STUDY OF A PEAT PROFILE ON THE FRISIAN COAST OF THE FORMER "ZUIDERZEE"

BY

M. VROMAN (Utrecht)

Received Dec. 15th, 1951

INTRODUCTION

On both sides of the watercourse, which connects the harbour of Makkum with the "IJselmeer", a wide expanse of low-lying land is found, which follows the Frisian coast. This is the "Makkumer Waard", whose soil profile forms the subject of this study. The soil samples were taken in the so-called "Zuidwaard", which lies to the south of the watercourse. Under a layer of young sea sand extending to a depth of about 2½ m, a two meter thick peat layer was found, which according to the Geological Map belongs to the large peatbog that at one time extended over all Friesland, Groningen and Overijsel.

The subsoil proved to consist of postglacial sand.

STRATIGRAPHICAL AND PALYNOLOGICAL DATA

a. Stratigraphy

Below the level of — 4.55 m [1] the soil consists everywhere of sand in which shells of *Hydrobia ulvae*, rests of *Carex*, *Eriophorum*, *Phragmites* and *Calliergon* and a few pieces of *Alnus* wood were found. The transition from sand to peat takes place at about — 4,55 m, but for the next 10 cm the peat still contains an admixture of sand and clay. In this clayey peat we found shells of *Hydrobia ulvae*, *Foraminifera* and *Cardium edule*, remains of *Calliergon* spec., *Leptodictyum riparium*, *Sphagnum* cf. *fuscum*, *Sph. imbricatum*, *Carex* and *Eriophorum*, and also a fragment of a *Salix* stem. We must assume therefore that the area lay at the beginning below sea level, but that the influence of the sea water gradually decreased so that peat formation became possible.

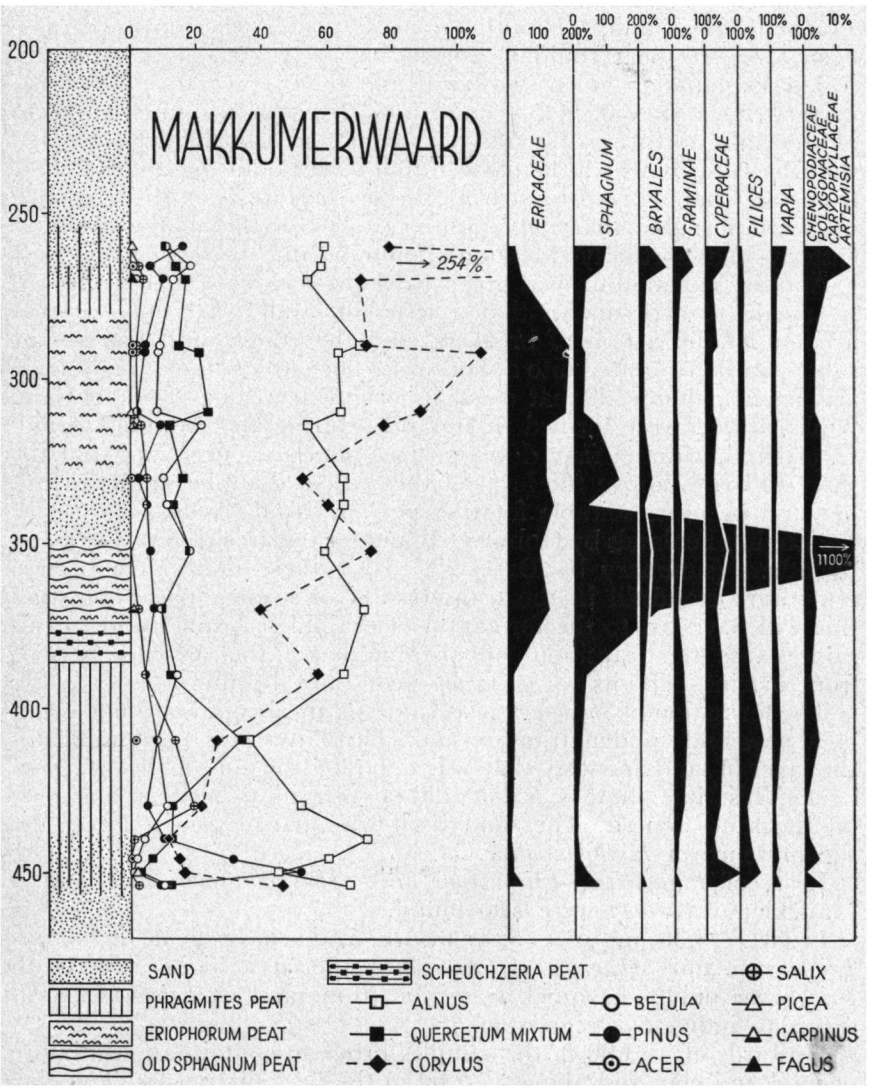
From — 4,45 m to — 3,85 m the peat consists mainly of *Carex*, *Phragmites* and *Eriophorum* rests. We also found in this part wood of *Betula*, a leaflet of *Calliergon giganteum*, and seeds of *Scirpus*, *Ranunculus flammula*, *Carex*, *Menyanthes trifoliata* and *Nymphaea alba*. The microscopical investigation revealed the presence of numerous *Diatomeae* (*Pennatae*) and of *Chara* (— 4,50 m to — 4,30 m).

The next section consists almost entirely of rests of *Scheuchzeria*, but fragments of *Leptodictyum riparium* and *Sphagnum* cf. *cuspidatum* were also met with.

[1] All depths are given with regard to the average sea level as found at Amsterdam.

From — 3,75 m to — 3,50 m the peat is built up of *Eriophorum.* The palynological investigation revealed the presence of numerous *Sphagnum* spores (1100 % at — 3,52 m). We must assume therefore that the submersion was followed by a period in which the soil gradually grew drier, and in which it lost a good deal of its mineral content. This created the conditions for the development of a high-moor vegetation.

According to TESCH (12) and POLAK (10) it is not necessary to assume a regression, for the succession marine deposits → *Phragmites* peat → *Carex* peat → *Sphagnum* peat can be explained in another



way. In their opinion the last glacial period was followed by a single continuous transgression. TESCH thinks that in the beginning of the Atlanticum the coherence between England and the continent was broken, and that during the rest of this period the Dutch coast stood under the influence of the tides. The Channel current would have transported large amounts of sand so that in front of the Dutch coast a long series of sand banks were formed. The gaps between these banks would finally have been closed, and so the shorewall would have arisen on which the sea dunes were formed. In the area behind the shorewall the salt was gradually washed out by the water of the rivers and by the rain, and when the soil once more began to subside *Phragmites* peat and, when the mineral content became very low, even *Sphagndm* peat could be formed.

The explanation given by TESCH and by POLAK can not be fully correct, for VAN VEEN (15) could show that practically no transport of sand in a northerly direction has taken place and BAAK (1) proved that the sand by which the old sea dunes were built up, did not come from the Channel coast, but from the sea bottom. For this reason it seems improbable that the gradual growth of the shorewall in an easterly and northerly direction should be due to sea currents.

Another explanation was given by TIMMERMANS (13), who proved by means of experiments that a series of sand banks may arise on account of the action of breakers, and that these sand banks may subsequently be united into a shorewall. The old sea dunes might have arisen on a shorewall that owed its origin to a long series of sand banks, which were formed in this way during the Atlantic period. In order that dunes may develop, it is, of course, necessary that the shorewall rises above the level of the sea, so that the sand can dry out and becomes suitable for transport by wind. As was shown for the English Fenlands by GODWIN (5) and for the area of NW-Germany by others (summary by DEWERS —3—), there must have been a temporary standstill in the transgression or even a regression, and this will have led to the formation of the old sea dunes and to this same cause the transition (in the middle of the Atlantic period) from marine deposits to *Sphagnum* peat must be due.

The formation of *Sphagnum* peat came to an abrupt end on account of a new and sudden transgression. The latter was responsible for the layer of sand and clay that was deposited on top of the *Sphagnum* peat. This time there was no gradual transition between the peat on the sand deposit. The sand itself was marine, as is proved by the presence of *Hydrobia ulvae*.

Rests of *Phragmites*, *Eriophorum* and *Sphagnum imbricatum* and a branchlet of *Calluna* were also found.

From — 3,30 m to — 3,00 m we again have peat, first with *Eriophorum* and *Sphagnum* cf. *cuspidatum* and at a higher level with *Eriophorum* only. The quick transition from sand to *Eriophorum* peat seems to indicate a regression.

Upwards of — 3,00 m the samples prove to contain an admixture of sand and clay and above — 2,60 m the peat disappears. The clay

and the sand contain a fair amount of fragmented plant rests, among we recognized *Phragmites*, much *Sphagnum imbricatum* and *Sphagnum* cf. *cuspidatum*. Numerous marine animals were also present, viz. much *Hydrobia ulvae*, one specimen of *Hydrobia stagnalis*, several species of *Foraminifera*, *Cardium edule* and a shell of *Rissoa membranacea*.

Upwards the samples become more and more sandy. This indicates a third marine transgression.

b. Palynology

The palynological investigation showed that the whole peat layer must have been formed in the Atlantic and Subboreal period (see the diagram).

The lowermost samples already contained more *Alnus* than *Pinus* pollen. At — 4,50 m however, *Pinus* reached a higher value than *Alnus*, but such a *Pinus* top is not unexpected in an Atlantic peat bog, for it was also observed by other investigators, e.g. by OVERBECK & SCHMITZ (9), SCHUBERT (11), BRINKMANN (2) and MULLER & VAN RAADSHOOVEN (7).

OVERBECK and SCHMITZ (9) and also SCHUBERT (11) and BRINKMANN (2) point out that their marine formations show everywhere a strong increase of the *Pinus* curve accompanied by a strong decrease of the *Alnus* curve, but that the pollen percentages of the other trees remain constant.

They are of opinion that these changes reflect a shifting of the woodcovered area under the influence of the transgressions. The alders, which grow mainly on bog peat, suffer first and then the long-distance transport of the coniferous pollen comes to the fore. This hypothesis finds support in the fact that the *Pinus* top is always accompanied by the appearance of *Picea* pollen, which disappears as soon as the percentage of the *Pinus* pollen begins to decrease. Differences in resistence to corrosion are according to OVERBECK & SCHMITZ in their diagrams of no importance, for if they were, the pollen of the deciduous trees would have suffered much more than the *Pinus* pollen, but this is not so. That these differences play no part, is, however, no general rule, for in some other instances they must apparently have played an important rôle.

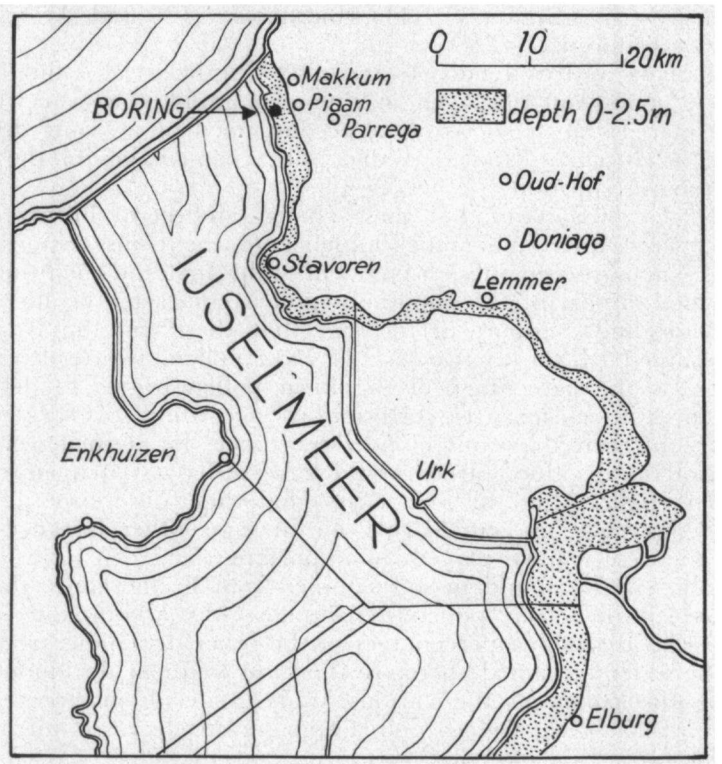
SCHUBERT (11) found in soil samples from Bremervörde that the decrease of the *Alnus* pollen percentages was accompanied by a decrease in the pollen percentages of the other deciduous trees, and that the alder remained therefore the most frequent deciduous tree. Among the pollen of the various kinds of deciduous trees also a selection took place: *Quercus* pollen appeared to decrease much more than that of *Tilia*, which is very resistent. SCHUBERT ascribes his findings to differences in resistance to corrosion.

In the Makkum profile the decrease in the pollen percentages of deciduous trees that accompanies the Pinus top, appears for every kind of tree, to be proportional to its previous value. For the mixed oakforest we found 1 *Quercus* and 2 *Tilia* pollengrains. At — 4,46 m, where we still have 31,3 % of *Pinus* pollen, there were 4 *Quercus*

and 6 *Tilia* pollengrains. If SCHUBERT is right, then the high *Pinus* values found in the lower part of the marine deposits at Makkum will probably be due to differences in the resistance against corrosion. The two other transgressions, which evidently also led to the formation of marine deposits, are not reflected in the course of the *Pinus* curve. MULLER & VAN RAADSHOOVEN (7) found at Urk a *Pinus* curve with the same general trend.

The Subboreal period probably begins in the diagram at — 3,10 m. MIKKELSEN (6) has in his diagram of Lake Even, Dalinge Gd. Bp. 21 (Denmark) also three *Corylus* tops; the second corresponds with the beginning of the Subboreal period, the third with the end of this period.

The Doniaga diagram given by FLORSCHUETZ (4) shows exactly the same character. At Doniaga, and also at Parrega, the peat formation stopped before the beginning of the Sub-atlantic period;



but at Oud-Hof it went on in the latter. FLORSCHUETZ is of opinion that this happened not only at Oud-Hof but everywhere in the south-western part of Friesland. When the area was submerged by the water by which afterwards the clay layer was deposited, the younger *Sphagnum* peat began to drift and was finally carried off. For Makkum

too this seems to be the most plausible explanation, for the corroded peat rests found above — 3,00 m contain large amounts of *Sphagnum imbricatum*, and this species plays the most important part in the formation of the younger *Sphagnum* peat. It is possible that the younger *Sphagnum* peat has been washed away in historical time, viz. in the thirteenth or the fourteenth century, when the "Zuiderzee" was formed. After the peat had been washed away, the younger sea sand was deposited.

According to VEENENBOS (14) this explanation, which was also brought forward by MULLER & VAN RAADSHOOVEN (7) is unsatisfactory. He points out, that further inland, where the influence of the inundation will have been very slight, with few exceptions (i.a. Oud-Hof), no younger *Sphagnum* peat is to be found. Therefore he thinks it more probable that the formation of *Sphagnum* peat during the Subatlanticum was confined to a limited number of localities.

The *Corylus* values found at Makkum are very high (254 % at — 2,65 m). This high percentage may partly be due to the presence of *Myrica* pollen, which cannot be distinguished with certainty from *Corylus* pollen.

DISCUSSION

MULLER & VAN RAADSHOOVEN (7) found in profiles from the North-eastern Polder indications for the presence of two transgressions in the Atlantic period. They regard the deposits formed during the first transgression (the *Unio*-clay phase) as an offshoot of the old blue sea clay. The *Unio*-clay was deposited in a basin, which had a narrow entrance at Urk. Up to Urk the deposits are more or less marine, but the deposits in the basin itself must have been formed in brackish or in fresh water (the sediment came from the west, the fresh water from the east). After the period in which the *Unio*-clay was formed, the influence of the transgression decreased and peat formation once more became possible. On the *Unio*-clay grew a *Phragmites* peat, which in its turn passed into *Sphagnum* peat. Along the border of the basin, where from the beginning of the Atlantic period the formation of *Carex* peat had continually gone on, now also *Sphagnum* peat was formed. The influence of the transgression therefore gradually decreased (perhaps even some regression may have taken place). The formation of peat in the period following the *Unio*-clay phase was at the end of the Atlanticum suddenly interrupted by a fast and violent transgression (the *Cardium*-clay phase). The *Sphagnum* peat passed into *Phragmites* peat and the latter was covered by a layer of clay. The clay had a strong marine character. This transgression too was suddenly ended: at Urk *Sphagnum* peat was formed almost directly on the clay and at Schokland the Atlantic peat bog was overgrown by wood.

This sudden regression took place before the beginning of the Sub-atlanticum and was followed by a period of more gradual transgression, during which the peat was washed away and the "Zuiderzee" came into being.

VAN ZEIST (16) found at the "Princehof" (in Central Friesland) also two narrow clay bands that must have deposited during the Atlantic period. Between these clay bands a transition from *Phragmites* peat to *Sphagnum* peat was met with. From the thinness of the clay bands VAN ZEIST concludes that the transgressions must have reached in this region their farthest point. In these clay bands he found high values for the pollen of *Compositae*, *Chenopodiaceae*, *Caryophyllaceae* and *Graminae*, which indicates a halophytic vegetation.

VEENENBOS (14) found that the transgression acquired towards the end of the Atlanticum a greater speed, but that it was finally stopped and made place for a regression. This regression was used by WASSINK to explain the horizont of Weber. The faster the lowering of the groundwater level took place, the more the composition of the Subboreal peat approached to that of Weber's horizont.

In the border area of the NE. Polder there is no difference in aspect between the Atlantic and the Subboreal peat, which means that the environment in which in these two periods peat was formed, differed but little. For this reason VEENENBOS is of opinion that the lowering of the groundwater level caused by the regression can not have been very important.

The absence of an important fall of the groundwater level in the Subboreal is due to the low level of the basin of the "Zuiderzee", in which several streams poured out their water, and to the narrowness of its connection with the sea.

The data obtained from the Makkum profile agree very well with what was found by the investigators mentioned above.

We now can compare our data also with the results obtained by other investigators who occupied themselves with the area round the North-sea.

GODWIN (5) found for the Fenlands that the transgression came to a stop in the middle of the Atlantic period and may even have made place for a small regression and that in the Subboreal undoubtedly a regression took place.

In the coast area of NW-Germany the postglacial transgression was several times interrupted.

SCHUBERT (11) found at Kehdingen a peat layer between the marine sediments. He explains this by assuming a standstill of the transgression, and he dates this standstill in the middle of the Atlanticum. Shortly before the beginning of the Subboreal a regression began.

SCHUETTE (DEWERS —3—) published in 1937 a curve representing the movements of the sea level. On account of the presence of a dark coloured clay layer with *Phragmites* rests which he found intercalated between marine deposits in a profile from Norderney, he came to the conclusion that about the middle of the Atlanticum a regression must have taken place.

BRINKMANN (2) found a more or less similar situation at Sehestedt. Both investigators moreover noted a regression in the Subboreal period.

Since the beginning of the Atlanticum the sea level in England, in Holland and in NW-Germany must therefore have undergone the following changes:

1. From the beginning to the middle of the Atlantic period a rise.
2. About the middle of the Atlanticum a slowing down of the rise (GODWIN, SCHUBERT) and perhaps even a fall (SCHUETTE, BRINKMANN).
3. In the later part of the Atlanticum a new and very rapid rise.
4. In the Subboreal period an important fall, which already began towards the end of the Atlanticum.
5. After the Subboreal period a slow rise, which was in several places responsible for the removal of the younger *Sphagnum* peat.

SUMMARY

The subject of this study are soil samples taken in the "Makkumer Waard", a wide expanse of low-lying land, which follows the Frisian coast. Stratigraphical and palynological investigations showed that in the beginning of the Atlanticum the area lay below the level of the sea, but that gradually the influence of the sea decreased and peat formation became possible. From the transition from marine deposits to *Sphagnum* peat (— 4,55 m to — 3,50 m) we must conclude that there has been a temporary standstill in the transgression, or even a regression, in the middle of the Atlanticum. Towards the end of the Atlantic period a sudden marine transgression followed, which deposited a layer of sand and clay on the *Sphagnum* peat (— 3,50 m to — 3,30 m).

Shortly before the beginning of the Subboreal (which probably sets in at — 3,10 m) an important regression began and an *Eriophorum* peat was formed directly on the clay (— 3,30 m to — 3.00 m).

It is probable that the peat formation went on in the Subatlanticum, but the younger *Sphagnum* peat is no longer present, for a third marine transgression, which lead to the formation of the "Zuiderzee", washed away the peat and deposited the younger sea sand.

The data obtained from the Makkum profile proved to agree very well with the results of other investigators who worked in the area round the North-sea.

REFERENCES

1. BAAK, J. A., 1936. Regional Petrology of the Southern North Sea. Diss. Wageningen.
2. BRINKMANN, P., 1934. Zur Geschichte der Moore, Marschen und Wälder Nordwestdeutschlands. III. Das Gebiet der Jade. Engl. Botan. Jahrbücher *66*, 370.
3. DEWERS, F., 1941. Das Alluvium. Geologie und Lagerstätten Niedersachsens, dritter Teil, Känozoïcum. Schriftenreihe der Wirtschaftwissenschaftlichen Gesellschaft zum Studium Niedersachsens. N.F. Bd. 3.
4. FLORSCHÜTZ, F., 1941. Palaeobotanische bijdrage tot de oplossing van het schalterprobleem van de Friesche Weiden. Tijdschr. Nederl. Heide Mij *53*, no. 12.

5. GODWIN, H., 1945. Coastal peatbeds of the North sea region, as indices of land- and sea-level changes. The New Phytologist Vol. 44, no. 1.
6. MIKKELSEN, V. M., 1949. Praestø fjord. Dansk Botanisk Arkiv. Bind 13, no. 5.
7. MULLER, J. en B. VAN RAADSHOOVEN, 1947. Het holoceen in de Noordoostpolder. Tijdschr. Kon. Ned. Aardr. Gen. LXIV, 153—185.
8. OVERBECK, F., 1934. Bisherige Ergebnisse der botanischen Moorforschung zur Frage der Küstensenkung an der deutschen Nordsee. Abhandl. Naturwissenschaftl. Verein zu Bremen Bd. XXIX, Heft 1/2, 48—73.
9. OVERBECK. F. und H. SCHMITZ, 1931. Zur Geschichte der Moore, Marschen und Wälder Nordwestdeutschlands. I. Das Gebiet von der Niederweser bis zur unteren Ems. Mitteilungen d. Prov. stelle für Naturdenkmalpflege Hannover, Heft 3.
10. POLAK, B., 1936. Pollen- und Torfanalytische Untersuchungen im künftigen Nordöstlichen Polder der Zuiderzee. Rec. d. trav. bot. néerl. XXXIII, 313—332.
11. SCHUBERT, E., 1933. Zur Geschichte der Moore, Marschen und Wälder Nordwestdeutschlands. II. Das Gebiet an der Oste und Niederelbe. Mitteilungen d. Prov. stelle für Naturdenkmalpflege Hannover, Heft 4.
12. TESCH, P., 1935. De vorming van de Nederlandsche duinkust. Groningen.
13. TIMMERMANS, P. D., 1935. Proeven over de invloed van golven op een strand. Leidsche Geol. Mededelingen. T. VI, afl. 3, 231—386.
14. VEENENBOS, J. S., 1950. De bodemgesteldheid van het gebied tussen Lemmer en Blokzijl in het randgebied van de Noordoostpolder. Diss. Wageningen.
15. VEEN, J. VAN, 1936. Onderzoekingen in de Hoofden in verband met de gesteldheid der Nederlandsche kust. Nwe Verhand. Bataafsch Genootsch. Rotterdam, 2e Reeks, 11e Deel.
16. ZEIST, W. VAN, 1950. An investigation into the earlier vegetation of Central Friesland (the Netherlands). Rec. d. trav. bot. néerl. XLII, 27—39.