

AGE AND VEGETATIONAL HISTORY OF THE COASTAL DUNES IN THE FRISIAN ISLANDS, THE NETHERLANDS¹

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ABSTRACT

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This paper presents the results of radiocarbon datings and pollen analyses of the coastal dunes of the Frisian islands off the northern coast of The Netherlands. The oldest dates obtained at each individual island decrease in an easterly direction and range from about 2800 BP for Vlieland to about 400 BP for Schiermonnikoog. Two types of deposits are distinguished: a. Older Dunes and b. Younger Dunes. The Older Dunes are characterized by intercalated organic beds. They formed between well before the beginning of the Christian era (e.g., on the island of Vlieland) and 755 ± 45 BP, locally even as late as 625 ± 50 BP (Ameland) or 430 ± 45 BP (Schiermonnikoog). The Younger Dune deposits, in which humic intercalations are very rare are related to a relief of parabolic dunes of considerable elevation. The formation of the Younger Dunes started before approximately AD 1400 (probably even more than a century earlier), and continues up to the present.

A comparison with the coastal dune area of the western Netherlands is discussed as well as some characteristics of the vegetational development.

INTRODUCTION

As part of the geological mapping of The Netherlands (scale 1:50.000), surveys were made in the Frisian islands off the northern coast of The Netherlands, between the North Sea and the Wadden Sea (Fig. 1). These surveys concern the islands of Vlieland, Terschelling, Ameland and Schiermonnikoog. Part of the information has already been published (DE JONG, 1975; VAN STAALDUINEN, 1977). This paper discusses the available radiocarbon datings, their geological position, and some of the results of the palynological investigations, which are related to coastal dune formation. Some tentative conclusions are drawn.

The radiocarbon dates generally are given in conventional ¹⁴C years BP, which means before AD 1950. When quoted in years AD, conversion to dendrochronological age was performed according to STUIVER (1982; cf. Table I). The sections that were radiocarbon dated were also studied by pollen analysis.

GEOLOGICAL POSITION

From the facies and succession of the Holocene deposits in the northern part of The Netherlands it seems likely that during the earlier part of the Holocene a barrier system existed north of the present Frisian islands (ZAGWIJN, 1974). It is assumed that the barriers later shifted southward. The present Frisian islands represent a temporary stage in a complicated process that is still going on. Besides the southward shift there are lateral displacements, particularly under the influence of tidal currents which scour the islands in some places and deposit substantial amounts of sand in other places. This may explain the unstable character of the islands. The subsoil consists of Holocene marine deposits down to a depth of more than 20 m below NAP (Dutch Ordnance Datum) except for the island of Vlieland, where these deposits are thinner. These sediments belong to the Westland Formation (ZAGWIJN & VAN STAALDUINEN, 1975).

The Frisian islands are characterized geologically by the presence of beach sands with relatively high overlying dunes on the northern side and tidal-flat deposits and low dunes on the southern side. In general sand deposits are more abundant at the western and eastern ends of the islands (Fig. 1). This situation has been strongly promoted by human influence.

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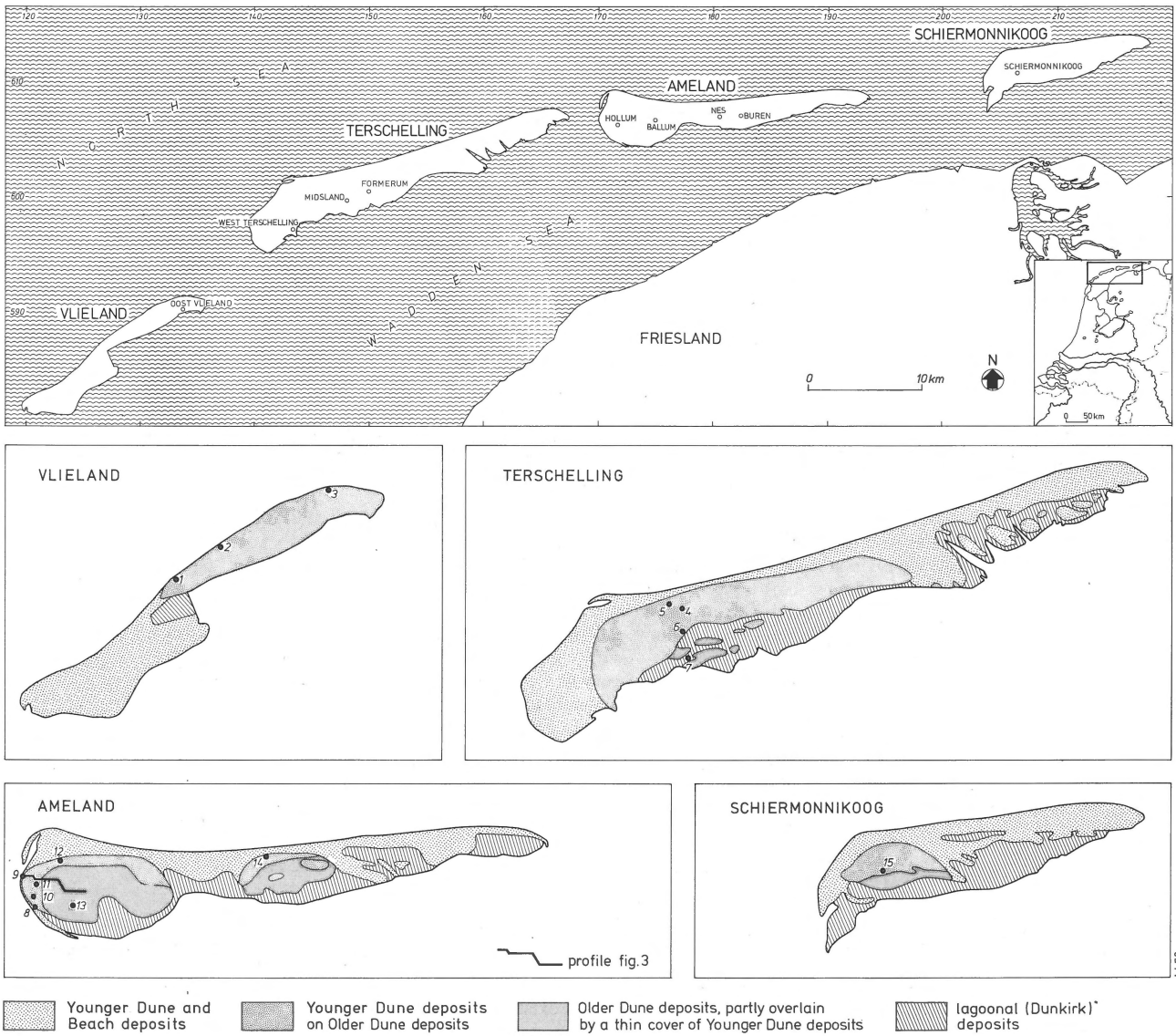


Fig. 1 Situation map. Geology mainly according to van Staalduinen (1977): 1. Vlieland strand I; 2. Vlieland strand IV; 3. Vlieland strand III; 4. Rijsplak I; 5. Rijsplak II; 6. Kooibosjes; 7. Hee; 8. Hollum strand I; 9. Hollum strand II; 10. Hollumberbosch II; 11. Hollumberbosch I; 12. Hollumerduinen; 13. Hollumermieden; 14. Nesserbosch; 15. Schiermonnikoog.

Morphologically two dune-systems can be distinguished, conventionally called Older and Younger Dunes. The Older Dunes, which are found at the surface in the southern part of the islands, consist of low hummocks. They represent the older cores of the islands, where presently the villages are situated. The northern and northwestern parts of the islands have higher dunes and dune ridges with large interdune areas. These dunes are predominantly parabolic (VAN DIJREN, 1934; KLIJN, 1981), they generally reach a height of + 20 m NAP, with elevations of even + 45 m on Vlieland and + 35 m on Terschelling. These dunes, which are called Younger Dunes, overly parts of lower Older Dunes.

A distinction between Older Dune sand and Younger Dune sand is also made on geological grounds. Because the

dune sands of the Frisian islands are poor in lime and shell debris, they cannot be used to distinguish Older from Younger Dune sand. Nor has evidence been found of a long period of soil formation separating the two sand bodies, as in the southwestern coastal dune area of The Netherlands. For the Frisian islands, however peat beds can be used to make a distinction: the Older Dune sands have intercalated beds of peat, whereas in the Younger Dune sand even thin humic layers are rare. The Younger Dune sand defined in this way is related to the relief of the Younger Dunes.

The difference between the northern part of the Dutch coast, which is poor in lime, and the SW part of the Dutch coast, which is rich in lime, reflects the difference in origin of the coastal sands. The dune sands of the Frisian islands, as

Table I
Summary of radiocarbon dates and related data for the samples investigated. Conversion to dendroyears AD is based on the graph published by Stuiver (1982), taking one standard deviation. Numbers correspond with those in Fig. 4.

Section	Depth	Material	Stratigraphic position	C14 date BP	GrN	Dendroyears AD
1. Vlieland Strand I 2. Vlieland Strand IV 3. Vlieland Strand III	0.07 - 0.08 m - NAP 0.11 - 0.12 m - NAP 0.04 - 0.08 m - NAP	peat sandy peat slightly sandy peat sandy	base of peat bed base of peat bed base of peat bed	2785 ± 55 2370 ± 70 1500 ± 30	6989 10248 9424	AD 540 - 600
4. Rijsplak I	0.07 - 0.15 m - NAP	Phragmites peat slightly clayey	base of peat bed	1620 ± 50	7258	AD 360 - 530
5. Rijsplak II/1 6. Rijsplak II/2	2.67 - 2.64 m + NAP 0.90 - 0.86 m + NAP	peat slightly sandy peat sandy	base of peat bed base of peat bed	1000 ± 30 1555 ± 50	7259 7260	AD 990 - 1030 AD 410 - 560
7. Kooibosjes 1 8. Kooibosjes 3 9. Kooibosjes 4 10. Kooibosjes 5	1.50 - 1.44 m + NAP 0.74 - 0.71 m + NAP 0.04 - 0.09 m - NAP 0.23 - 0.27 m - NAP	peat slightly sandy peat slightly sandy peat clayey peat highly clayey	base of peat bed entire peat bed top peat bed bed intercalated in clay	755 ± 45 875 ± 60 1405 ± 35 1490 ± 50	7261 7262 7263 7264	AD 1220 - 1290 AD 1040 - 1260 AD 600 - 660 AD 530 - 640
11. Hee	0.09 - 0.15 m - NAP	peat	base of peat bed	655 ± 45	7265	AD 1280 - 1390
12. Hollum Strand I 13. Hollum Strand II	0.44 - 0.42 m + NAP 0.86 - 0.83 m + NAP	peat slightly sandy peat sandy	base of peat bed base of peat bed	1015 ± 35 1125 ± 55	10254 9423	AD 980 - 1020 AD 780 - 980
14. Hollumberbosch II/I 15. Hollumberbosch II/II 16. Hollumberbosch I/I 17. Hollumberbosch I/II 18. Hollumberbosch I/III 19. Hollumberbosch I/IV	1.02 - 0.98 m + NAP 1.24 - 1.21 m + NAP 2.04 - 2.01 m + NAP 1.93 - 1.92 m + NAP 0.94 - 0.92 m + NAP 0.69 - 0.66 m + NAP	peat highly sandy peat sandy sand strongly humic peat strongly sandy peat slightly sandy peat slightly humic	base of peat bed base of peat bed layer in sand layer in sand layer in sand layer in sand	980 ± 80 920 ± 230 820 ± 110 930 ± 100 1260 ± 50 1250 ± 35	10255 10256 10258 10259 10260 10261	AD 980 - 1160 AD 880 - 1290 AD 1040 - 1290 AD 990 - 1220 AD 670 - 850 AD 680 - 850
20. Hollumerduinen 21. Hollummieden	3.03 - 2.98 m + NAP 0.60 - 0.56 m + NAP	peat highly sandy sand very humic	almost whole bed base of peat bed	140 ± 60 560 ± 60	10257 10253	after AD 1660 AD 1300 - 1420
22. Nesserbosch	1.97 - 1.94 m + NAP	peat sandy	base of peat bed	625 ± 50	10262	AD 1290 - 1390
23. Schiermonnikoog	0.18 - 0.13 m + NAP	peat sandy	base of peat bed	430 ± 45	7267	AD 1430 - 1480

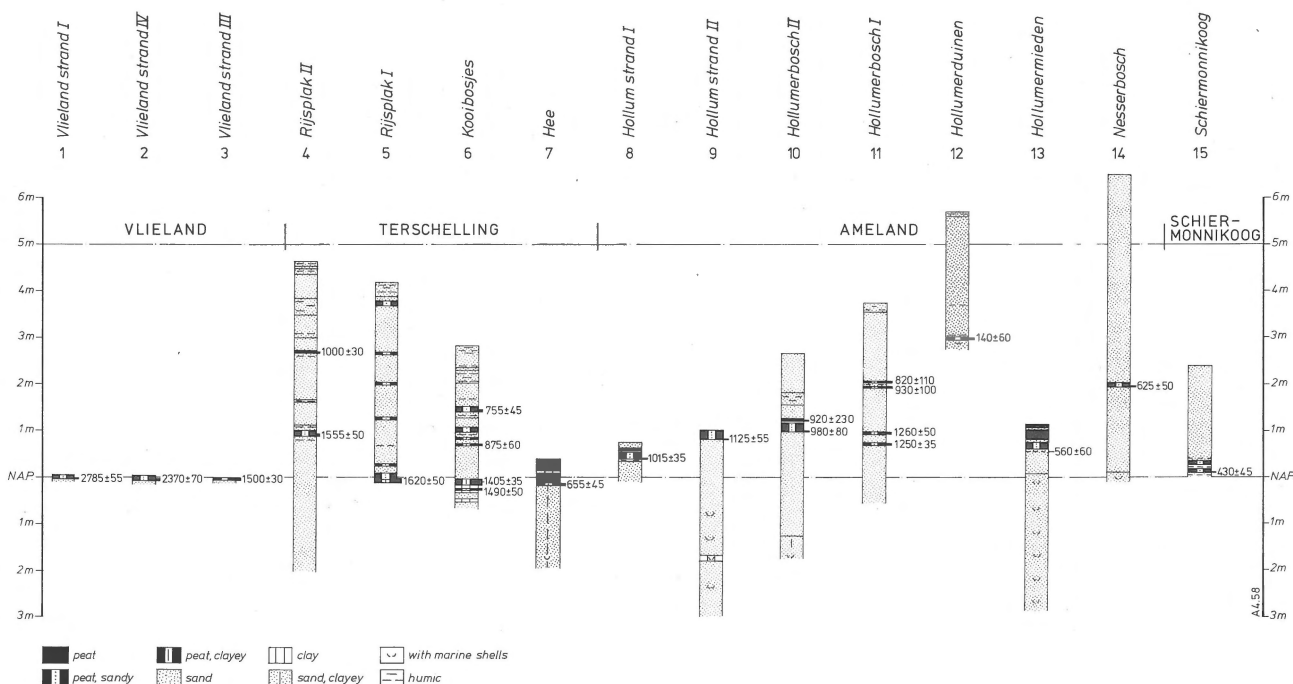


Fig. 2
Radiocarbon-dated peat horizons in beach exposures (Vlieland) and bore holes (Terschelling, Ameland, Schiermonnikoog) in the Frisian islands. Site locations by number are marked in Fig. 1. Radiocarbon dates in years BP.

well as the dunes in the N part of the west coast of The Netherlands, are poor in lime. The beach sands in both areas are relatively poor in shell material. The sands of Schiermonnikoog, however, contain slightly more lime than those of Vlieland, Terschelling and Ameland.

The recent, very open vegetation, with oligotrophic species as *Calluna vulgaris*, *Erica tetralix*, *Empetrum nigrum* and *Myrica gale*, is characteristic for a low lime environment (HOLKEMA, 1870; VAN DIEREN, 1934). *Hippophaë rhamnoides* is scarce and is restricted mainly to the youngest coastal dunes, which have not been subjected to leaching. The Polypodioid-Empetretum plant community is characteristic for the northern slopes of the dunes, especially on Terschelling (WESTHOFF, 1947).

POLLEN-ANALYTICAL RESULTS AND RADIOCARBON DATES

Vlieland

In Vlieland, three peat beds that are exposed on the North Sea beach have been investigated. These peat beds differ in age and overlying dune sand of unknown thickness (Fig. 2). The radiocarbon dates (Table I) indicate that the island was in existence at least as early as about 2800 BP. At the time the coastline must have been situated considerably farther north.

Pollenanalytical data indicate a forest vegetation for the oldest peatbed (about 2800 BP), in which *Corylus* dominated. Scrub elements as *Myrica*, *Salix*, *Hippophaë* and *Juniperus* are present. Cerealia and *Plantago lanceolata* clearly point to prehistoric agricultural activities. The peat bed dated at 2370 BP shows a more open vegetation in which the influence of prehistoric man is still observable. *Juniperus* and *Hippophaë* are scarce. The peatbed dated at 1500 BP (VIth century) shows a very open vegetation with rather abundant *Calluna*, indicating heath. *Juniperus* as well as signs of human influence again are present.

Terschelling

In Terschelling, peat beds are intercalated in dune sands in the Rijsplak II, Rijsplak I, and Kooibosjes boreholes (Fig. 2). The Rijsplak II and I borings were made in an interdune area of the typical dune region, whereas the Kooibosjes boring is situated in the transition toward the lower-lying southern part of the island. The lowermost peat bed in each of these three borings has a similar age, ranging from 1620 to 1490 BP, i.e. from about AD 360-620. In the Rijsplak II section this bed is intercalated in dune sands. Rijsplak I shows some estuarine influences in the basal part of the peat. In the Kooibosjes section the peat lies on top of estuarine deposits.

Pollenspectra from these lowermost peat layers, show the presence of dune scrub with *Myrica* and *Hippophaë* and a dominance of *Salix* and *Juniperus*. It may therefore be concluded that there were large areas with an open vegetation

and locally dune scrub; heather occurred in the vegetation (mainly *Calluna*), but was not abundant. The spectra clearly show indications of human inhabitation.

The spectra from the peat beds that are intercalated in the overlying dune sand, and which predominantly date from the early Middle Ages, generally indicate a very open, herbaceous vegetation. There are some intervals with dune scrub (*Salix* and *Myrica*; *Juniperus* and *Hippophaë* very scarce) and an extension of *Calluna* in certain localities, but pollen of this plant does not dominate in the spectra. In contrast to the recent vegetation, *Empetrum* and *Polypodium* are almost absent.

Ameland

Peat beds were also found intercalated in dune sands in the northwestern part of Ameland. Fig. 3 is a west-east section (for location, see Fig. 1) showing the geological situation in this area. The section may also serve as a general section running from the North Sea, over the Frisian islands to the Wadden Sea. Here, no superficial clayey deposits were found. Such deposits occur frequently, however, in other places on the Wadden Sea side of the Frisian islands, sometimes within the embanked area. Of the investigated sections Hollum Strand (see Fig. 2) is the only one included in the cross-section (Fig. 3, extreme left). This site and that of Hollum Strand I have peat beds exposed on the eroded western coast. The Hollumerbosch I and II and Hollumerduinen bore holes are from the dune area. The Hollumermieden boring was sunk east of the village of Hollum in a peat-filled depression. The northern extension of this plain is cut by the cross-section (Fig. 3) in its eastern part. The oldest ¹⁴C dates (about 1250 BP) indicate a younger age than that of the oldest peat beds of Terschelling. The datings imply that the island of Ameland was already in existence in or before AD 800. The date of Hollumerduinen indicates that the overlying dune sand is very young, agrees with the known historical age of the dunes at this site (ISBARY, 1936).

The pollen-spectra from the peat beds are rather similar and demonstrate an extremely open landscape with some scrubs (*Salix*). *Hippophaë* is scarce, while *Calluna* is present in low values only. Only a few pollen grains of *Juniperus* and *Myrica* have been detected. There are indicators of human influence in all investigated sections.

There is another dune area farther east around the village of Nes, an area which is separated from the dunes near Hollum. In this Nesserbosch section (Fig. 2) a radiocarbon date of a peat layer that is intercalated in dune sands points to a XIVth century age (625 BP). Pollen spectra from the basal part of this peat bed indicate an open herbaceous vegetation in which *Hippophaë* was rather abundant. In the upper part of the peat *Salix* dominates and *Juniperus*, *Hippophaë* as well as *Calluna* are present in low values. Cerealia and *Plantago lanceolata* indicate human influence in the area throughout the entire period during which the peat bed was formed.

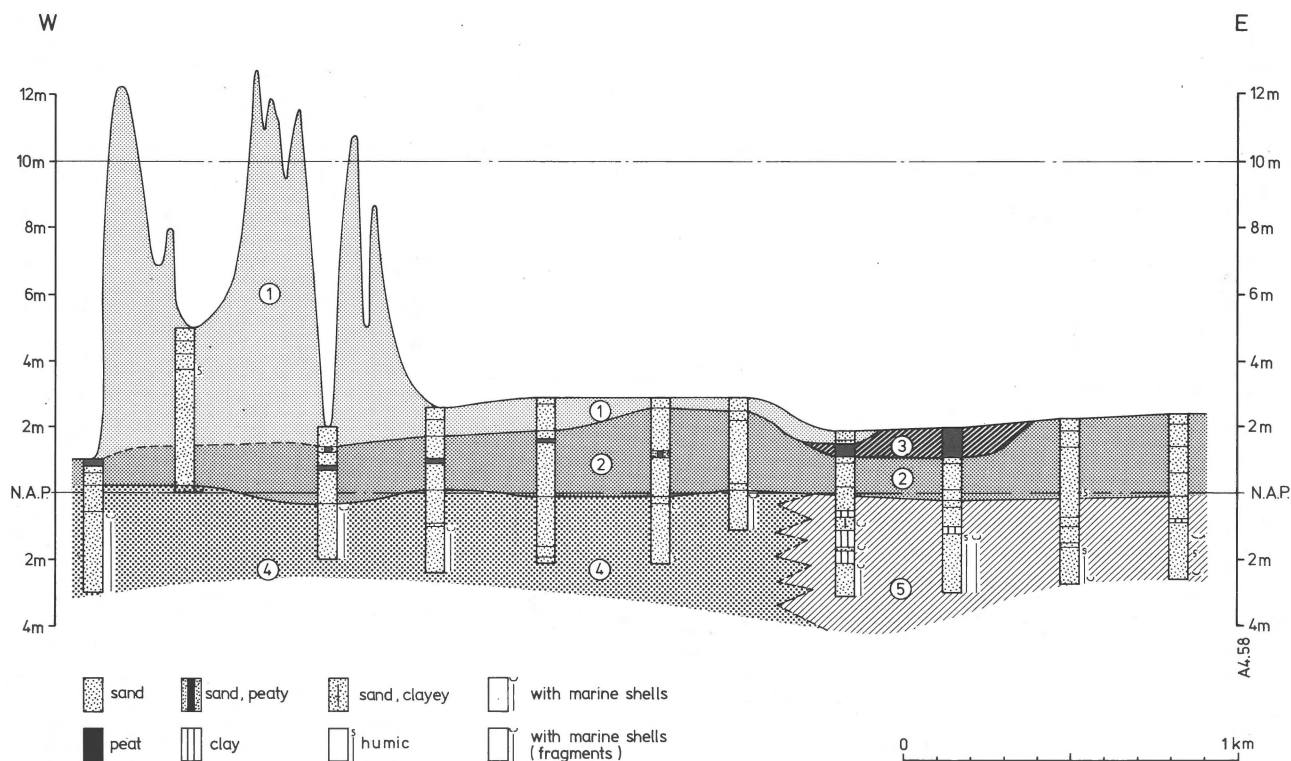


Fig. 3
Stratigraphic interpretation of W – E Section through boreholes on Ameland. Position of section marked in Fig. 1. Based on data supplied by District Noord, Rijks Geologische Dienst. 1. Younger Dune sands; 2. Older Dune sands; 3. Holland peat; 4. beach sands; 5. tidal flat (Dunkirk) deposits.

Schiermonnikoog

On the island of Schiermonnikoog, one peat bed has been investigated by radiocarbon dating and pollen analysis (DE JONG, 1975). This peat bed that is intercalated in dune sand was found in the centre of the village of Schiermonnikoog. The peat bed dates from the XVth century and is overlain by dune sands. On these sands the village (at that time called Oosterburen) was built in the eighteenth century after an older settlement (Westerburen), off the recent western coastline, had been obliterated when that part of the island was inundated.

Pollen analysis of the peat bed points to a rather open vegetation with dune scrub. Initially *Hippophaë* was abundant but soon replaced by *Salix*. *Calluna* was very scarce and *Juniperus* absent.

The spectra show signs of human influence throughout the whole peat bed.

ADDITIONAL REMARKS

The age of the oldest peat bed on each individual island (Fig. 4) indicates a minimum age of the island. Where the peat beds overly marine deposits, the ^{14}C datings give an approximate date for the final marine influence. Where the peat overlies dune sand, there must have been an earlier phase of dune

formation. In section Rijsplak II (Terschelling, Fig. 2), grain-size analyses indicate that the top of the marine deposits lies at -0.90 m NAP. If this is accepted as the former mean high-water level, the age of the interface with the dune sands can be put at 1000 BC, according to the curve of relative rise of the mean sea level (JELGERSMA, 1979). In other cases such detailed information is lacking. Macroscopic features of drilling samples do not permit determination of the transition from marine sand to dune sand with great accuracy. From the Ameland cross section in Fig. 3 it is clear, however, that the marine deposits reached a higher level on this island (indicating a younger age) than the marine deposits in the Rijsplak section on Terschelling.

CONCLUSIONS

1 – The oldest dates of peat formation obtained for each of the Frisian islands decreases from west to east. The dated peat beds are partly underlain by dune sand, hence the datings indicate a minimum age of the individual islands. Therefore the time at which they became land, also decreases from west to east. Peat beds dating from before the beginning of the Christian era have only been found on Vlieland.

2 – A substantial part of the sedimentation of the Older Dune sands took place after the beginning of the Christian era. The youngest date obtained for the termination of this sedimentation is:

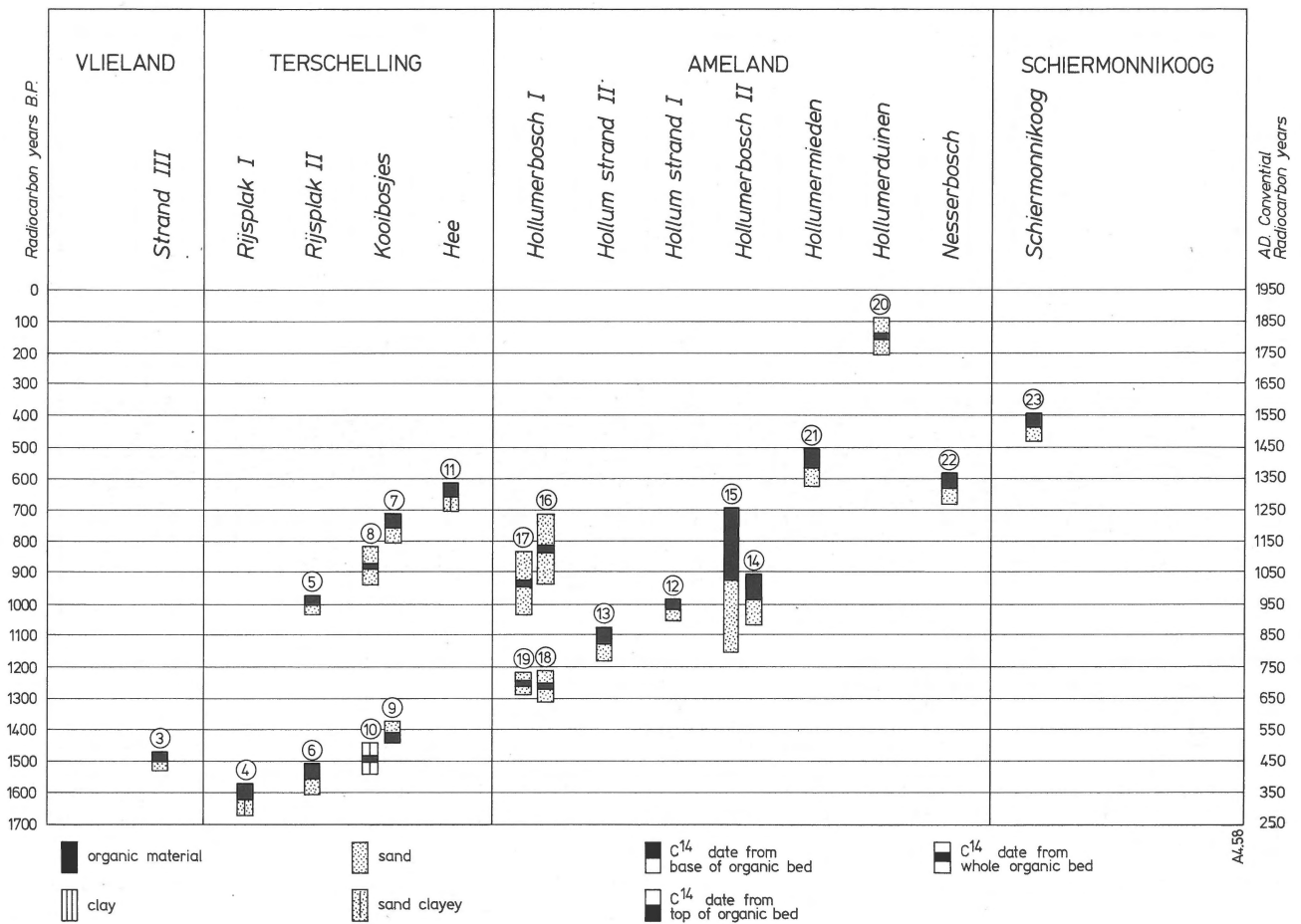


Fig. 4

Conventional radiocarbon dates of the Frisian Islands, plotted against time. Length of columns represents the time interval including one standard deviation; lithology indicates the stratigraphic position of the investigated sample. Dates for each island in order of the oldest available. The numbers correspond with those in Table I. Dates older than 1700 BP (Vlieland) omitted.

Terschelling (Kooibosjes 1)	755 ± 45 BP = AD 1220-1290
Ameland (Hollum)	820 ± 110 BP = AD 1040-1290
Ameland (Centre, Nesserbosch)	625 ± 50 BP = AD 1290-1390
Schiermonnikoog	430 ± 45 BP = AD 1430-1480

This indicates that Older Dune sands sedimentation continued longer in the eastern islands.

3 - No dating is available for the onset of the sedimentation of the Younger Dune sand. Since there is no indication for a substantial hiatus between the deposition of the Older and Younger Dune sands, the dates for the end of the Older Dune sand sedimentation may be regarded an estimate for the earliest deposition of the Younger Dune sands. In this connection attention should be paid to the time when peat began to form in areas south of the distribution limit of the Younger Dunes on both Terschelling (section Hee; AD 1280-1390) and Ameland (section Hollumermieden; AD 1300-1420). Peat formation here may be related to a rise of the groundwater-table as the result of an extension dune area, i.e. by the formation of the Younger Dunes. This would mean that the onset of the Younger Dune sand sedimentation dates

from before approximately AD 1400. Because the rise of the groundwater-table may have been retarded compared to the actual dune formation, an approximate date between AD 1200 and 1400 may be considered reasonable for the beginning of the formation of Younger Dunes.

4 - The conclusions mentioned under points 2 and 3 indicate that termination of deposition of the Older Dune sands as well as the onset of sedimentation of the Younger Dune sands may have been diachronous throughout the islands, i.e., earlier in the west and later in the east.

5 - The limited number of ¹⁴C dates (some with large standard deviations) from the peat beds intercalated in the Older Dune sands, prevent a time correlation for peat growth and sand deposition that is valid for the whole region.

6 - Pollen analyses indicate that there was some forest on Vlieland around 2800 BP whereas from 2370 BP onwards there was only open vegetation. For all of the islands the pollen-analytical data from peat beds of about AD 400 and later, indicate open dune vegetations with local scrub. On Terschelling, *Juniperus* was initially abundant, but was soon replaced by *Salix* and *Myrica*. On Vlieland and Terschelling,

Calluna was present but not dominant, whereas *Empetrum* was very scarce. *Calluna* is scarce on Ameland and Schiermonnikoog. In the sections of Ameland-Nesserbosch and Schiermonnikoog, *Hippophaë* occurs in appreciable amounts, indicating that the environment at that time was already richer in lime, as it is today compared with the more western part of the Frisian islands.

7 – All pollen diagrams indicate human interference with vegetation, i.e., both in diagrams of peat layers dating from before the beginning of the Christian era and in diagrams from beds of medieval age. Although part of the pollen may have come from the mainland, it is not probable that all of these palynomorphs originated at a distance as great as that. Moreover, the data agree with the archaeological finds from Terschelling (ELZINGA, 1974), where habitation of Older Dunes beginning in AD 800 has been proven. The present data indicate that habitation occurred even a few centuries earlier. On historical grounds, Ameland must already have been in existence in AD 800 (BANTELMANN ET AL., 1976). This makes it likely that Older Dunes were present on Ameland at that time, as confirmed by the radiocarbon dates.

8 – In comparison with the coastal dune formation in the western Netherlands (JELGERSMA ET AL., 1970; ZAGWIJN 1984a) the following statements can be made:

a) Considerable amounts of dune sand accumulated on the Frisian islands after the beginning of the Christian era and before about AD 1200, i.e., during a period when apparently only minor amounts of dune sand were deposited in the western coastal dune area.

b) Due to the proximity of the sea, the dunes on the Frisian islands used to be (and still are) a more dynamic environment than that of the coastal dune area in the western part of The Netherlands. For the latter area, however, little information is available about dune areas close to the beach (ZAGWIJN, 1984b).

c) For the Frisian islands it is difficult to make a distinction between Older and Younger Dune sands on the basis of the lithology of these sands. Although the criterion for the presence or absence of peat beds may seem arbitrary, there is a similarity to those parts of the western coastal dunes where dune-sand sedimentation continued after the beginning of the Christian era. This supports the subdivision of the dune sands used in this paper, into Older Dune deposits and Younger Dune deposits, both members of the Westland Formation. On the Frisian islands, the Younger Dunes also reflect a strong activation of the formation of dunes. It is not clear, however, whether this can be explained by subaqueous erosion and steepening of the coast, as in the western coastal area.

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