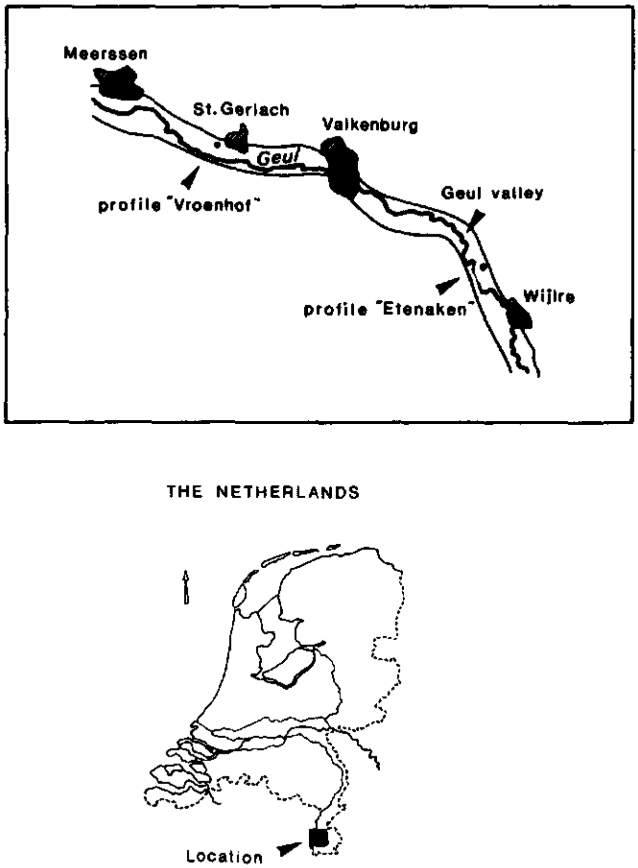


Fig. 1. Location of the two 'Vroenhof' and 'Etenaken' profiles.

The Vroenhof profile is located in a small basin area of the river clay landscape in the Geul valley at a relatively great distance from the river course with its accompanying levees, and out of reach of a colluvium. It consists of an approximately 1.40 m layer of fluvial loess resting on the peat in an undisturbed position.

The Etenaken profile is in a comparable situation as regards the course of the river but located within reach of a colluvium along the margin of the valley. The colluvial material does not rest on a layer of fluvial loess but is in direct contact with the peaty subsoil. This situation suggests that deposition of the colluvial loess may have been preceded by some erosion, leading to the disappearance of the former fluvial loess layer and the top of the peat. Near the bottom of the colluvium it contains peaty particles.

Profile descriptions.

Vroenhof profile

0–141 cm. Fluvial loess.

141–160 cm. Clayey[1] *Carex* peat with fairly extensive decay.

160–170 cm. Humic clay[1].

170–200 cm. Clayey[1] *Carex* peat with fairly extensive decay.

200–250 cm. *Carex* peat with moderate decay.

250– cm. Humic sand.

Etenaken profile

0–220 cm. Colluvial loess with small pieces of baked loam, charcoal, potsherds and some gravel. From 0–60 cm the soil appeared to be raised by human agency.

220–227 cm. Colluvial loess mixed with peaty particles which increase in a downward direction.

227–330 cm. *Carex* peat alternately with fairly extensive decay. Fragments of limestone are present at various depths.

330–360 cm. *Carex* peat mixed with fluvial loess which increases in a downward direction. Locally it is calcareous.

360– cm. Fluvial loess mixed with some peaty material.

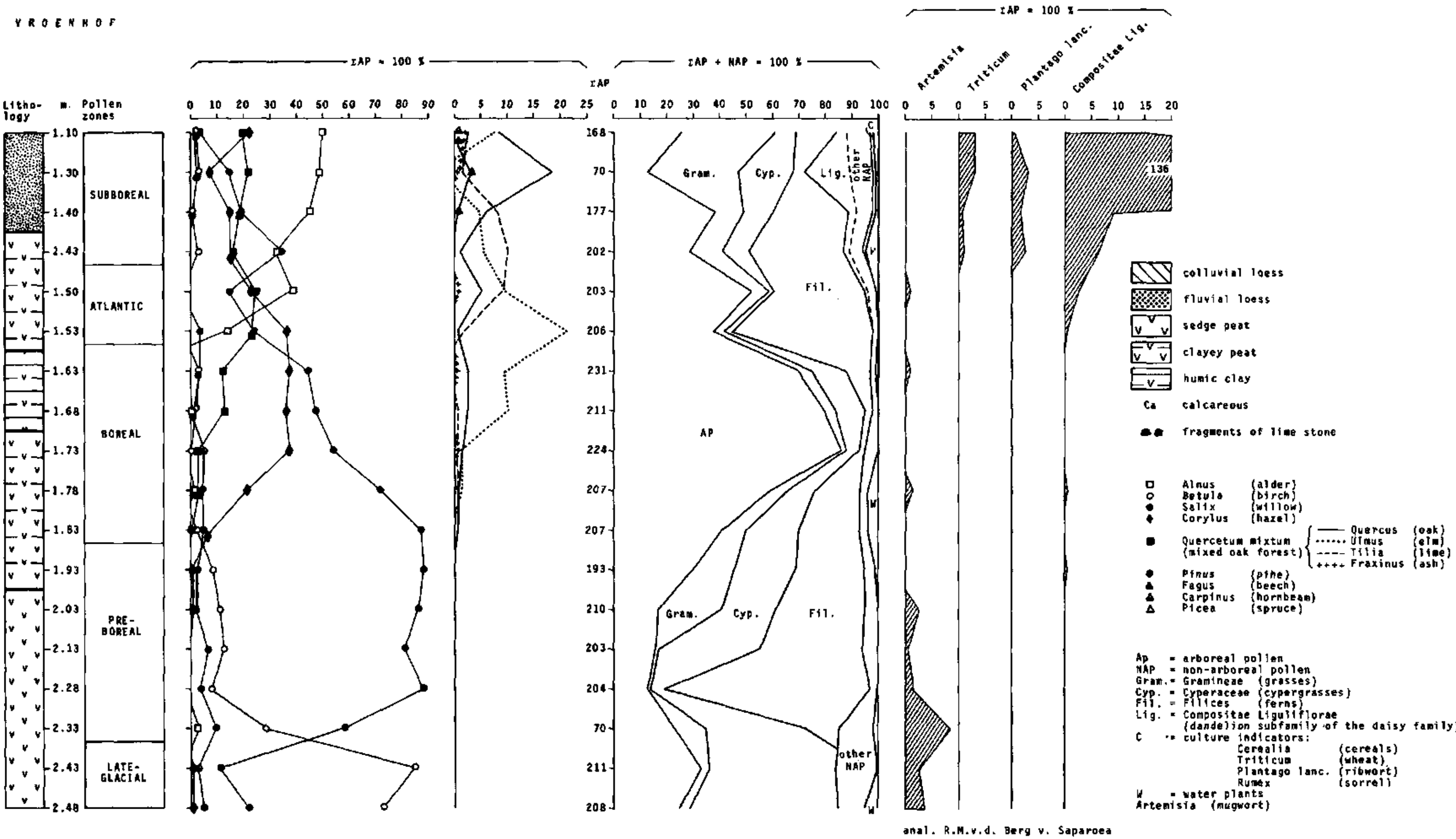
It may be inferred from the occurrence of clayey material in the peat in the Vroenhof profile and the fragments of limestone in the other profile that the peat was periodically flooded during formation. The flood water may have eroded peaty material which could have been deposited elsewhere. Local decay of the peat shows that periods with a low water table must also have occurred. It was at those times that the pollen grains in the peat were attacked by micro-organisms, giving the pollen wall its generally fairly severely corroded appearance.

3. SOME POLLEN ANALYSIS PROBLEMS

Owing to selective pollen corrosion the two pollen diagrams may give a somewhat distorted picture. This would explain why *Carpinus* is represented in the Vroenhof diagram by one pollen grain only viz. in the topmost Subboreal spectrum and is completely absent from the Etenaken diagram, even in the Sub-atlantic zone where it might have been expected (see also p. 56). *Fraxinus* is also absent from the latter diagram. According to the literature both species often show little resistance to corrosion.

In the mineral subsoil of the Etenaken profile the pollen concentration below 3.65 m was so slight that the samples analysed contained too little pollen to afford a complete spectrum. To obtain a better insight the pollen counts were added to a single spectrum, viz. 3.85 m.

1 The grain-size distribution of the 'clay' component was not analysed, but it may be assumed that it mainly consists of loess.


VROENHOF
Litho-logy
m.
Pollen zones
ΣAP = 100 %
ΣAP
ΣAP + NAP = 100 %
Artemisia
Triticum
Plantago lanc.
Compositae Lig.
SUBBOREAL
ATLANTIC
BOREAL
PRE-BOREAL
LATE-GLACIAL
1.10
1.30
1.40
2.43
1.50
1.53
1.63
1.68
1.73
1.78
1.83
1.93
2.03
2.13
2.28
2.33
2.43
2.48
168
70
177
202
203
206
231
211
224
207
207
193
210
203
204
70
211
208
Gram.
Cyp.
Lig.
other NAP
Fil.
AP
C
W
136
colluvial loess
fluvial loess
sedge peat
clayey peat
humic clay
Ca calcareous
fragments of lime stone
Alnus (alder)
Betula (birch)
Salix (willow)
Corylus (hazel)
Quercetum mixtum (mixed oak forest)
Quercus (oak)
Ulmus (elm)
Tilia (lime)
Fraxinus (ash)
Pinus (pine)
Fagus (beech)
Carpinus (hornbeam)
Picea (spruce)
Ap = arboreal pollen
NAP = non-arboreal pollen
Gram. = Gramineae (grasses)
Cyp. = Cyperaceae (cypergrasses)
Fil. = Filices (ferns)
Lig. = Compositae Liguliflorae (dandelion subfamily of the daisy family)
C = culture indicators:
Cerealia (cereals)
Triticum (wheat)
Plantago lanc. (ribwort)
Rumex (sorrel)
W = water plants
Artemisia (mugwort)
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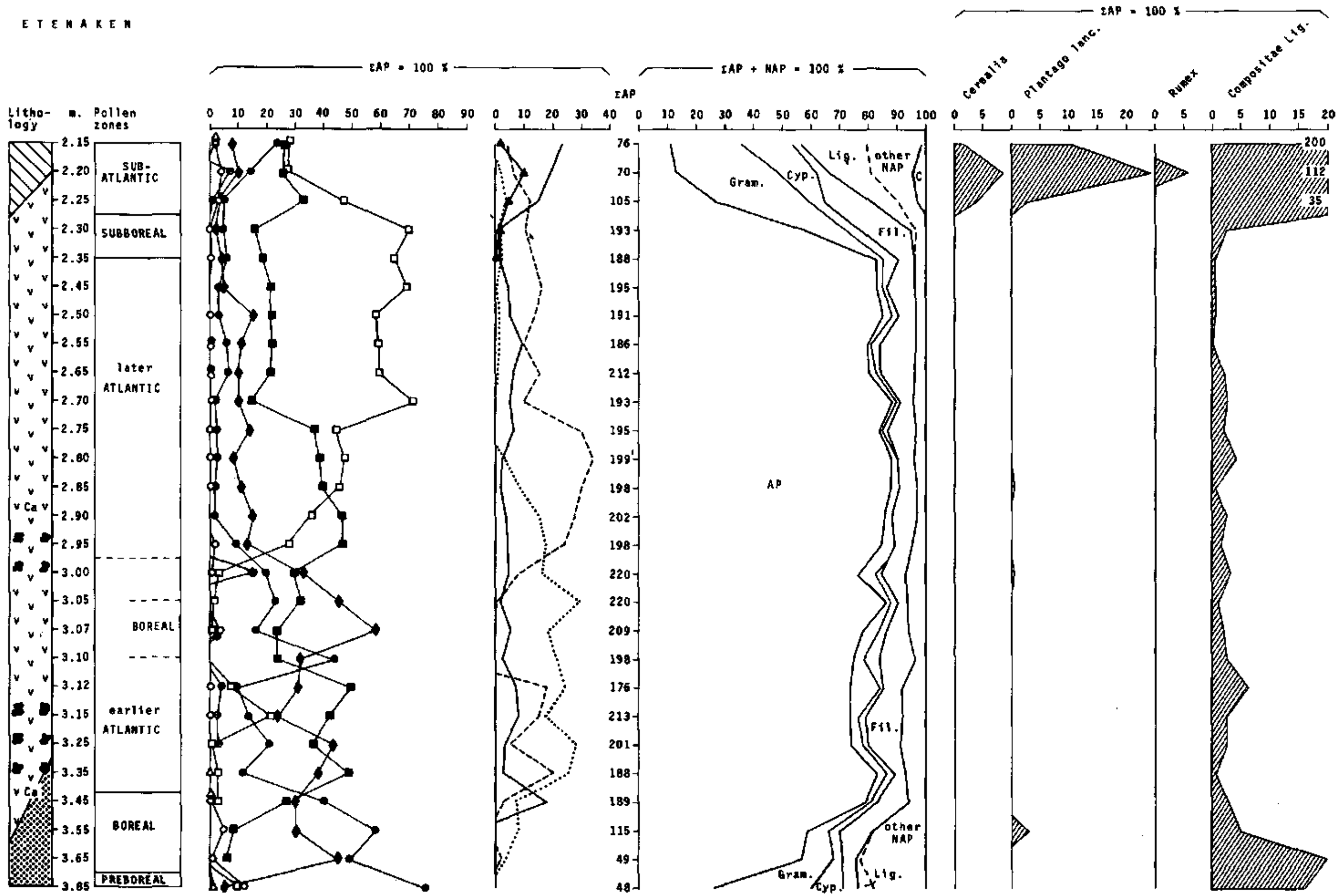
E T E N A K E N



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4. DESCRIPTION AND INTERPRETATION OF THE DIAGRAMS

In the diagrams the first column shows the lithology of the soil profile, the second the pollen zones, and the third the tree-pollen percentages based on the total of all tree species (including *Corylus*) (ΣAP = 100%). The fourth column shows on a larger scale the proportion of each of the four components of the Quercetum – mixtum (Q.M.), *Quercus*, *Tilia*, *Ulmus* and *Fraxinus* and also the representation of *Fagus* and *Carpinus*, neither of which appears before the later Holocene. The fifth column is an overall picture of the vegetation, the percentages being calculated on the basis of combined arboreal pollen and non-arboreal pollen (ΣAP + ΣNAP = 100%). The values for *Artemisia*, cereals and agricultural weeds are given on the extreme right. *Artemisia* is a common species in Late-glacial pollen spectra and is evidence of open terrain conditions.

The ratio of all arboreal pollen to all non-arboreal pollen (ΣAP : ΣNAP) is usually a good index of the extent to which the surrounding area was covered with forest. A high ratio indicates a dense forest, a low one an open vegetation. To obtain the best impression one should omit from the pollen assemblage considered plant species which grew in the neighbourhood of the sampling site, as otherwise the pollen of these species would be over-represented. To assess the extent to which the more elevated, drier soils in the areas around the two profiles analysed were covered by forest during the periods represented by the diagrams, we could omit the ferns, cyper grasses, part of the grasses and herbs, and also the water plants, all of which had their habitat on the moist soils of the valley floor. The local character of part of the non-arboreal pollen is evident from the fact that the non-arboreal species show so much higher percentages in the Vroenhof diagram than in the Etenaken diagram.

But this method of calculation was found to be ineffective; after omission of the ferns, cyper grasses and water plants for which a moist habitat may be taken for granted, the curve for the ΣAP : ΣNAP ratio was yet erratic in the Vroenhof diagram. Apparently much of the remaining NAP pollen also came from the moist vegetation near the profile although the actual proportion cannot be determined. As a result we did not construct a diagram giving reduced percentages.

The two diagrams will be discussed together below, to begin with the diagram in which the pollen zone under discussion shows the clearest or simplest pattern.

4.1. Late-glacial zone

The arboreal section of the Late-glacial spectra in the Vroenhof diagram is highly dominated by *Betula*. The low ΣAP : ΣNAP ratio and the fairly high *Artemisia* percentages indicate an open vegetation. Here and there some birch occurred. *Corylus*, transitory represented by 1%, was not yet growing in the vicinity.

4.2. Pre-boreal zone

In the Pre-boreal zone of the Vroenhof diagram *Pinus* shows a rapid advance to high values to the detriment of *Betula*. This is a common feature of diagrams from South Limburg and adjacent areas. *Corylus* puts in a definite appearance towards the end of this period. The $\Sigma AP:\Sigma NAP$ ratio is low as a result of local growth of ferns and cyper grasses. At the top of this zone the ratio increases somewhat. During the Pre-boreal period *Artemisia* disappears. The landscape became covered with a uniform fir forest which afforded little space for herb growth.

The only spectrum of Pre-boreal age in the Etenaken diagram has much the same composition as the topmost Pre-boreal spectrum in the Vroenhof diagram although the Filicinae percentage is much lower.

Unlike the latter diagram, the Pre-boreal zone of the Etenaken diagram falls within a deposit of fluvial loess. This coincidence may explain the relatively high *Alnus* value and the representation of *Picea* in this zone in the Etenaken diagram. Both pollen types may have originated from older soil layers and have been redeposited together with the loess material in which they are found.

4.3. Boreal zone

The Boreal zone of the Vroenhof diagram starts with an increase in *Corylus* to the detriment of *Pinus* and the appearance of the Q.M. Thereafter the latter also increases to the detriment of *Pinus*. The increase is chiefly in respect of a single component of the Q.M., viz. *Ulmus*. The $\Sigma AP:\Sigma NAP$ ratio reaches a very high figure. The forest is of a less uniform character than during the Pre-boreal period.

Broadley speaking the Etenaken diagram is a compressed picture of the above Boreal diagram section. One striking difference is the *Quercus* peak at 3.45 m.

4.4. Atlantic zone

The very high $\Sigma AP:\Sigma NAP$ ratio in all Atlantic spectra in the Etenaken diagram indicates a dense forest vegetation.

Pinus shows a marked recession at the beginning of the Atlantic period whereas the Q.M. makes a further advance. *Corylus* provisionally maintains its ground. The beginning of the Atlantic zone is put at the crossing of the *Pinus* and the Q.M. curve (cf. Janssen, 1960). At a much later stage *Alnus* comes to the fore. This phenomenon is also found in a diagram from the more southerly country of Luxemburg (Riezebos and Slotboom 1974), whereas Janssens's diagrams from South Limburg show *Alnus* dominance during the whole Atlantic period as well as during the later stage only. In this connection we also refer to the pollen diagrams from sand soils in the neighbouring part of Belgium (Munaut 1967) in which *Alnus* is of minor importance during the whole Atlantic period.

The Q.M. is first dominated by *Ulmus* and later by *Tilia*. Higher *Ulmus* values followed by higher *Tilia* values are also found in several diagrams from adjacent regions in Belgium and Germany (see JANSSEN 1960, p. 67 and WOILLARD 1975, p. 98). But this succession is not a general rule. For instance, two of JANSSEN's diagrams in which the older part of the Atlantic period is represented, show a dominance of *Quercus* or *Tilia*, whereas in both cases *Ulmus* is last. As in the earlier part each of the three species may dominate in the later part of the Atlantic zone.

Apparently local forest composition had a marked effect on the fossil pollen floras. This must be due to the limited extent of the small peat moors from which the experimental material was taken.

Between 310 and 305 cm the diagram shows an erratic pattern. *Pinus* and *Corylus* occasionally attain high values whereas *Tilia* is missing from two of the spectra. In the Atlantic zone of two of JANSSEN's (1960) diagrams *Pinus* is also temporarily represented with fairly high percentages. He explains this by assuming that the tree still formed part of the forest vegetation of South Limburg during the Atlantic period, or that the high representation is due to certain vegetation conditions as an indirect result of which the proportion of pollen conveyed over a long distance became over-represented in the pollen rain.

We prefer a different explanation and assume that peaty material originating from an older peat layer containing Boreal spectra is inserted in the soil profile at the depth in question. This could be the result of one or more of the inundations to which the peat moor was so often subjected during formation. Peaty material from elsewhere may have been eroded and redeposited at the site of the Etenaken profile (cf. VAN ZEIST 1958/59, p. 24).

Intercalation of an older peat layer in a later peat deposit is a fairly common feature. It is occasionally found near the coast and near or in (former) lakes. Obviously it may also occur in the flood area of a river.

In this connection we would point out that some of JANSSEN's diagrams show a gap, also presumably as a result of erosion.

It is clear from the Atlantic spectra below and above the section in the Atlantic zone just discussed that a mixed oak forest occurred in the fairly close vicinity. Its most important tree was *Tilia*, particularly in the later Atlantic period. But during the earlier part dominance of this tree may also be assumed, despite the fact that the spectra suggest a moderate dominance of *Ulmus*. It should be remembered, that unlike the other tree species, *Tilia* is insect-pollinated and consequently has a relatively low pollen dispersion capacity, which is why it is usually very much under-represented in pollen diagrams.

During the later part of the Atlantic period the Alnetum gained ground in the surroundings of the profile. As increasing *Alnus* percentages are a common feature during this period (see above, p. 53) the most plausible explanation is that near the valley floor the mixed oak forest was superseded by the Alnetum owing to the increasing humidity of the soil. But JANSSEN's diagrams show that local alder growth on carr peat may also have occasionally contributed to a higher proportion of *Alnus* pollen in the pollen rain.

The two Atlantic spectra in the Vroenhof diagram, representing the older and later stage respectively, give a fragmentary picture of a similar vegetation development during the Atlantic period. But unlike the Etenaken diagram they show relatively high *Pinus* and *Corylus* values. The same can be seen in the Sub-boreal spectra above. Now these spectra are all present in clayey peat or fluvial loess, unlike the corresponding spectra in the other profile where fluvial sedimentation did not occur in any form. This is why we assume that the relatively high *Pinus* and *Corylus* percentages are largely due to secondary pollen deposition, i.e. from the flood water. It is striking that the Atlantic spectra rich in *Pinus* in JANSSEN's diagrams (see above) also originate from soil layers deposited in an aquatic environment, viz. peaty gyttja and alder peat mixed with calcareous lake sediment. In this connection we would also point out that relatively high *Pinus* percentages are more commonly found in fluvial sediments in the Netherlands.

4.5. SUB-BOREAL ZONE

In contrast to the common picture the Etenaken and Vroenhof diagrams do not show a clear retreat of *Ulmus* and/or *Tilia* at the transition from the Atlantic to the Sub-boreal zone. The most conspicuous feature of the Sub-boreal zone of the Etenaken diagram is that non-arboreal pollen again dominates arboreal pollen, a position it had lost since the Early Holocene. *Fagus* now appears, but otherwise the zone closely resembles the arboreal section of the Atlantic spectra.

The later part of the Sub-boreal period is absent, tallying with the assumed erosion of the fluvial loess and the upper peat layer (see p. 48). Later Sub-boreal spectra are in fact found in the Vroenhof diagram in which *Quercus* moves up to higher percentages, showing a peak at 1.30 m. *Tilia* and *Ulmus* recede to low values, although the latter moves up again at the top of the zone. *Fagus* is present. *Carpinus* is only found once, viz. in the topmost Sub-boreal spectrum (cf. p. 56). The high representation of the non-arboreal pollen in the Vroenhof diagram is accompanied by the representation of cultivation indicators, viz. cereals and some agricultural weeds. These occur from the bottom spectrum of the zone just below the fluvial loess deposit. The coincidence is good evidence that the forest vegetation declined as a result of reclamation and cultivation of the forested soil in the vicinity. The percentages for the Compositae-Liguliflorae are high in the fluvial loess. This may partly be due to the fact that pollen of this sub-family originated from a secondary pollen source, viz. the eroding cultivated soil, in which it may have occurred in high concentrations (see below, p. 57). The same may also be true of the pollen of the other cultivation indicators.

The above theories do no apply to the Etenaken diagram. The absence of cultivation indicators could mean that during the earlier part of the Sub-boreal farming was only carried out either at a great distance or on a very small scale in the profile environment.

For the relatively high *Pinus* and *Corylus* percentages in the Vroenhof diagram we refer to the discussion of the Atlantic zone in the same diagram.

The Etenaken diagram shows that the change in the composition of the Q.M. continued during the Sub-atlantic. According to FIRBAS (1949, p. 170) a final advance of the oak may be ascertained in landscapes during the Middle Ages (Zone Xa), where, having regard to other observations, an intensified use or destruction of the forest has to be assumed. He assumes that such activities might also have occurred, now and then, during early-historic and prehistoric eras. To some extent this may explain the advance of *Quercus* during the Sub-boreal period shown in the Vroenhof diagram.

4.6. SUB-ATLANTIC ZONE

The Sub-atlantic zone is represented in the Etenaken diagram only. It entirely coincides with the colluvium. In addition to pollen sedimented from the air this deposit naturally contains pollen redeposited together with the eroded loess. The bottom 7 cm may also contain pollen displaced secondarily with the peaty material at that depth in the colluvial loess. Despite these complications the pollen curves are normal.

Fagus shows an advance but subsequently recedes again. *Carpinus* is completely absent, a feature also seen in many Sub-atlantic spectra in JANSSEN's (1960) diagrams. He believes this to be due to a marked human influence on the forest composition but, as mentioned above (p. 49) differential decay of *Carpinus* pollen in the colluvial material may also have been a factor.

Corylus and especially the Q.M. become more important than in the preceding zone. *Quercus* retains its great dominance in the Q.M. The *Alnus* and *Pinus* curves show a marked shift: the first recedes and the other advances. The non-arboreal pollen, which includes a great deal of culture pollen, is now represented with very high percentages.

It may be inferred from the decline in *Alnus* values that during the Sub-atlantic period the lower humid soils near or on the valley floor were also used for farming, the alder carr being cleared to make room for grassland.

The advance of the *Pinus* curve must be an indirect effect of the decline of the forest vegetation in the region in the course of the Sub-atlantic period (cf. JANSSEN 1960), declining production and dispersion of the regional tree pollen resulting in a relative rise in tree pollen conveyed over a long distance. We do not think it could reflect an absolute increase in the precipitation of *Pinus* pollen due to more recent pine plantations because it is hardly likely that the 2.20 layer of colluvium at the bottom of which the Sub-atlantic spectra were found, would have been deposited over its entire depth since such a late date.

5. SOME CONCLUSIONS

The limited scope of the investigation prevents us from drawing any definite conclusions. We believe, however, that a close connection between the type of the Holocene mineral valley fill and the age of the pollen spectra near the bottom of this deposit, as found during this investigation, may be more generally found in the Geul valley. Relatively late spectra can always be expected in the colluvial loess, and in the fluvial loess such spectra will in any case be found in the basin areas where it covers a more or less peaty substratum.

The formation of this fluvial layer began during the period when the landscape was only cultivated to a very limited extent, i.e. the Sub-boreal period, the colluvial deposits being formed later during the Sub-atlantic period and probably mainly since the Roman era when the region was extensively farmed. In this connection we refer to the results of RIEZEBOS and SLOTBOOM's (1974) palynological investigation of soil material from slopes covered with loess in Luxemburg. They concluded that there also colluviation did not become important before the Sub-atlantic period.

Although the *Tilia* percentages in the Sub-atlantic and later Sub-boreal spectra are often low, they may nevertheless indicate that lime played a certain part in the development of the forest vegetation during the more recent Holocene. In this connection we must again remember the tree's relatively low pollen dispersion capacity.

But information on the existence of former lime forests may also be obtained from a quite different source than palynological studies, viz. from ancient documents and place-names (S. VAN DER WERF, oral comm. 1979). Some mediaeval documents show that remnants of lime forests must have existed as late as the Middle Ages. The same conclusion may be drawn from certain place-names in South Limburg, e.g. the village name 'Terlinden'[1] and the farm-road name 'Mheerlindje'[1] found near the village of Mheer. Place-names containing the element 'linde' are also found in the Netherlands outside the South Limburg loess area, in regions where the soil is formed by cover sand. It is interesting to note that high *Tilia* percentages are fairly common in the Atlantic or Sub-boreal zone of pollen diagrams from soil profiles which developed in cover sand.

The high Compositae-Liguflorae percentages in the upper mineral part of both profiles deserve particular attention. These high values should not lead us to draw any conclusions as to the proportion of this sub-family in the vegetations represented. HAVINGA (1962, 1971) and BOTTEMA (1975) showed that high concentrations of Liguliflorae pollen are found fairly frequently in mineral soil as a result of differential pollen preservation or deposition by digger-bees. The latter author notes that environments created or influenced by man (and farmers in particular) often favour the existence of the bees. It may therefore be assumed that part of the Liguliflorae pollen in question originates from cultivated soil

[1] 'Linde' is the Dutch for 'lime tree'.

rich in Liguliflorae pollen. It must have been carried and redeposited together with the eroded soil material which now constitutes the fluvial and colluvial deposits.

6. SUMMARY

A tentative investigation was carried out into the age of the fluvial and colluvial loess deposits in the valley of the river Geul in South Limburg (Netherlands). Two soil profiles were studied palynologically, one consisting of a layer of fluvial loess on peat and the other of colluvial loess on peat. It was found that at the site of the profiles the deposits both date from the era at which agriculture had already made its mark on the landscape. The fluvial sedimentation began during the earlier part of the Sub-boreal period, when the landscape was only cultivated to a very limited extent. The colluvial deposit is of later date, being formed during the Sub-atlantic period, probably mainly since the Roman era when the soil became intensively cultivated.

Special attention is paid to the significance of the *Tilia* percentages and the high Compositae-Liguliflorae percentages in the diagrams.

7. SAMENVATTING

EERTIJDSE VEGETATIE EN SEDIMENTATIE IN HET DAL VAN DE GEUL

Er is een voorlopig onderzoek uitgevoerd naar de ouderdom van de fluviatiele en colluviale lössafzettingen in het dal van de Geul. Daarbij zijn twee profielen palynologisch onderzocht, respektievelijk bestaande uit fluviatiele löss op veen en colluviale löss op veen. Het bleek dat de beide lössafzettingen ter plaatse van de onderzochte profielen stammen uit de tijd, waarin de landbouw zijn stempel reeds op het landschap had gedrukt. De fluviatiele sedimentatie begon tijdens het oudere deel van de subboreale tijd, toen het landschap nog maar in zeer beperkte mate in cultuur was. De colluviale afzetting vond plaats in de subatlantische tijd, waarschijnlijk vooral sedert de Romeinse tijd, toen de bodem reeds intensief werd bebouwd.

De aandacht wordt gevestigd op de aanwezigheid van verschillende toponymen in de streek, waarin de naam van de lindeboom terug is te vinden. Dit wijst erop, dat de linde nog in de Middeleeuwen een niet te verwaarlozen rol in de vegetatie speelde. De lage *Tilia*-percentages in de subboreale en subatlantische pollenspektra van de beide diagrammen zijn mede een gevolg van de reeds zo vaak vermelde slechte verspreiding van het stuifmeel van deze boom.

De hoge Compositen-waarden kunnen op indirekte wijze met de landbouwcultuur in verband worden gebracht.

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