A PALYNOLOGICAL INVESTIGATION OF THE LOWER PEAT IN THE PROVINCE OF FRIESLAND, THE NETHERLANDS

BY

J. VAN DONSELAAR and F. P. JONKER (Utrecht)

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Up till now the lower deposits of peat (in Dutch: veen-op-grotere-diepte = peat at greater depth) have been investigated in the Netherlands mainly in the Western part of the country, viz. in the provinces of Noord-Holland, Zuid-Holland and Zeeland. The analyses have shown that the development of this, now comparatively well known peat layer must have begun either in the second half of the boreal period or else in the beginning of the atlantic one, and that it must have come to an end in the first half of the latter. Among the earlier investigators the botanist Mrs VERMEER–LOUMAN and some geologists had arrived at the conclusion that the sudden transgression of the North sea which made an end to the formation of peat, took place in the boreal period, and that the whole lower deposit of peat, therefore, was of boreal age (lit. 7). This opinion, however, was sufficiently disproved by FLORSCHÜTZ, and all subsequent analyses have confirmed the view that the peat formation must have stopped early in the atlantic period (lit. 2, 3, 4). The same conclusion was arrived at by GODWIN as a result of his investigations of the lower peat found in SE England (lit. 5, 6) and by several German investigators as a result of their analyses of the lower peat, found in NW Germany.

Only one analyses of the lower peat in the province of Friesland, in the Northern part of the Netherlands, has sofar been published. The geologist VAN ANDEL found near Kiesterzijl, at a depth of only 3.50 m a thin layer of peat. He identified it with the lower peat from the W part of the Netherlands which occurs several meters deeper. His two diagrams show a boreal age for the basal layers and an atlantic age for the top ones and they confirm therefore the conclusions,obtained in the W part of the country (lit. 1).

During the month of June, 1950, a number of deep borings have been carried out on the territory of the large municipality of Barradeel in the province of Friesland. These borings have been made possible by a grant from the Frisian Academy at Leeuwarden, by the assistance of the department for the maintenance of dikes, roads, bridges and canals in the Province of Friesland and by that of the board of the

Wieringermeer. We wish to express here too our deep-felt gratitude for their help.

Some time before these borings were carried out, the second author visited a deep pit, excavated for the construction of a new sluice near Harlingen, just outside the territory of the municipality of Barradeel. Even at the bottom of this 10 meter deep pit the lower peat was not yet reached but there were a few lumps of peat, that had come to light when a number of poles had to be driven in. These lumps have been analysed by Mr K. B. A. BODLAENDER. One part of them showed boreal spectra, the other part atlantic ones, which means that there was a complete agreement with the results, obtained by VAN ANDEL in Friesland, and by other investigators in Western Holland. The only discrepancy with the description given by VAN ANDEL is found in the great difference in depth of the analysed layers. This difference is the more remarkable as the localities are situated only a few kilometers apart from each other and as the surface is quite flat. Our fig. 1 shows a pollen diagram of a sample of lower peat collected in the part of Barradeel that is situated SE of Harlingen. The layer occurs at a depth of 4.30—4.80, is overlain by marine sand and rests on a layer of cover sand that is rich in humus. As the cover sand below the peat shows typical late-boreal spectra, the development of the peat must have begun in the neighbourhood of the transition between Boreal and Atlanticum. A remarkable feature are the high tops in the *Corylus* line, a boreal top of 283 % and a top at the boreal-atlantic transition of even 1170 %. A large part of the area was apparently during that time covered with *Corylus* bush, which must have ousted all the other trees and shrubs. As *Corylus* in contradistinction to *Betula* and other species was not included in the pollen sum of 150 tree pollen grains used for the construction of the diagram, this abundance of *Corylus* pollen caused a rise of the pollen percentage of *Pinus* and of some other trees. A second diagram of the same layer (fig. 2) constructed after *Corylus* had been included in the pollen sum, gives a much better impression of the pollen production of the forests by which the area must have been surrounded. Though it is still usual to exclude *Corylus* from the pollen sum, this shows that it is better included. This is the more desirable as *Corylus* is not at all confined to the shrub layer of the forests. However, a difference between the two diagrams becomes important only when the percentage of *Corylus* pollen is very high.

With regard to the other botanical remains we can give the following particulars: the dark cover sand contained fragments of *Phragmites* and of *Cyperaceae*. The basal part of the peat was rich in drift sand and it contained fruits of *Potamogeton*, *Carex* and *Betula*, wood of *Betula* and remains of stems and roots of *Cyperaceae*. The next 10 cm (4.70—4.60) still contained fruits of *Potamogeton* and *Carex* but in addition to these the remains of *Eriophorum* tufts and much *Alnus* wood. Up to 4.40 the peat was formed by *Eriophorum* rests mixed with *Carex* and with a few leaves of *Sphaguum*. In the upper part of the peat the quantity of *Sphagnum* remains increased considerably, but *Erio-*

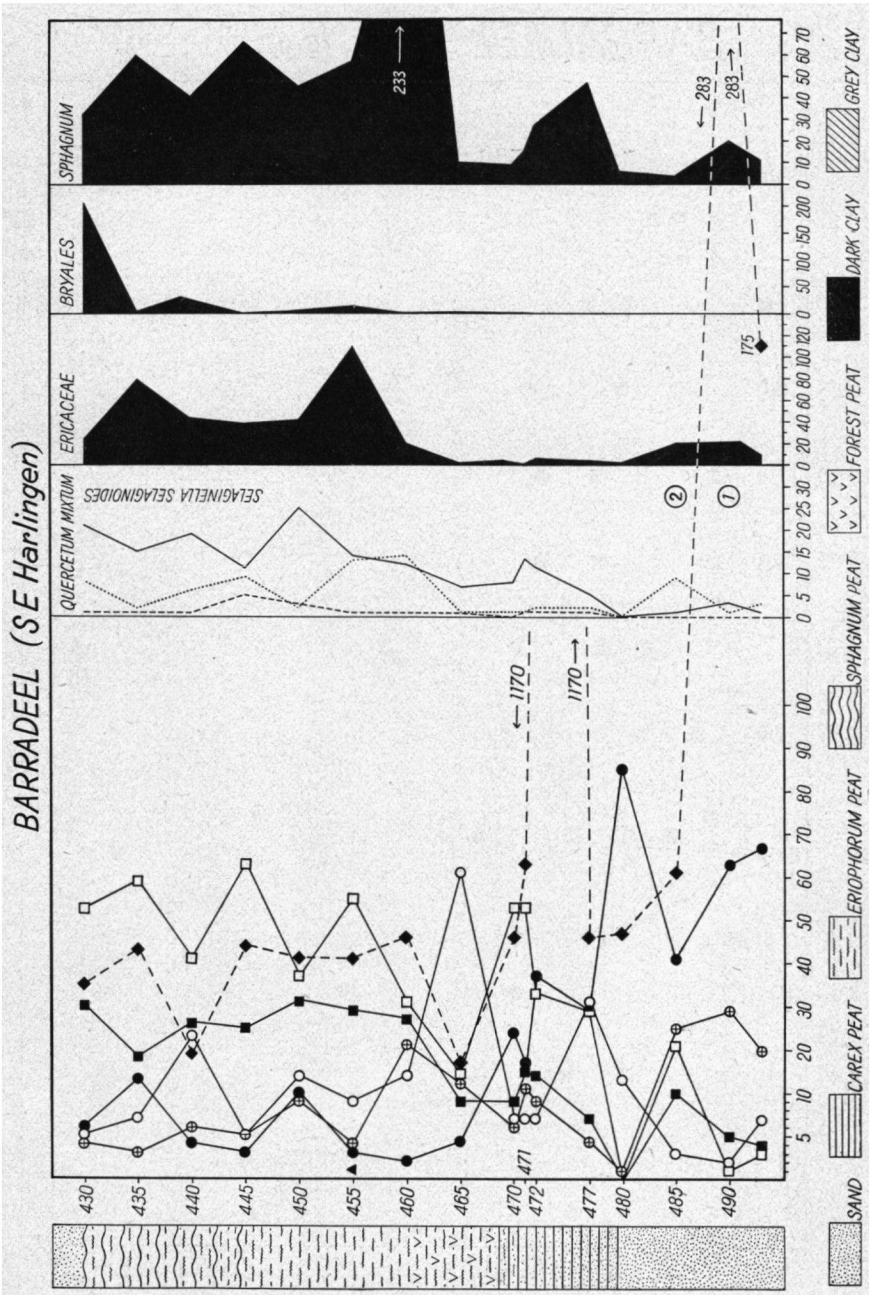
BARRADEEL (S E Harlingen)
QUERCETUM MIXTUM
SELAGINELLA SELAGINOIDES
ERICACEAE
BRYALES
SPHAGNUM
1170
1170
283
283
175
233
SAND
CAREX PEAT
ERIOPHORUM PEAT
SPHAGNUM PEAT
FOREST PEAT
DARK CLAY
GREY CLAY

Fig. 1

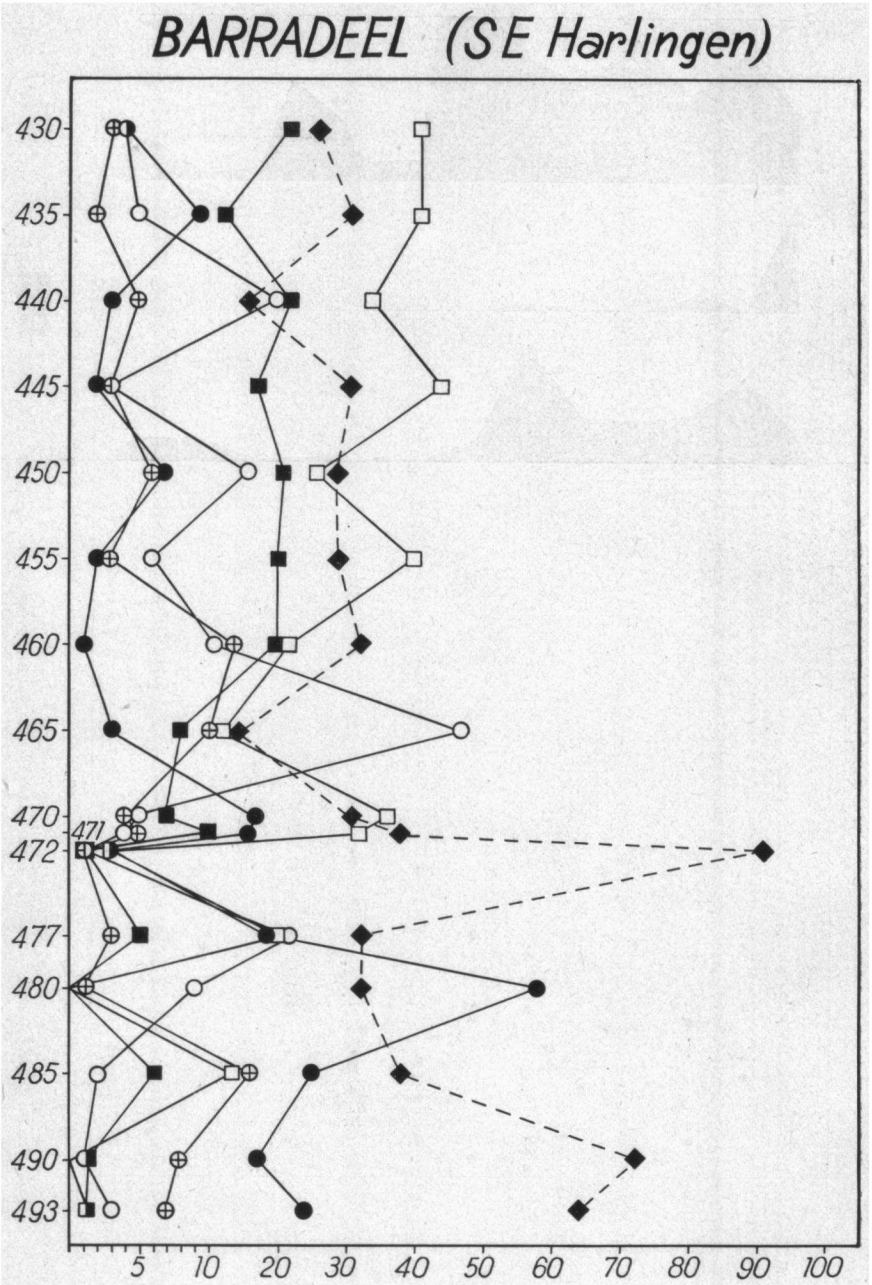
BARRADEEL (SE Harlingen)
430
435
440
445
450
455
460
465
470
471
472
477
480
485
490
493
5
10
20
30
40
50
60
70
80
90
100

Fig. 2

phorum remained an important component; seeds of *Juncus* were found and in the upper 10 cm the peat contained large quantities of fruits and seeds of *Triglochin palustre*. This shows that during the formation of the peat the environment changed from eutrophous to mesotrophous and that it became finally more or less oligotrophous. During the earlier part of the peat formation drift sand was swept into the bog, which shows that even in the Atlanticum the sands were not yet fixed by the vegetation.

Another profile we bored in the part of Barradeel that lies N of Harlingen (see diagram, fig. 3). The peat here occurs at a depth of 590—525. The formation of the peat begun in the latter part of the boreal period and here too the boreal-atlantic transition is marked by a slight indication of a *Corylus* top. The layer of sand rich in humus on which the peat rests, is here much thinner. The peat was formed in a *Carex-Sphagnum* bog; on top of this basal peat layer which contained a good deal of fine sand, we found a thick layer of *Eriophorum* peat, in the upper part mixed with *Sphagnum*, which indicates a change of the environment from the mesotrophous to a more or less oligotrophous condition. In the middle of the peat layer we found in immediate succession indications of two transgressions, each transgression characterized by the succession sand — pale clay — a dark clay that is rich in humus — pale clay — sand. These bands are of marine origin, for we found besides fruits of *Potamogeton* remains of *Ostracoda* and *Foraminifera*, spicula of *Spongiae* and shells of the molluscs *Mytilus edulis*, *Retusa alba*, and *Macoma baltica*. These two transgressions had no influence on the percentages of tree pollen. The percentage of *Sphagnum* spores, however, decreased considerably. The percentage of spores derived from *Bryales* increased from 0 % to 60 %. The possibility that the marine layers have been shoved in during a much later transgression by which the upper part of the peat was separated from the lower part, can not be fully excluded. However, the typical succession of thin sand and clay layers and the decrease in the number of *Sphagnum* spores make it probable that the transgression layers are autochthonous. This means that a temporary breaking in of the sea took place, and that at the end of that period peat formation was resumed.

Fig. 4 shows the pollen diagram of the lower peat near the hamlet of Firdgum, where peat formation began in the vicinity of the transition between Boreal and Atlanticum, recognizable i.a. once more by a *Corylus* top. The layer is 26 cm thick and consists in the basal part of forest peat, formed in an alder brook. The upper 6 cm is pure *Sphagnum* peat consisting of excellently preserved *Sphagnum rubellum* mixed with *Webera nutans* and *Aulacomnium palustre* [1]. This is the more remarkable as the atlantic *Sphagnum* peat (old moss peat) of our raised bogs is always highly humified and shows hardly any recognizable remains of *Sphagnum* plants. CARL ALBERT WEBER, one of the founders of modern peat investigation, was of opinion that the atlantic *Sphagnum*

[1] We are much indebted to Dr W. MEYER from Amsterdam, now at Bogor (Java), for the identifications of the mosses.

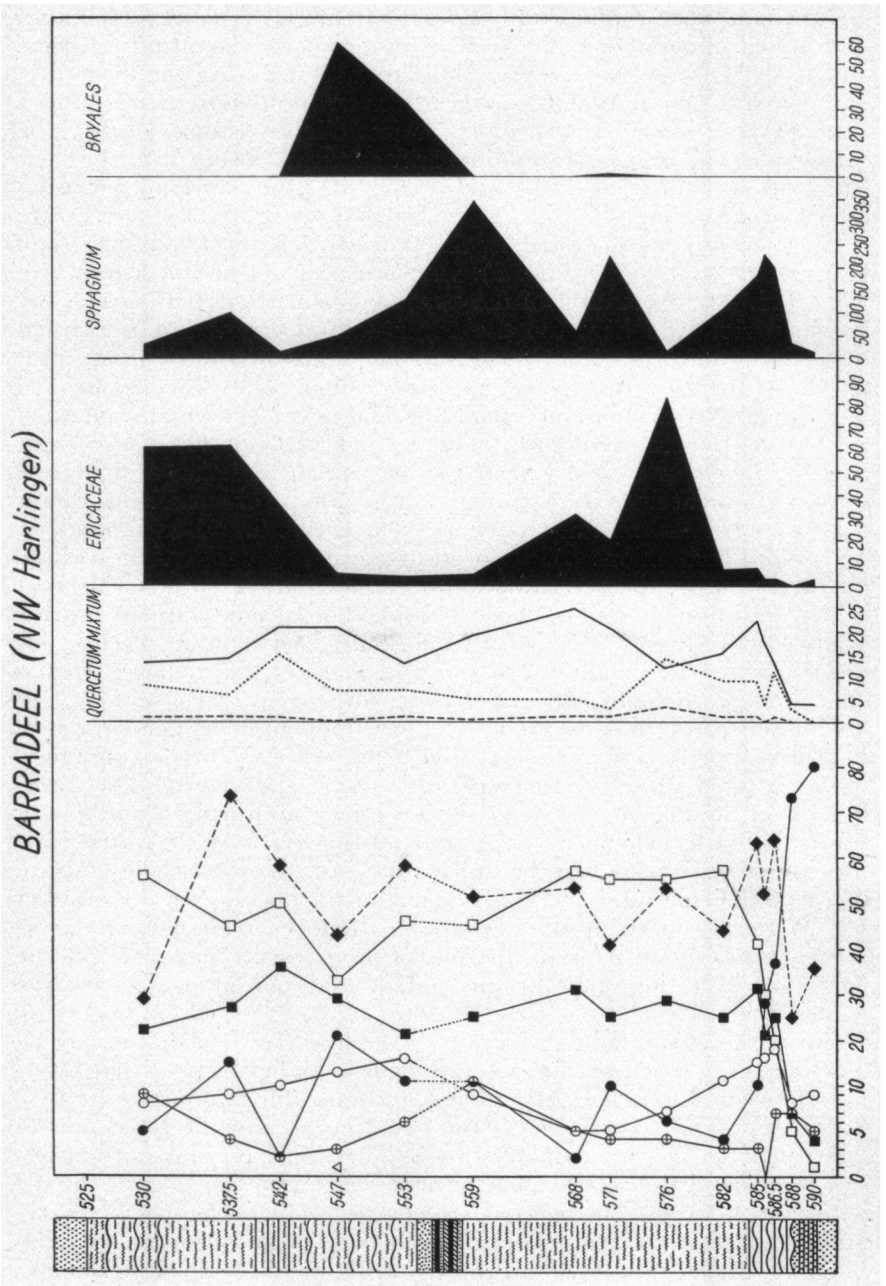
BARRADEEL (NW Harlingen)
QUERCETUM MIXTUM
ERICACEAE
SPHAGNUM
BRYALES
525
530
537.5
542
547
553
559
568
571
576
582
585
586.5
588
590

Fig. 3

peat originally must have shown the same appearance as the young (subatlantic) *Sphagnum* peat. In a later and much warmer period, according to him the subboreal one, a decay set in which led to the formation of highly humified peat that we now find in these layers

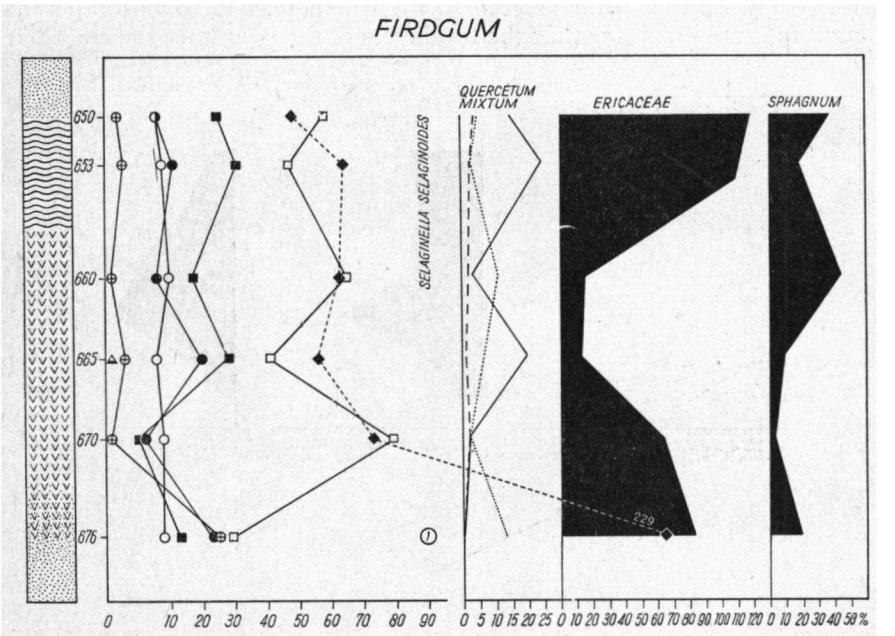

Fig. 4

(lit. 8, 9, 10). Here we found a *Sphagnum* peat covered by marine sands by which already in the atlantic period the supply of air was cut off. The peat consequently did not decay when the peat bog was overflown by the sea. This suggests that the atlantic *Sphagnum* peat too may originally have had the same appearance as the young *Sphagnum* peat and that the decay may have taken place in a later period. Whether this transformation requires a change of climate, as WEBER assumed, is another undecided question.

Below the "Tjummarumer Miedpolder" (see diagram, fig. 5) we found no peat, only a 13 cm thick layer of dark cover sand, rich in humus. Palynological investigation showed that the layer was of boreal age, and corresponded with the boreal sand that we found below the peat layer SE of Harlingen (fig. 1). The lowest spectrum of the diagram, where the sand contained no humus, shows too much secondary pollen to be taken into consideration. The sand contained, just as the sand below the peat layer SE of Harlingen, some microspores of *Selaginella selaginoides*. At this place the peat was probably swept away by the sea, which means that the latter must have worn out a deep channel.

Below the villages Sexbierum and Wynaldum, in the municipality

of Barradeel, we found no peat either. Below Wynaldum the marine sands of the tidal flats, by which the peat is usually covered, rested on the boulder clay. This means that all the younger layers must have been swept away by the sea. Below the village of Tjummarum we found only a very thin layer of peat, which proved to be of boreal age. This means either that the top layers of the peat have been eroded

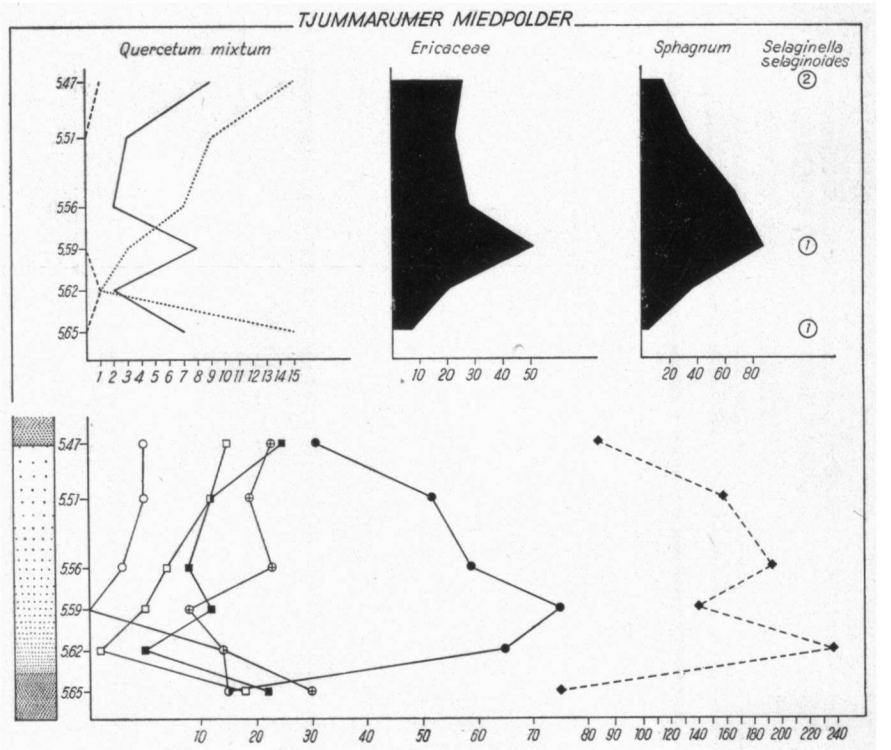

Fig. 5

by the sea or that the sea already broke in to this area before the latter were formed.

Our investigations show that in the earlier part of the holocene period a rise of the sea level must have caused a rise of the ground water level: as soon as the ground water reached the surface, the area was covered by plant growth (the dark sand, rich in humus), and peat formation begun. The growth of the peat was made possible by a continuous rise of the ground water level but came to an end when the expanding sea reached the area and the bog was covered by the sands of the tidal flats. In the W part of the country the lower peat developed in a fresh water laguna and the environment therefore was eutrophous to mesotrophous. In our area the circumstances changed during the formation of the peat layers from eutrophous to more or less oligotrophous. The top layers of the lower peat from Firdgum

even represent an oligotrophous raised bog, consisting chiefly of *Sphagnum rubellum.*

Peat layers of more recent date have not been met with in our borings. We are as yet unable to give an explanation of the highly varying depths at which the lower peat was met with; in places that were horizontally only a few kilometers apart, the depth at which the peat was found, differs several meters.

REFERENCES

1. ANDEL, TJ. VAN, Pollenanalytische datering van een holocene transgressie in Noord-West Friesland; in Geologie en Mijnbouw XI (1949), p. 171—173.
2. FLORSCHÜTZ, F., Bespreking van het proefschrift van Dr C. G. VERMEER-LOUMAN: Pollenanalytisch onderzoek van den West-Nederlandschen bodem; in Tijdschr. Kon. Aardr. Genootsch. (Nov. 1934), p. 1—8.
3. FLORSCHÜTZ, F., Laagterras en "veen op grootere diepte" onder Velzen; in Tijdschr. Ned. Aardr. Genootsch. LXI (1944), p. 25—33.
4. FLORSCHÜTZ, F. en I. M. v. D. VLERK, Duizend eeuwen geschiedenis van den bodem van Rotterdam; in De Maastunnel II (1939), p. 1—6.
5. GODWIN, H., Coastal peat beds of the British Isles and North Sea region; in Journ. of Ecology XXXI (1943), p. 199—247.
6. GODWIN, H., Coastal peat beds of the North sea regions as indices of land- and sea-level changes; in The New Phytologist XLIV (1945), p. 29—69.
7. VERMEER-LOUMAN, C. G., Pollenanalytisch onderzoek van den West-Nederlandschen Bodem; Thesis Amsterdam 1934.
8. WEBER, C. A., Grenzhorizont und Klimaschwankungen; in Handel. 20e Ned. Nat. Gen. Congr. (1925), p. 260—261.
9. WEBER, C. A., Grenzhorizont und Klimaschwankungen; in Abh. Nat. wissensch. Ver. Bremen XXVI (1926), p. 98—106.
10. WEBER, C. A., Grenzhorizont und ältere Sphagnumtorf; in Abh. Nat. wiss. Ver. Bremen XXVIII (1930), p. 57—65.