A PALYNOLOGICAL STUDY OF THE HOLOCENE AND LATE-GLACIAL IN SOUTH-EAST FRIESLAND (THE NETHERLANDS)

by

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The borings, on which this study is based, were made within a radius of circa 5 miles around Opeinde, a village in the province of Friesland near the Friesland-Groningen border.

OPEINDE (Diagram I)

This profile is based on a series of samples taken from a vertical peat bank that indicated the place where the peat digging, by which the greater part of the bog had been removed, had stopped. The series of samples extended from the surface down to the hard-pan below the peat. The sand on which the peat was deposited proved to contain rests of *Calluna* (A_0 layer). The coagulation of Fe-compounds (B-layer) occasioned by this *Calluna* vegetation obviously lead to the development of the peat deposit. Besides the peat the gray sand (A_2-layer) was pollenanalytically examined. The results of this analysis can only be regarded as reliable if we may assume this sand has been deposited gradually and has retained in the successive layers a part of the pollen-rain in undisturbed condition (lit. 4). If it should appear that the curves of the "sand diagram" pass gradually into those of the overlying peat, this would support our supposition of a gradual "growth" of the sand deposit. Comparison with the diagrams III and V relating to neighbouring bogs and with diagram II pertaining to the same bog, shows that the decrease of the percentage of *Alnus* pollen and the increase of the percentage of *Betula* pollen in our "sand diagram" is indeed not abnormal.

As to the age of the hard-pan, which as account of the finding of artefacts is also a matter of archaeological interest, the same comparison renders probable that the sand of this hard-pan has been deposited at the end of the boreal period or at the beginning of the atlanticum. Absolutely reliable information with regard to its age could not be obtained because of the scarcity of pollen in this sand.

A phenomenon that is very clearly brought out in the diagrams III and V, is that just before the intersecting of the *Pinus* and *Alnus* lines (the boreal-atlantic limit) a layer is found in which the *Betula* pollen outnumbers the *Pinus* pollen. In diagram I this is on account of the scarcity of pollen not directly observated.
A distinct border-layer (Grenz-layer, subboreal) is easily observed and is characterized by the ending of a gradual decline of the *Corylus* curve after its atlantic top. Remarkable is the appearance of *Fagus* before the subboreal (lit. 1 and 8). *Carpinus* occurs already in the Grenz-layer.

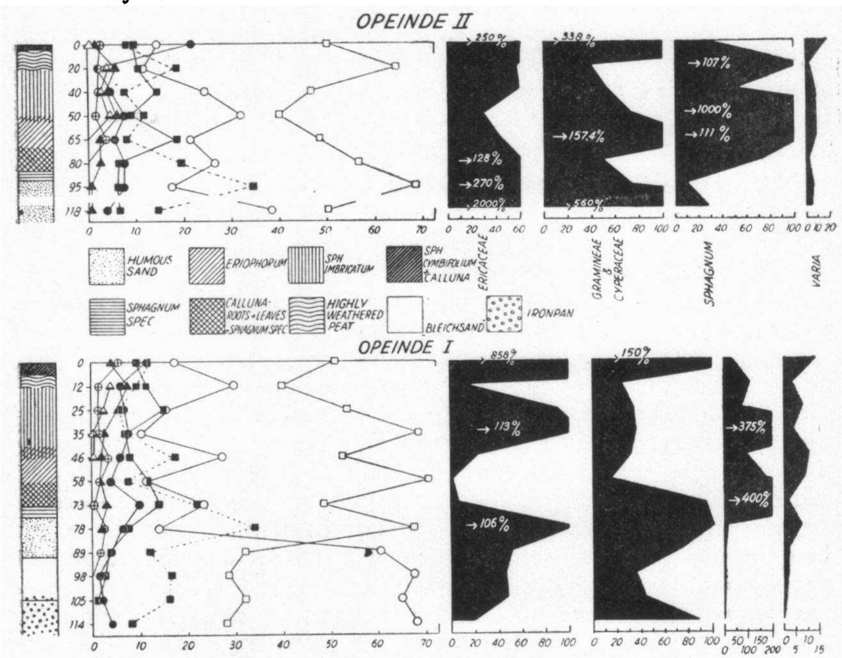

Fig. 1. Diagrams I and II, Opeinde

Striking is the increase of the percentage of *Ericaceae* pollen to very high values (858% in I and 1660% in III) near the surface. How is this fact to be interpreted? FLORSCHÜTZ and WASSINK (lit. 8) have pollenanalytically investigated the central part of a large raised bog that was covered only with heather. They found in its surface layers a percentage of Ericaceous pollen of 100%. The same authors moreover examined small bogs overgrown with heather and lying in the midst of a wide heath (lit. 9). Here they found percentages of circ. 2000%. Realizing that both localities are surrounded by an extensive heath vegetation and that the accessibility to the pollen-grains of the heather is the same in both cases, the cause of the difference in the amount of Ericaceous pollen must be sought in the greater density of the heather vegetation outside the bog. This greater abundance of *Ericaceae* may have been caused by edaphic factors or, and this is more probable, it may have been a question of time: on the dry soil the heather may already have been present before it began to settle on the bog. In the same way the bogs of which the remains were studied by us must have been surrounded by an ever denser heather vegetation.

OPEINDE (Diagram II)

In the centre of the above mentioned rest of the raised bog a boring was carried out. The diagram corresponds approximately to that of Opeinde I. But if we suppose that the rate of growth of the peat was the same as in Opeinde I, the formation of peat must have started somewhat earlier, which may have been due to the presence of a depression in the sand bottom.

Of this underlying sand no samples could be obtained because the peat borer was incapable of boring through sand.

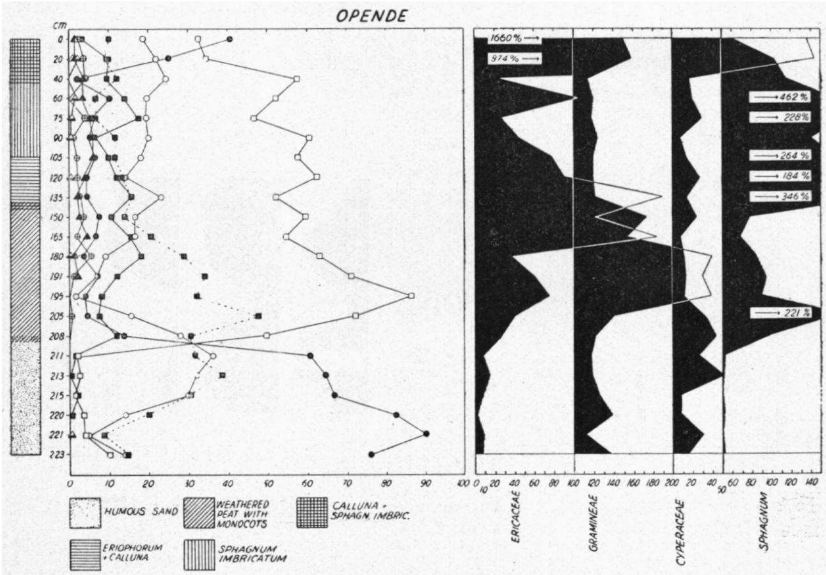

Fig. 2. Diagram III, Opende

OPENDE (Diagram III)

The old peat proved to be much corroded. The young Sphagnum peat is overgrown with heath.

The pollen diagram again shows the same remarkable features that were noted above, as the appearance of *Fagus* before the Grenz-layer (Here *Carpinus* too appears before the subboreal) and the tendency of the percentage of the *Betula* pollen to exceed that of the *Pinus* pollen at the intersecting of the *Pinus* and *Alnus* curves. The latter fact is also evident in an unpublished diagram relating to the same bog and composed by FLORSCHÜTZ. Two *Corylus* tops are found, a first maximum in the boreal and a second one in the atlanticum.

Remarkable is the increasing percentage of *Pinus* pollen towards the surface. This increase may be attributed to recent plantation of *Pinus sylvestris*. The same increase is shown in the other diagrams, diagram V excepted.

HEMRIKKERVELD (Diagram IV, Sphagnum bog in the midst of Pinus plantation)

Considering the course of the different tree-pollen curves we might come to the conclusion that the formation of peat has begun in the boreal. This boreal with its *Pinus* and *Corylus* tops would have its ending at the intersecting of the *Pinus* and *Alnus* curves and would be succeeded by the atlanticum, characterized by the appearance and subsequent increase of the *Quercetum mixtum*.

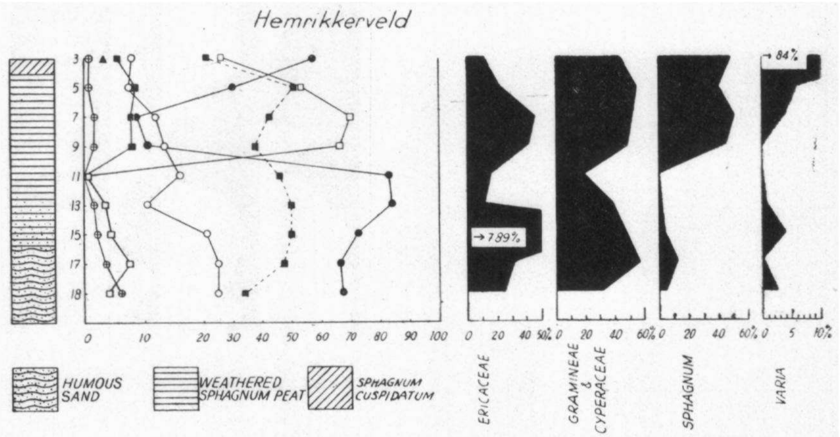

Fig. 3. Diagram IV, Hemrikkerveld, near Beetsterzwaag

In the upper layers *Fagus* pollen appears and the percentage of *Pinus* pollen increases as usual. Two facts, however, make this interpretation doubtful:

1. the thinness of the peat layer,
2. the presence of pollen of cereals in the lowermost spectrum, which indicates human activity.

These facts suggest an entirely different interpretation which is given in the following paragraph.

The bog is not as old as the lowermost pollen spectra suggest; on the contrary it is a recent bog, situated in a rather vast area of *Pinus* plantations. Shortly before the intersecting of the *Pinus* and *Alnus* curves an old *Pinus* plantation had been felled and a new one planted. This explains the decrease of the percentage of *Pinus* pollen. Until then the percentage of *Alnus* pollen was low owing to the dominance of *Pinus* trees and perhaps also to the poor access of the *Alnus* pollen to the bog which was sheltered by the *Pinus* plantation. The appearance of pollen belonging to the components of the *Quercetum mixtum* may be ascribed to the presence of a more modern mixed plantation in the neighbourhood. The growing up of the new pine plantation caused an increase of the *Pinus* percentage and a decrease of the percentage of *Alnus* pollen. The *Fagus* pollen in the uppermost spectrum may have been derived from a beech alley in the vicinity of the bog.

Legauke (Diagram V)

The high percentages reached by the pollen of herbaceous plants in the lowermost three spectra indicate in connection with the scarcity of tree pollen the presence of a nearly treeless landscape (tundra). Afterwards there was a period of dense forest growth (the percentages of herb pollen decrease) in which *Betula* pollen dominates at first strongly, later on less markedly. Then the first thermophilous trees appear (praeboreal). Before the *Pinus-Alnus* intersecting we see the boreal *Pinus* top; at the intersecting *Pinus* is outnumbered by *Betula*, whereas after the intersection the normal atlantic top of the *Quercetum mixtum* appears. *Fagus* appears in obviously recent layers. This "recentness" however may be called in question. The other diagrams show that *Fagus* was already present in Friesland before the Grenz-horizont. (This peat has been deposited under water and a proper Grenz-horizont therefore is absent). If it is true that the first appearance of *Fagus* pollen indicates the transition from the subboreal to the subatlanticum the thinness of the peat deposited since the beginning of the subatlanticum might

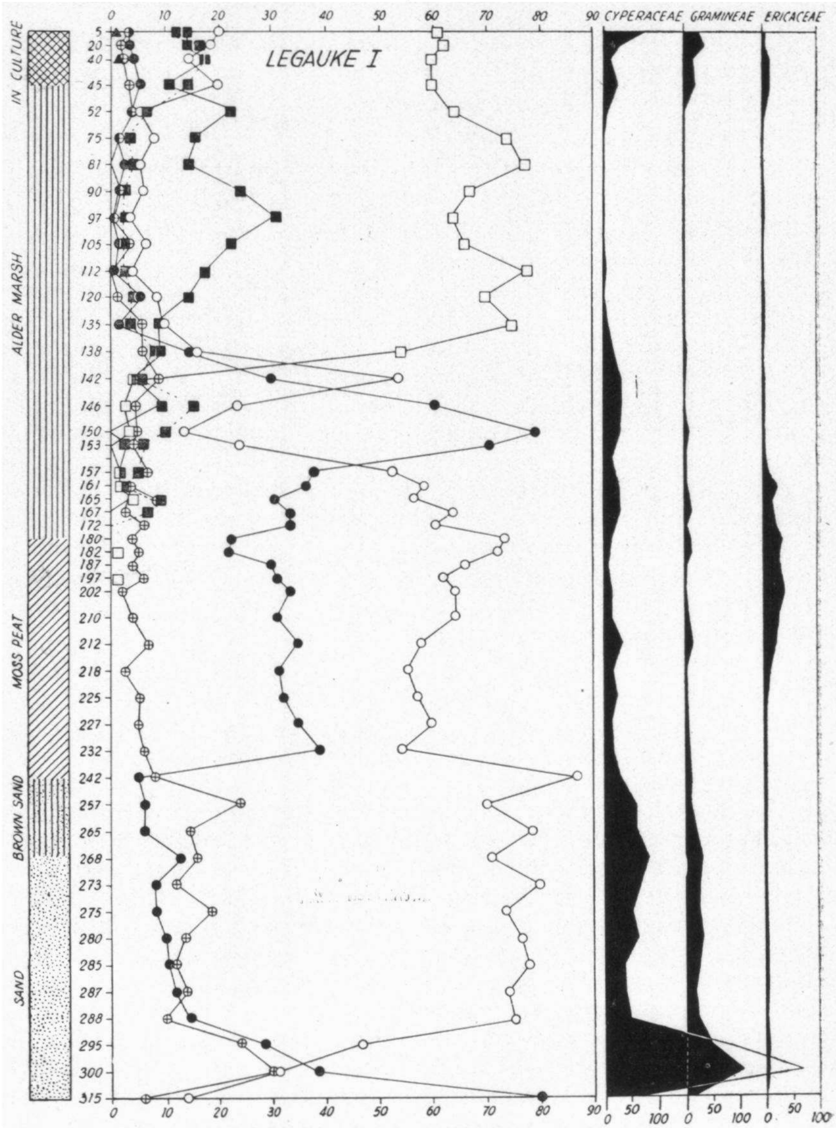

Fig. 4. Diagram V, Legauke I (near Opeinde)

be a cause of wonder. However there are two facts, which can clear up this difficulty: 1. the *Pinus* curve does not show an ascending course towards the surface as it does in the other diagrams (cf. III) and 2. the high percentages of Ericaceous pollen found near the surface in the other profiles are absent too, although it cannot be denied that the *Ericaceae* percentage shows a tendency to increase. An investigation of FLORSCHÜTZ and WASSINK (lit. 9) has shown that the importance of the heath began to increase at the time of the subboreal. After all there is reason to suppose that the more recent layers are absent in this locality.

The most interesting part of the diagram is the late-glacial, particularly in connection with the presence of a Alleröd-oscillation. Regarding this part, our diagram shows a striking resemblance to a diagram of a raised bog in the province of Drente published by WATERBOLK (lit. 13). This author found in the deposit formed after the tundra time a decrease of *Salix* pollen followed by a decrease of *Betula* pollen, the latter connected with an increase of *Pinus* pollen and with a low percentage of herb pollen. Afterwards the *Pinus* pollen decreases and the percentages of *Betula* pollen and of the herb pollen again increase. The just mentioned *Pinus* top corresponds with a dark zône containing *Pinus* fragments, which is intercalated in the profile between sandy layers. The author suggests that this is to be explained as follows: At the time of the dark zône the lake has fallen dry by the melting of the frozen underground (improvement of the climate) and after that the bottom was overgrown by *Pinus*. Later on the groundwater level again began to rise.

The same sequence is shown in our diagram, although the dark zône corresponding with the *Pinus* top at —232 cm is absent. However it is striking that just when the climate began to improve (indicated by the increase of the percentage of *Pinus* pollen which starts at 242 cm below the surface) the brown colour of the sand, which makes the impression that it is due to coagulation of colloidal iron, disappears. The connection between this phenomenon and the improvement of the climate is not clear.

A second diagram, which is confined to the late-glacial part was worked out according to the method of IVERSEN (lit. 11). The diagram is divided in three parts. *A*, the general part, shows the percentages of tree pollen plotted from left to right and the joint percentages of anemophilous herbs and *Ericales* plotted from right to left. The curves of the latter group are separately shown in *B*. In *A* the number of pollen grains of each spectrum forms the pollen total. The *Corylus* pollen however is not included in this total, but it is in the same way as the pollen of the non-anemophilous herbs (the curves of those latter are shown in *C*) calculated as a percentage of the pollen total. *A* clearly shows the change in the distribution of trees and herbs in course of time. Moreover the T.P.F.

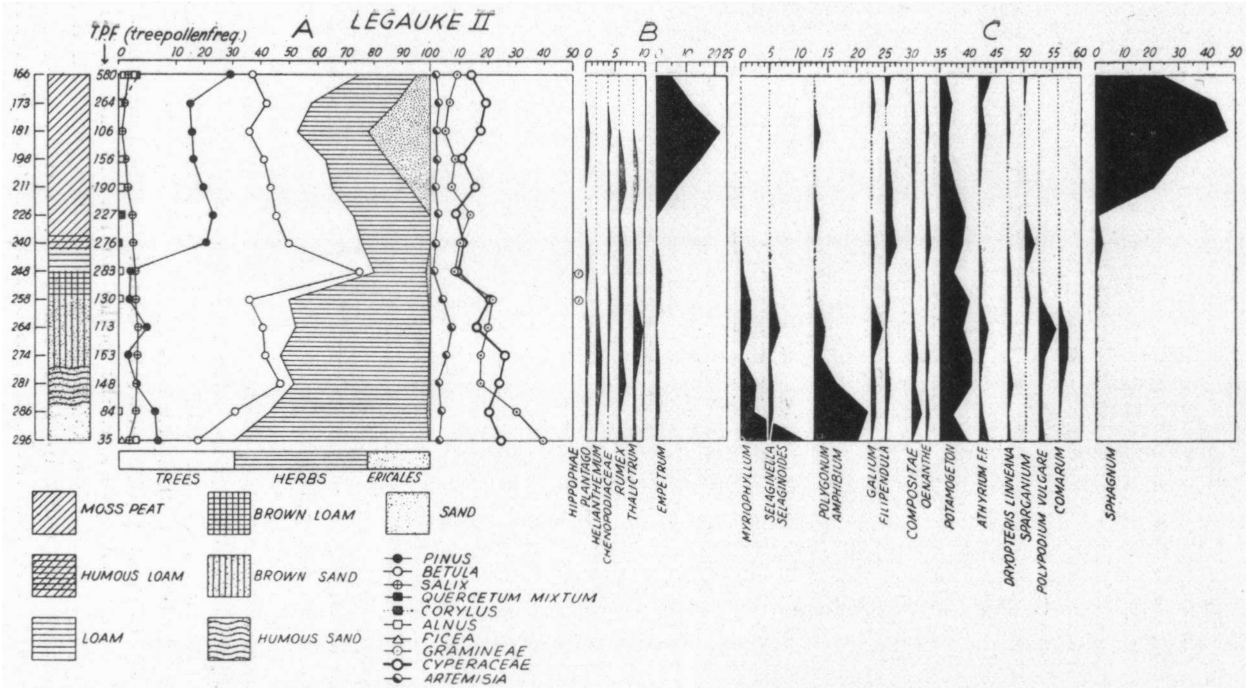

Fig. 5. Diagram VI, Legauke II (near Opeinde)

(tree pollen frequence = number of pollengrains per slide 24 × 32 mm) gives an impression of the forest type (close or open). The improvement of the climate, characterized by the overgrowing of the herbs by the development of a forest that gradually becomes denser, is easily observed.

A diagram, published by VAN DER HAMMEN (lit. 10) shows that also in the Netherlands the Alleröd is preceded by a smaller oscillation. In our diagram the same phenomenon can be observed, especially when we concentrate our attention on the slight increase of the T.P.F. at —281 cm and —274 cm. We are allowed therefore to apply here the division of the late-glacial proposed by IVERSEN and taken over by VAN DER HAMMEN: Earliest Dryastime, Bölling oscillation, Earlier Dryastime, Alleröd-oscillation and Late Dryastime, followed by the preboreal.

Criteria for the maximum of the Alleröd-oscillation may be:

1. the *Pinus* top (according to WATERBOLK)
2. the lowest percentages of herb pollen (in VAN DER HAMMEN's diagram with a *Pinus* top)
3. the higher T.P.F. (in our diagram connected with the lowest percentages of herb pollen).

The Late Dryastime is characterized by a mighty increase of *Empetrum* heaths. The time preceding the Alleröd is characterized by the presence of *Helianthemum*, *Hippophaë*, *Selaginella selaginoides*, *Polygonum amphibium*, a not very prominent top of *Artemisia*, maxima of *Cyperaceae* and *Gramineae*. With the exception of *Polygonum amphibium* the same species or genera were found by VAN DER HAMMEN.

Finally I should like to take the opportunity to record my appreciation for the helpful cooperation of Mr. J. SIEBINGA, physician at Opeinde. I am also indebted to Dr. F. P. JONKER for his valuable advice and suggestions.

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