PALAEOBOTANICAL INVESTIGATIONS IN THE VICINITY OF THE SNEEKER MEER (PROVINCE OF FRIESLAND, THE NETHERLANDS)

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(With Tab. I).

This paper deals with the investigation of soil samples taken near Terhorne on the North-East shore of the "Sneeker Meer", an expanse of water in the province of Friesland. (see fig. 1)

According to the geological map, the peat around this large body of water is covered by an 1—4 dm thick layer of young marine clay, but at the place where our samples were taken, the peat reaches the surface. A series of samples were collected from the whole depth of this peat-deposit (see diagram I). The surface lies here 0.35 m below the level of the sea. (As the sealevel is taken the N.A.P., the average height of the water level at Amsterdam.) At a depth of 2.15 or 2.20 m the borer reached the underlying sand. It proved impossible to penetrate with the borer used by us more than 5 to 10 cm into the sand. This sand (diagram I*a*, which shows the lowest part of diagram I on an enlarged scale) proved to be of a red-brown colour.

At a distance estimated at 50 to 100 meters from this bore-hole the lake was at one place filled up with earth by the Provincial Service for the Improvement of the Frisian canals; and here a deep pit was dug for the construction of a sluice that is to be used in the canal Lemmer — Groningen. In the walls of the sluice-pit it was possible to study the deeper layers. (see fig. 2)

Under the artificial deposit of earth there was a dark, highly corroded layer of peat, about 20 to 25 cm thick. The top of this peat deposit corresponds — as to its depth — with the bottom of the Sneeker Meer, which means that it lies circ. 1.90 m below sea level. At the lower end the peat gradually merges into grey sand (from circ. 2.13 m down to circ. 2.23 m below sea level) and this grey sand passes into a brown, compact sand, the B-layer (up to circ. 2.33 m below sea level). In this layer then proved to be an iron-pan, from which also samples were taken (see diagram II).

Below the iron-pan follows about a meter of yellow sand. Below this, on the Western wall of the sluice-pit, one could see, from 3.15 m to 4.15 m below sea level, an alternation of clay- and sandlayers, which proved to be strongly folded. Some narrow humous bands

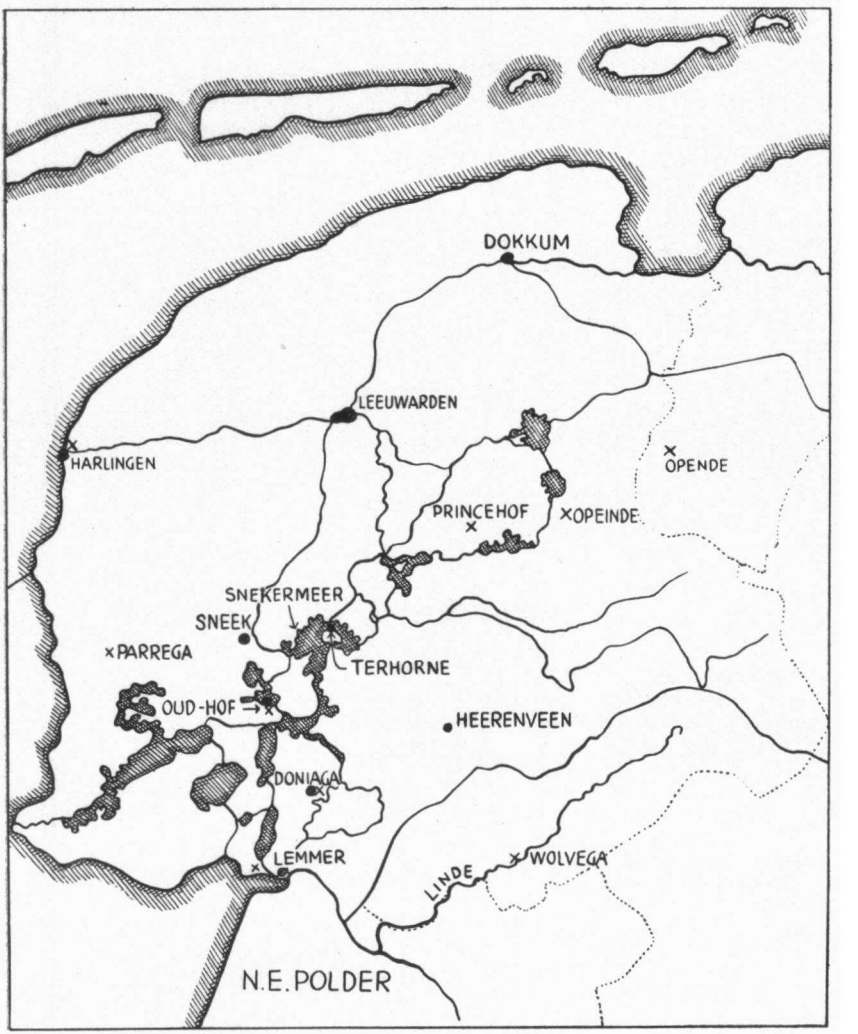

Fig. 1. Map of the Province of Friesland; × = boring

were intercalated between these layers. At 4.15 m below sea level there was a layer that obviously contained peat (III 4.15 m). With a small spade material of these layers was taken from the wall of the pit. Because the bottom of the pit was filled with water, it was impossible to reach the lower layers.

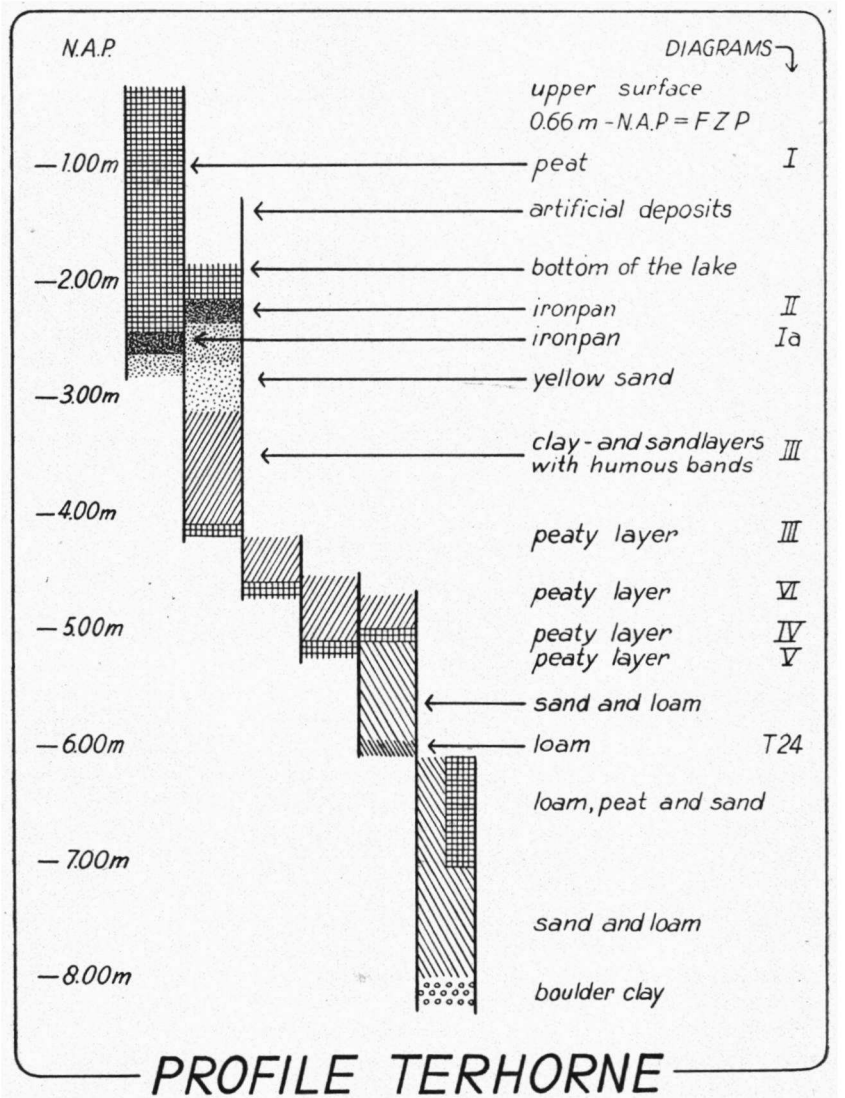

Fig. 2. Profiles of the peat and the sluice pit

The same "peaty" layer occurred also at other places, at the northern side of the pit, and showed — together with the adjoining

layers — a similar folding etc. as the layers represented in diagram III. This "peaty" layer was found at one place as a circ. 10 cm thick, hard, darkbrown somewhat sandy deposit of peat at a depth of circ. 4.65 m below sea level. (diagram VI); at the place, where prof. dr. F. FLORSCHUETZ took his photo's as a more humous layer and at two neighbouring spots situated 5.15 m below sea level as a brown deposit of peat, some centimeters thick (see spectrum IV). At the last mentioned spot this layer was reached, like the loam layer T24, which is found at a depth of 5.95 m to 6.15 m below sea level, by digging in the bottom of the pit.

Where possible, the material was examined on its pollen content as well as on the presence of fruits, seeds and other plant remains. In preparing the samples for the pollen analyses the KOH method was used, sometimes preceded by treatment with HF. To obtain a pollen spectrum we took 150 pollengrains of trees, leaving those of *Corylus* out of consideration; on the base of this pollen total the percentages were calculated. With a few spectra Iversen's counting method was used (IVERSEN — 1936-10; described in Dutch by VAN DER HAMMEN -1949-9-); as this proved to be no improvement compared to the first method, the diagrams obtained by this method are not reproduced.

It must be mentioned that I included — in contrast to VAN DER HAMMEN — pollengrains of *Abies*, *Picea*, etc., which in some spectra are likely to belong to the so-called secondary pollen, into the pollen total. The chance that a grain belongs to the secondary pollen or not, varies and as the percentages with which we are concerned, are rather small, their inclusion will exercise but little influence on the pollen percentages of the other trees.

It appears from the reports of two borings, received from Mr. E. J. VAN DER LAAN, the surveyor attached to the above mentioned Provincial Service, that the top of the boulder clay lies near the Terhorne sluice-pit at a depth of circ. 8.75 m. The report on one boring however mentions for the part between 6.75 m and 7.75 m below sea level besides loam and sand also peat. I did not see this material. Because the boulder clay, which is of Riss-glacial age, lies deeper, and considering the age of the layers which are lying above this peat deposit (cf. the description given below) it is possible that this peat has been formed in the Riss-Würm-interglacial or in the first (Twentian) Würm-interstadial.

The loamy layer (T24; see profile fig. 2) at circ. 6.00 m below sea level was neither rich nor poor in pollengrains. Of the 150 tree-pollengrains 90.7% proved to be *Pinus*, 4% *Abies*, 2% *Picea*, 3.3% *Betula*. Among the herbaceous pollen the *Cyperaceae* alone reached

a somewhat higher percentage, viz. 40.7%; *Ericaceae*, *Gramineae*, *Varia*, *Empetrum* and also *Sphagnum* spores did not reach more than a few percents. The percentage of *Pinus* pollen, determined by counting under the microscope, may be a little too high, for the *Pinus* pollengrains were, in contrast to those of *Picea* and *Abies*, often rather corroded and had partly fallen into pieces. There were also seeds of *Potamogeton*, *Batrachium* and, predominantly, *Carex*. Considering the pollen spectrum (with *Abies* and *Picea*) and the age of the layers below and above the layer T24, one is inclined to think that it is of interglacial (Riss-Würm) or interstadial (Twentian) age, though it is not completely sure that the pollen of *Abies* and *Picea* really is autochthonous.

Between the just mentioned layer T24 and the "peaty" layer there is sand, partly of a loamy character. The "peaty" layer, which is found at depths between 4.15 m and 5.15 m below sea level shows pollen spectra (III 4.15 m; IV, V and VI) with fairly large percentages of pollen, derived from thermophilous trees. *Corylus* pollen reaches percentages ranging from 8 to 60%. Confusion with pollen of *Betula nana* is in my opinion not possible. *Quercus* pollen is absent from the uppermost spectrum of diagram VI, shows rather low percentages in III 4.15 m., VI 4.65 and VI 4.70 m., and rather high ones in V and IV: 14 and 22.7%! *Alnus* pollen too has been found a few times, and occasionally also a pollengrain of *Carpinus*, *Acer* and *Abies*. Since the pollengrains of the above mentioned thermophilous trees have been found in peaty material — in contrast to IVERSEN -1947-11 — and since the grains moreover were not at all corroded, while the layers, though folded, were certainly not completely "turned upside down", I consider this pollen to be autochthonous.

Furthermore it must be mentioned that the percentage of the pollen of *Betula* is high with regard to that of *Pinus* pollen. The percentage of the Cyperaceous pollen ranges between 100 and 500%. Several times microspores of *Selaginella selaginoides* were found and once I noted a spore of *Lycopodium annotinum*.

The varia consist chiefly of pollen of *Compositae*, *Umbelliferae*, *Caryophyllaceae*, *Valeriana*, *Saxifraga hirculus*, *Myriopyllum*. Besides these always one or more *Artemisia* pollengrains were present; moreover pollen of *Rhamnus* and *Myrica* was found in III 4.15 m; of *Batrachium* in IV, V and VI 4.65 m. Occasionally pollengrains of *Ranunculus*, *Potamogeton*, *Labiatae*, *Chenopodiaceae*, *Rubiaceae*, *Epilobium*, *Thalictrum* were met with.

This layer proved to contain seeds of: *Batrachium*, *Potamogeton*, *Carex*, *Scirpus*, *Eleocharis*, *Juncus*, *Comarum*, *Ranunculus Flam-*

mula, Hippuris vulgaris, Menyanthes trifoliata, Myriophyllum alterniflorum & *M. verticillatum, Stellaria, Empetrum*; oospores of *Chara*, and macrospores of *Selaginella selaginoides*. The first six genera were represented by different species and by a large number of seeds.

In V parts of the leaves of *Scorpidium scorpioides* (L.) Limpv. were found and the microscopical examination revealed the presence of a few *Spagnum* leaves and some lateral roots of *Carex*.

It appears from the above mentioned data that this "peaty" layer must have been formed under eutrophic circumstances and in a period in which a temperate climate prevailed. It is questionable whether this warmer period corresponds with one of the known Würm-interstadials; anyhow it can not be identical with the Allerød-oscillation. When we compare the pollen analytical data with the pollen diagram obtained from the sluice-pit at Hengelo (FLORSCHUETZ & VAN DER VLERK -1936-6- and 1938-8-) it appears that there is very little resemblance with the Twentian interstadial. Our impression is that the warmer period met with in Terhorne may agree with the Masurian interstadial.

The layers which were found above the "peaty" layer, (see III 3.95 m — 3.15 m) proved to be poor in pollengrains and in seeds. Because of the scarcity of pollen no spectra could be obtained. Pollengrains of thermophilous trees were not found; the numbers of the Cyperaceous pollen proved to be relatively high. A few seeds of *Batrachium, Carex, Eleocharis, Menyanthes trifoliata* and *Myriophyllum verticillatum* were present.

In the layers III 3.95 m — 3.15 m and in the "peaty" layer kryoturbate phenomena were clearly seen. (see photographs, fig 5 and 6, Tab. I). The layers namely were strongly folded, sometimes interrupted, and showed frostfissures, filled up bulges, etc. (see the photo's). In our opinion the conclusion is justified that we meet here the same kind of phenomena as EDELMAN, FLORSCHUETZ & JESWIET (1936 -1-) observed near Hengelo and Wiene, *i.e.* with phenomena that have been caused by an alternation of freezing and melting of the soil, and that these events will probably have taken place in the last part of the Würm-glacial and/or in the late-glacial period.

Above the layers mentioned in the preceding paragraph we find about a meter of yellow sand, which will have been deposited in the subsequent period.

Above this yellow sand on several spots the iron-pan is found. On account of the resemblance between the pollen diagrams II and I*a*, of the red-brown colour of the sand, and of the hardness

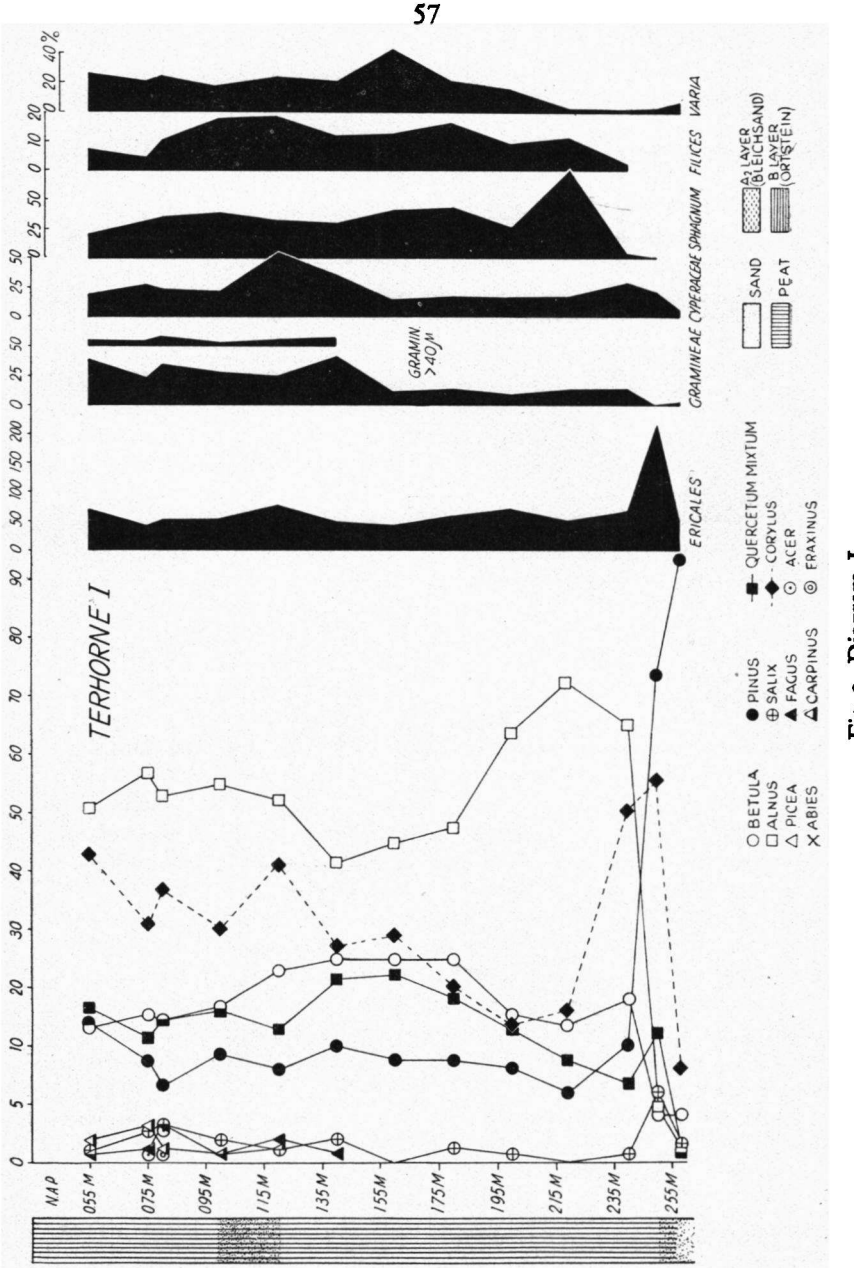

Fig 3. Diagram I

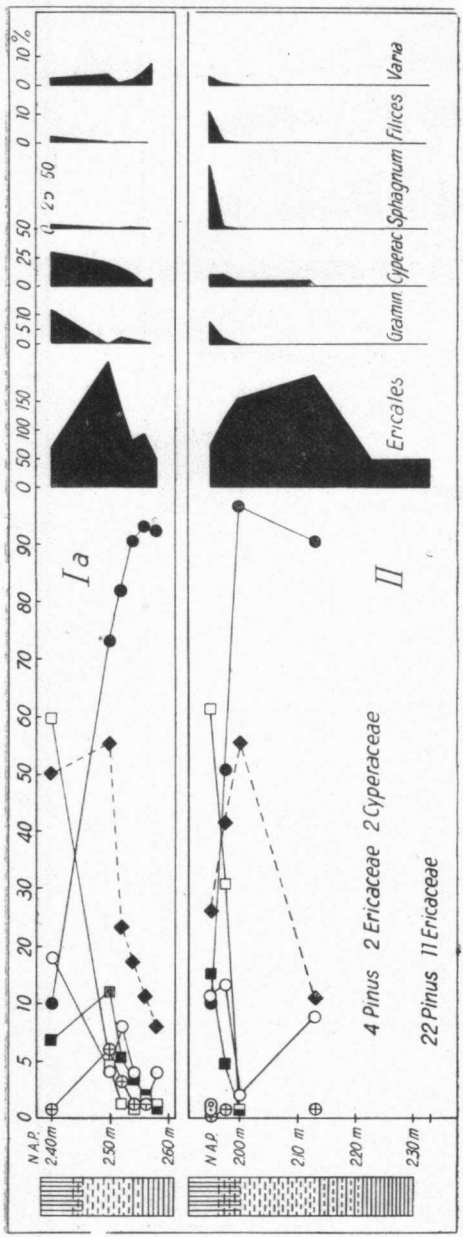

Fig. 4. Diagrams Ia—II

of the material the conclusion is drawn that the iron-pan must also be present under the peat of diagram I*a*. The material, from which the iron-pan has been formed, was deposited as the uppermost part of the cover sand. As the pollen spectra in the A_2layer (Bleichsand) succeed each other quite normally, as many twigs of *Calluna* were found and as the pollen diagrams of two spots (II and I*a*) moreover resemble each other very closely, I come to the conclusion, that the pollen diagram of these A_2layers is comparable with one obtained from peat, which means that it reflects the composition of the pollen rain that descended on the spot itself. When this is right, the A_2layer owes its origin to the fact that at this place the heather, by which the wind-blown sand was consolidated, could maintain its growth in an upward direction. It appears from the pollen diagrams (II and Ia) and from the age of the superposed peat, that the material for the formation of the iron-pan must have been deposited in the boreal time. The percentages of the pollen of the

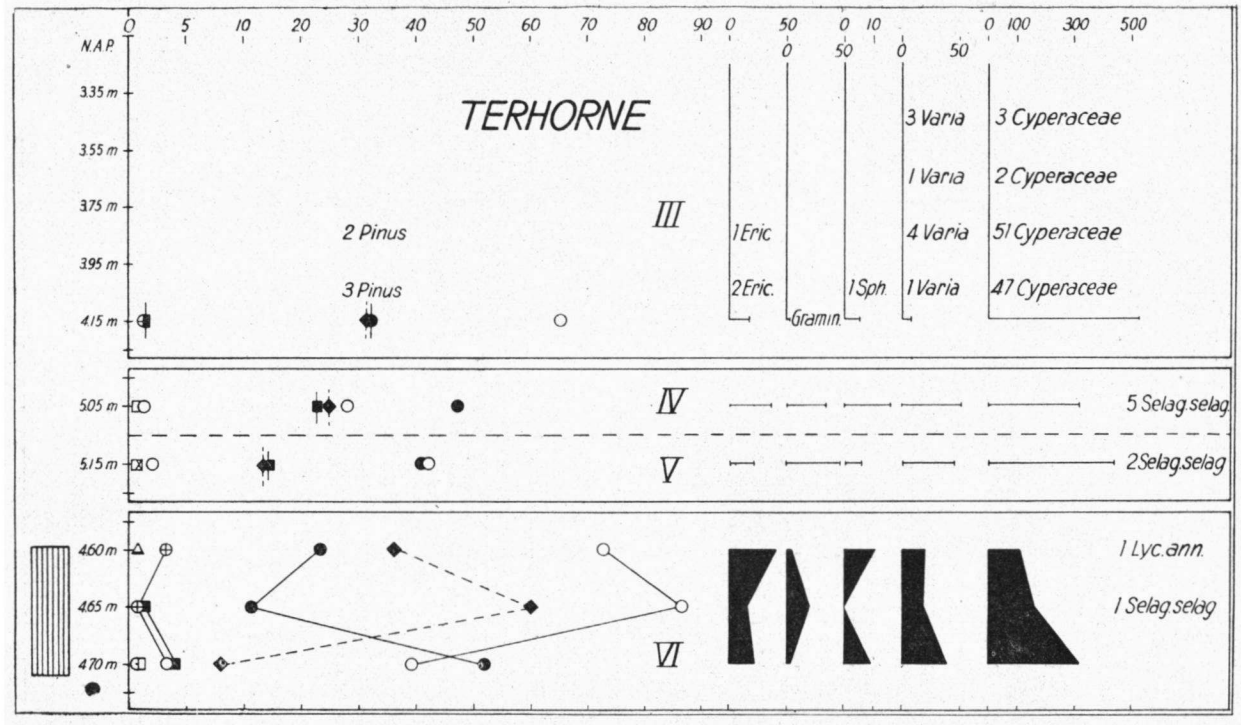

Fig. 4. Diagrams III—VI

thermophilous trees are still low, but increase upwards; the percentage of the pollen of *Pinus* is high, but decreases upwards. In both diagrams a boreal maximum of *Corylus* pollen is present. The B-layer (Ortstein) is rather poor in pollen, and considering the age of the overlying sand, the material of this layer may have been deposited in the early boreal time, perhaps during last stage of the praeboreal period. In the iron-pan layers no seeds were found, but there were many small twigs and other fragments of *Calluna*. It is also worth mentioning that the maximum of the Ericaceous pollen is not particular high and is found in the lower part of the A_2 layer.

The iron-pan is not only developed in the soil in and near the sluice-pit but also under the Sneeker Meer, for according to a communication of Mr. VAN DER LAAN a hard layer is present in the bottom of the Sneeker Meer. Elsewhere too in the North of the country remains of a boreal *Calluna* heath have been found: D. SCHROEDER (1934-18-) discovered them in the higher part of the Wieringermeerpolder close to Wieringen, with a maximum of the Ericaceous pollen of 550%, G. G. VERMEER-LOUMAN (1934-19-) also in other parts of the Wieringermeerpolder, with maxima of the Ericaceous pollen up to circ. 200% (here it extended on the higher spots partly into the atlanticum), while B. POLAK (1936-17-) found maxima of Ericaceous pollen (predominantly of the *Calluna-type*) between 100 and 200% and once of circ. 350% in the humous sand that was found to underly the peat in different borings in the N.E. polder. These percentages do not differ much from the maxima of Ericaceous pollen, observed in the samples from Terhorne. In several other borings made in the N.E. polder (B. POLAK); at Doniaga, Oud-Hof and Parrega (FLORSCHUETZ -1941-4-) and in the Prinsenhof near Eernewoude (Friesland, see map: VAN ZEIST -1950-20-) no indications however have been found of the presence of a heather vegetation. Heath probably was in the boreal time in the North-Western part of the Netherlands a common landscape type. In view of the rather low values of several of the maxima reached by the pollen of the *Ericaceae*, we can not assume that this region was uniformally covered by heath. The type of vegetation apparently depended on local circumstances.

The transition from sand to peat coincides almost completely with the transition boreal — atlanticum, which is pollen analytically recognisable by the intersecting of the curves representing the percentages of *Pinus* and *Alnus* pollen.

The study of the atlantic and post-atlantic material did not reveal many interesting facts. The lowest layers (2.05 m — 1.45 m below the surface) consist of highly corroded peat, in which no or very

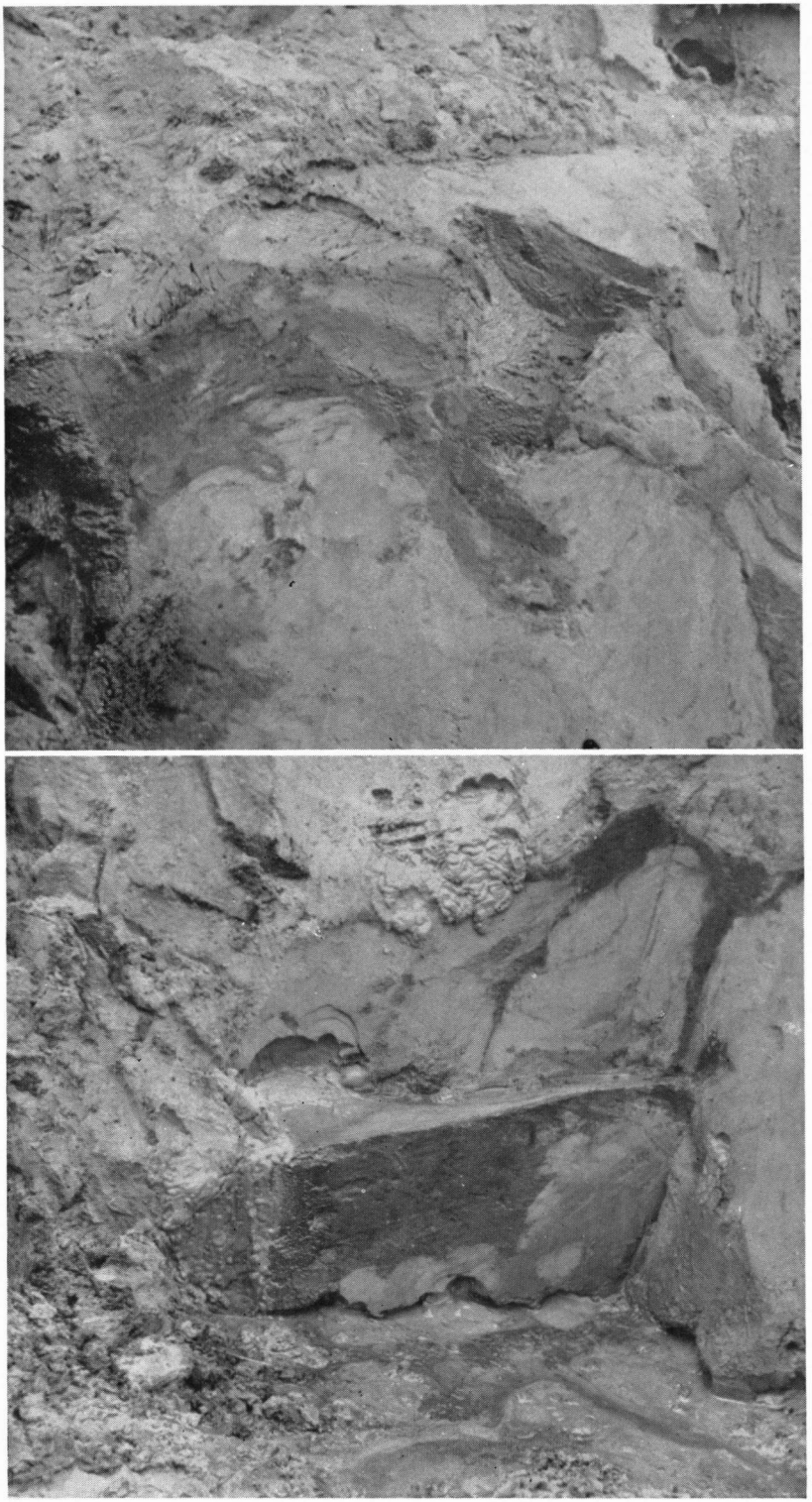

Fig. 5 and 6. "Peaty" layer, showing kryoturbate phenomena.

few recognizable plant remains were found. Going upwards we observe a gradual transition from eutrophic to mesotrophic peat; and at 1.25 m below the surface we meet for the first time pollen of Cereals and of *Fagus*, while that of *Carpinus* appears in the spectrum at 1.05 m below the surface. From the above mentioned data we draw the conclusion that the deposit of the subboreal time probably begins somewhat more than a meter below the surface. It is noteworthy that the peat between 0.85 m and 0.65 m below the surface is rather sandy. Because the sand is fine-grained, there is a good chance that it has been deposited by wind, and this would be in agreement with the supposed subboreal age.

The presence of a „Grenzhorizont" could not be proved. However the *Corylus* pollen reaches a small top at 0.85 m below the surface. The transition to the subatlanticum lies perhaps circ. 0.65 m below the surface. Leaves of *Sphagnum imbricatum* were found at 0.40 m below the surface; and at this depth at any rate we meet therefore with subatlantic material. In the highest part of the peat human influence clearly asserts itself: the percentage of the *Pinus* pollen increases somewhat.

With regard to the drift of a few pollen curves in atlantic and post-atlantic times the following deserves mention: *Fagus* pollen is not found until the end of the atlanticum or the beginning of the subboreal period. At some places in Friesland *Fagus* appears earlier, viz. in the middle of the atlanticum: Opeinde and Opende (DE PLANQUE, FLORSCHUETZ -1950-16-), Parrega (FLORSCHUETZ -1941-4-), Prinsenhof (VAN ZEIST), Harlingen (BODLAENDER; not published); at other places: Doniaga and Oud-Hof (FLORSCHUETZ -1941-4-), Lemmer (BOSSCHAERT, not published), Wolvega (JONKER -1947-12-) although not earlier than in the subboreal time. Fagus shows at Terhorne low values, maximally 3.3%. This confirms, in accord with the results obtained in the northern part of the Netherlands and in N.W. Germany: Doniaga, Oudhof; Prinsenhof; Opeinde, Opende; Westerwolde (ESHUIS -1936-2-); Bourtanger Moor (KOCH -1934-13-); Mittelems (KOCH -1934-14-); N.W. Germany (OVERBECK & SCHMITZ -1931-15-), the supposition of OVERBECK & SCHMITZ (1931) that the influence of the beech gradually decreases from East to West. *Carpinus* also shows low values.

Pinus pollen shows — except in the most recent time — low values, between 7 and 10%; the percentage of Betula pollen is higher and ranges between 15 and 25%. This was to be expected on account of the rather western situation of our locality. The *Quercetum mixtum* percentage is neither low nor high; the pollen of the oak outnumbers by far that of the other components of the *Quercetum mixtum*.

Usually about the half or more of the varia pollen proved to be derived from Composites; the *Chenopodiaceae* and the *Caryophyllaceae* too form mostly a part of the varia that is worth mentioning. The pollengrains of the two last mentioned families however reach together, in respect to the tree pollen, mostly only percentages of 5 to 6%; in two spectra, namely those relating to a depth of 1.05 m and 1.25 m below the surface, a somewhat higher percentage, viz. circ. 10% was found. This percentage, however, seems to me too small to deserve much attention. It does not necessarily indicate a marine influence.

The study of the other plant remains found in the peat layers does not give much support to this supposition either. In these layers namely — besides *Phragmites* remains — only seeds of *Carex*, *Eleocharis*, *Scirpus* (among which sometimes *Scirpus maritimus*) and occasionally of *Potamogeton*, *Lycopus*, *Chenopodium album*, *Ranunculus* and *Urtica urens* were found.

The investigation, made at the request of Mr. M. WIEGERSMA, president of "It Fryske Gea", has been carried out in the Botanical Museum & Herbarium of the State-University Utrecht (director prof. dr. J. LANJOUW). I want to thank Mr. VAN DER LAAN for his communications and his kind assistance at the borings and dr. F. P. JONKER for his constant interest and aid.

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