AN OUTLINE OF THE GEOLOGICAL HISTORY OF THE COASTAL DUNES IN THE WESTERN NETHERLANDS

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1. INTRODUCTION

In the early sixties, the geological history, the vegetation history, and the archeology of the coastal dunes became subject of extensive investigation. A full account of this study will be found in an article by S. Jelgersma, J. de Jong, J.F. van Regteren Altena, and W.H. Zagwijn to appear this year. The present article, a summary of two lectures given during the meeting of the INQUA Subcommissions for the Study of the Holocene and for Baltic and North Sea Shorelines, only deals with the results mentioned in the publication referred to above. The lectures were intended as a preparation for the coastal dunes excursion.

On the geological map of the Netherlands two types of dune landscape can be distinguished: the 'Older Dunes' and the 'Younger Dunes'. These two types were introduced by v a n B a r e n (1913 and 1927) as a result of studies made on vertical dune sections. Figure 1 indicates the distribution of these two types along the Dutch coast. Between Hook of Holland and Schoorl both dune types can be distinguished. Along the rest of the Dutch coast Younger Dunes only are present, although Older Dunes are thought to have existed as well, the latter being eroded by the invading sea before the deposition of the Younger Dunes. There the younger dunes can be found lying on top of late Roman or younger tidal deposits.

The landscape of the Older Dunes is made up of a series of low ridges more or less parallel to the present coastline, separated from each other by depressions filled with peat and clay. The low ridges are covered by small irregular dune forms. Underneath the Older Dunes coastal barriers are present, the topography of which is concealed by the overlying Older Dunes. The western part of the Older Dunes is covered by the Younger Dunes.

The Younger Dunes represent a different landscape when compared with the Older Dunes. In contrast to the comparatively low Older Dunes (original height up to 10 metres) they can rise to 40 metres above mean sea-level. Other differences are the typical morphological features found in the Younger Dunes only: foredunes near the coastline and the typical pattern of parabolic dunes inland (v a n S t r a a t e n 1961). The main difference, however, between the Older and the Younger Dunes is their date of origin. The Older Dunes were formed in the Subboreal and early Subatlantic and nearly everywhere completed before the Roman period. On the other hand the first phase of the Younger Dunes did not start before the 12th century A.D.

As mentioned before, between Hook of Holland and Schoorl the Younger Dunes overlie the western part of the Older Dunes (see figure 2). This has been recently observed during large-scale excavations undertaken in the region of the Younger Dunes southwest of Haarlem (dunes belonging to the Municipal Waterworks of Amsterdam) and at IJmuiden (site of the Royal Netherlands Blast Furnaces and Steelworks). More details concerning the above mentioned areas can be found in J e l g e r s m a et al. (1969).

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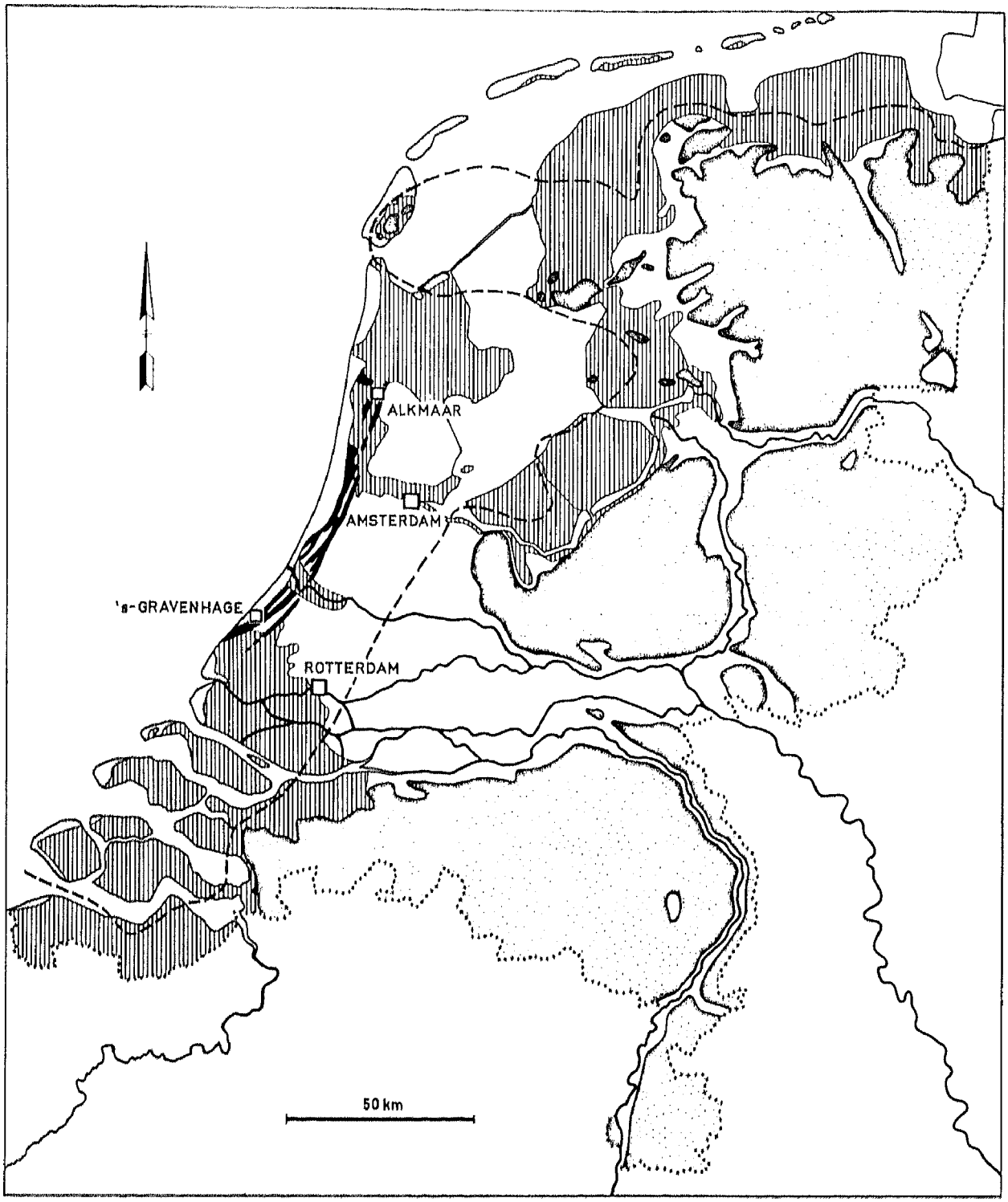
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2. COASTAL BARRIERS

Underneath the Older Dunes a series of coastal barriers is present. Their morphology, concealed by the overlying Older Dunes, is not known in detail. Only the main trend of the barriers can be distinguished; it seems to be related to the pattern of spits attached to river-mouths and estuaries (see figure 2 and Jelgersma et al. 1969).

Detailed investigations by means of a series of cored borings across the coastal area near The Hague (Scheveningen) have demonstrated the existence of two phases of barrier formation, the traces still being present in the subsoil (van Straaten 1965, Zagwijn 1965). The oldest phase, comprising two ridges, was formed between 5000 and 4700 years ago[3]) during the transgression phase of Calais III. Seawards of these oldest ridges the deposition of comparatively fine sand and clay beds occurred on top of a gently sloping sea floor. This shallow sea floor was gradually filled up and overlaid by a second phase of barrier formation. During this period, the transgression phase of Calais IV, a series of ridges developed, starting about 4200 years ago and probably ending 3800 years ago. It seems likely that the system of development of the coastal barrier ridges near The Hague can be used to explain the time of origin of the coastal barriers south and north of the detailed investigated section. To sum up: it may be remarked that during the Subboreal an important progradation of the Dutch coastline occurred resulting in a series of coastal barrier ridges.

According to recent investigations three important river-mouths or inlets between Hook of Holland and Schoorl were present at the time: the Rhine-Meuse mouth near the Hook of Holland of today (probably the Helinium of Pliniu s Nat. Hist. IV 101), the Old Rhine mouth near Leiden, and an inlet near Egmond which connected up with the Utrecht Vecht-Eem system (see figure 3). Despite previous suggestions (a.o. Pons and Wiggers 1959, 1960), other inlets between Hook of Holland and Schoorl are unacceptable.

3. OLDER DUNES (figure 3)

Aeolian deposition (Older Dunes) started almost immediately after a coastal barrier had been completed. Since the progradation of the coastal ridges, from east to west, was gradual, it is clear that the beginning of the deposition of the Older Dunes is not synchronous. In general the aeolian deposition of the Older Dunes decreases in age from east to west. This means that in the eastern part of the coastal barrier system the aeolian deposition was short-lived and subsequently vegetation began to develop. The oldest known Older Dunes deposits were probably formed after 4800 years ago (according to van Straaten 1965 and Zagwijn 1965),and were completed before 4100 years ago. The latter date was produced by an overlying occupation layer containing traces of a Late Neolithic[4]) settlement at Voorschoten (Glasbergen, Groenman-van Waateringe and Hardenberg-Mulder 1967). In the western part of the Older Dunes, sand accumulation took place until the Roman period.

Our investigations have shown that dune formation was not continuous from 4800 years ago until Roman times. Periods of soil, peat and gyttja formation alternated with periods of aeolian deposition. These phenomena are demonstrated by a series of soil, peat and gyttja horizons intercalated in dune sand, as observed in various vertical sections. Radio-

[3]) Ages given in 'years ago' refer to radiocarbon dates.

[4]) The archeological periodization used in this text is defined in: De periodisering van de Nederlandse Prehistorie, Ber. Rijksd. Oudheidk. Bodemonderz. 15-16, 1965-66, p 7-11.

Fig. 1

The Netherlands: distribution of the Older and Younger Dunes, Calais and Dunkirk Deposits.

1. Dunkirk Deposits
2. Younger Dunes
3. Inland limit of Calais Deposits
4. Coastal barriers and Older Dunes
5. Pleistocene and older formations at or near the surface

The white part of the Netherlands represents Holocene peat and fluvial deposits.

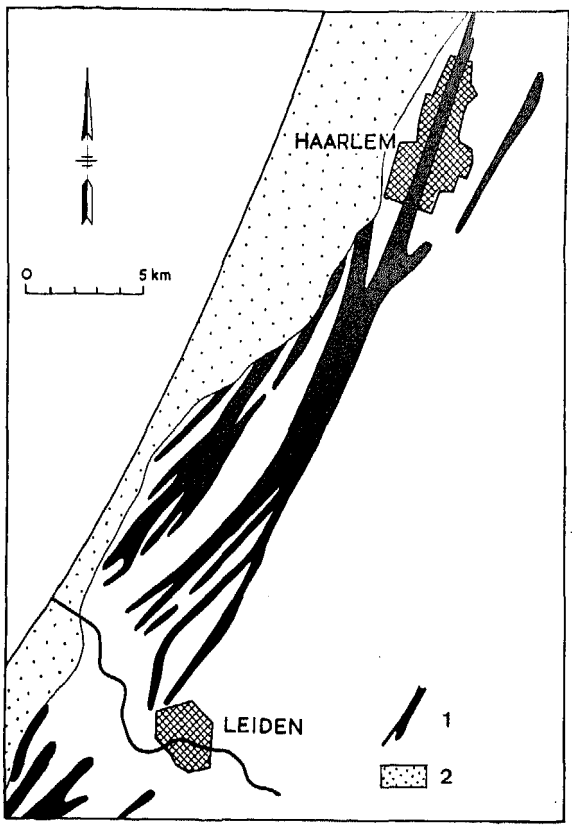

Fig. 2

Occurrence of Older and Younger Dunes between Haarlem and Leiden with the Old Rhine mouth.
1. Older Dunes
2. Younger Dunes

carbon dating together with pollen-analysis and archeological investigations have revealed that these soil and peat horizons have been synchronous over a large area along the Dutch coast. Pollen diagrams from peat and gyttja sections reveal that during phases of soil and peat formation the vegetation cover was dense (forest, shrubs), whereas during aeolian phases vegetation was open.

Figure 4 gives an impression of the succession of deposits found in the dune area south-west of Haarlem; the same scheme applies to the area of the Steelworks near Velsen visited during the excursion of the 2 INQUA Subcommissions. As shown in figure 4 the phases of the Older Dunes are divided by peaty layers. These peaty layers are truncated at different places by the aeolian deposits of overlying Older Dunes phases. On top of the Older Dunes a marked vegetation horizon separates the Older Dunes from the overlying Younger Dunes. In topographically high places this vegetation layer, C, is developed as a podsolic soil, in depressions a peat or gyttja layer can be present.

On top of the Older Dunes underneath the peat layer C, part of a native settlement from the Roman period has been excavated. At the same spot (terrain of the Steelworks) a settlement dating from the 12th century A.D. has been discovered on top of the C peat. The last settlement antedates the time of formation of the Younger Dunes. In the Older Dunes south-west of Haarlem and near Velsen three peaty layers are distinguished which are called B1, B2 and B3 layers. In the latter two layers Iron Age ware has been discovered. Radiocarbon and archaeological

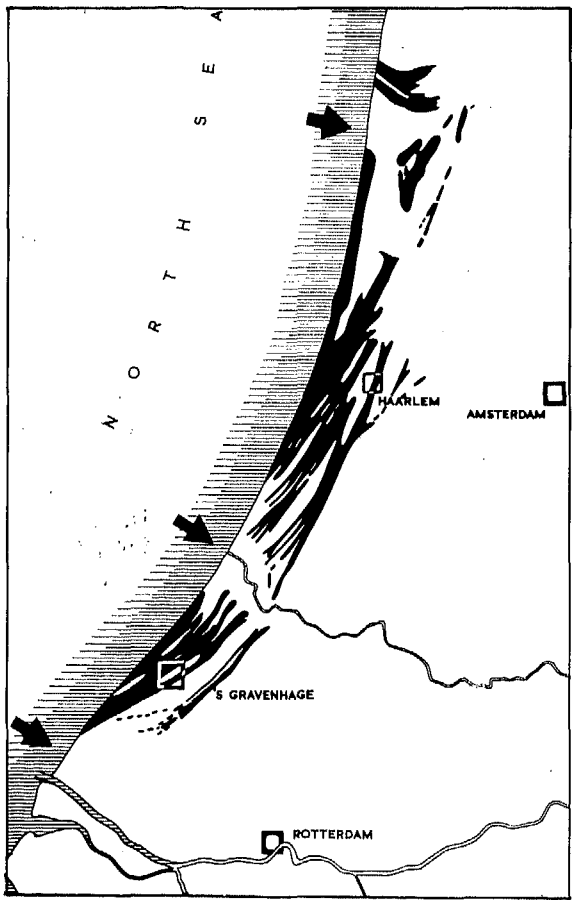

Fig. 3

The western Netherlands: the Older Dunes landscape with the Meuse and Rhine mouths and the inlet connected up with the Utrecht Vecht-Eem system.

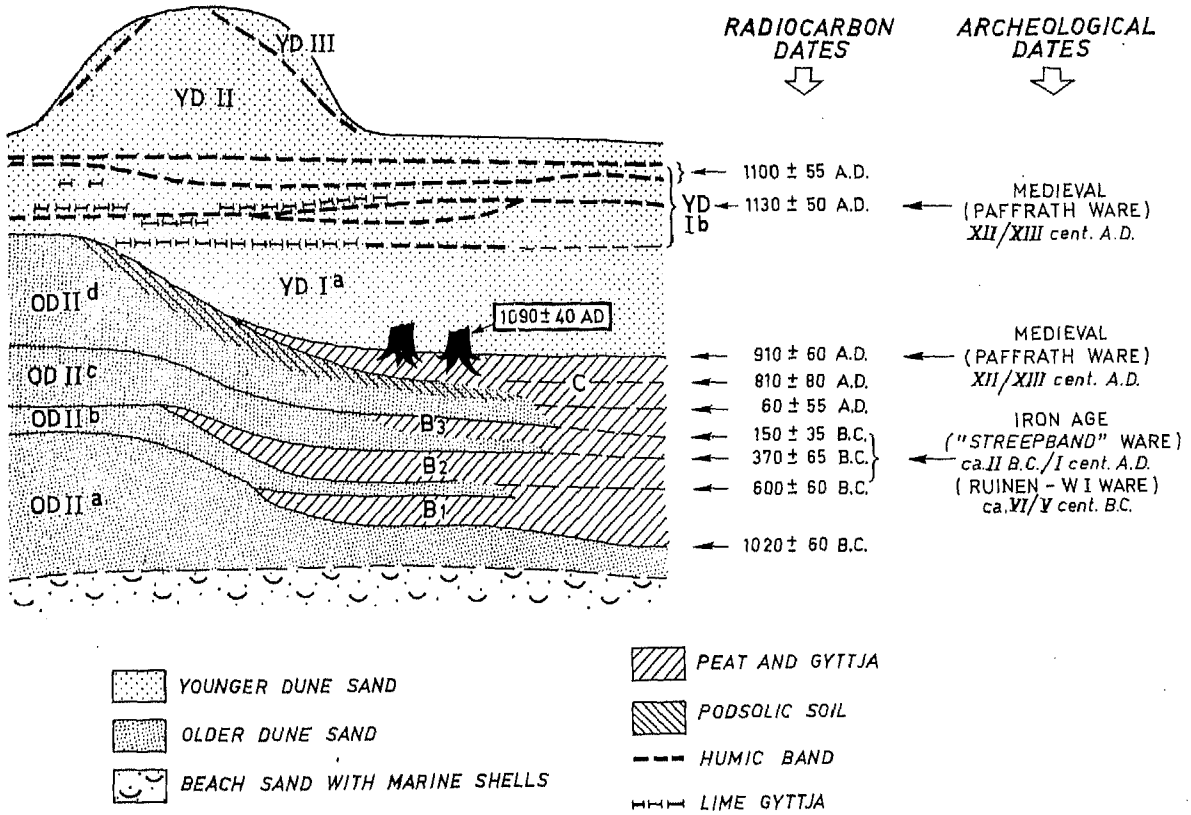

Fig. 4

The dunes of the Municipal Waterworks of Amsterdam (south-west of Haarlem): Schematic section of the dune deposits.

dates have been indicated in the scheme of figure 4. The oldest known vegetation layers in the Older Dunes sand, A layers, are connected with the occurrence of Late Neolithic, and Early Bronze Age settlements[5]); these A layers are not represented in the scheme of figure 4, because they appear only in the eastern part of the coastal barrier system. Figure 5, which presents a time scheme of the occurrence of wet phases (soils, peats or gyttjas) and dune formation in relation to the transgression phases of the backswamp, gives a dating of the A layers. This scheme will be discussed in part 5.

[5]) Hoards and stray-finds of Middle Bronze Age bronze implements also indicate the presence of Middle Bronze Age settlements.

4. YOUNGER DUNES

As indicated in the figures 1 and 2, in which Older Dunes as well as Younger Dunes are present, the latter do not reach as far inland as the Older Dunes. The morphology of the Younger Dunes can be described as follows: near the coast foredunes are present and landinwards several series of parabolic dunes with a SW-NE direction can be distinguished. The Younger Dunes are rather high, 20-40 metres above mean sea level. The landward limit of the Younger Dunes is often, though not everywhere, defined by a rather steep slope.

The Younger Dunes are separated from the underlying Older Dunes by a marked podsolic soil, the result of the reafforestation period between the 1st and the 12th century A.D., and in depressions by a peat or gyttja layer. It was found that the new forest was cut down by man, as witness the logs and trunks that were well preserved under the overlying sand. It

is very likely that the Younger Dunes would never have been deposited so far eastwards had the forest covering the Older Dunes remained intact.

After a standstill phase of about 11 centuries with only local aeolian deposition (Older Dunes III), the formation of the Younger Dunes began in the 12th century A.D. As indicated in figure 4 the sedimentation of the Younger Dunes also occurred in several phases. The first, Younger Dunes Ia, can be looked upon as a levelling phase: the crests of the Older Dunes were truncated and the depressions filled up. Subsequently the original topography of the Older Dunes became obscured and a plain came into being. This Younger Dunes phase Ia, which most probably occurred under relatively dry climatic circumstances, was succeeded by phase Ib. This second phase is characterized by a horizontal layered sand complex intercalated with three to five very thin peaty layers. According to the investigations of snails and the pollen content of these humic layers, this complex has been deposited in a wet plain. Consequently the deposition of the second phase took place under wetter conditions than its predecessor. Phase Ib should be dated to between the 12th and the 14th (?) century A.D.

The third phase, Younger Dunes II, has been deposited on top of the wet plain. During Younger Dunes II phase an enormous amount of cross-bedded sand was deposited in a few groups of parabolic dunes. During this phase the present landscape was formed; in the 18th-century only a few local aeolian redepositions took place (Younger Dunes III). The following observation can be made about the age of the Younger Dunes II: the present parabolic dune landscape can be recognized on 17th-century maps. In our opinion this phase was completed before the end of the 16th-century maps. In our opinion this phase was completed before the end of the 16th-century.

5. DISCUSSION OF THE EVIDENCE

In figure 6 a graphic representation of the coastal history during the last 5000 years is given. Three

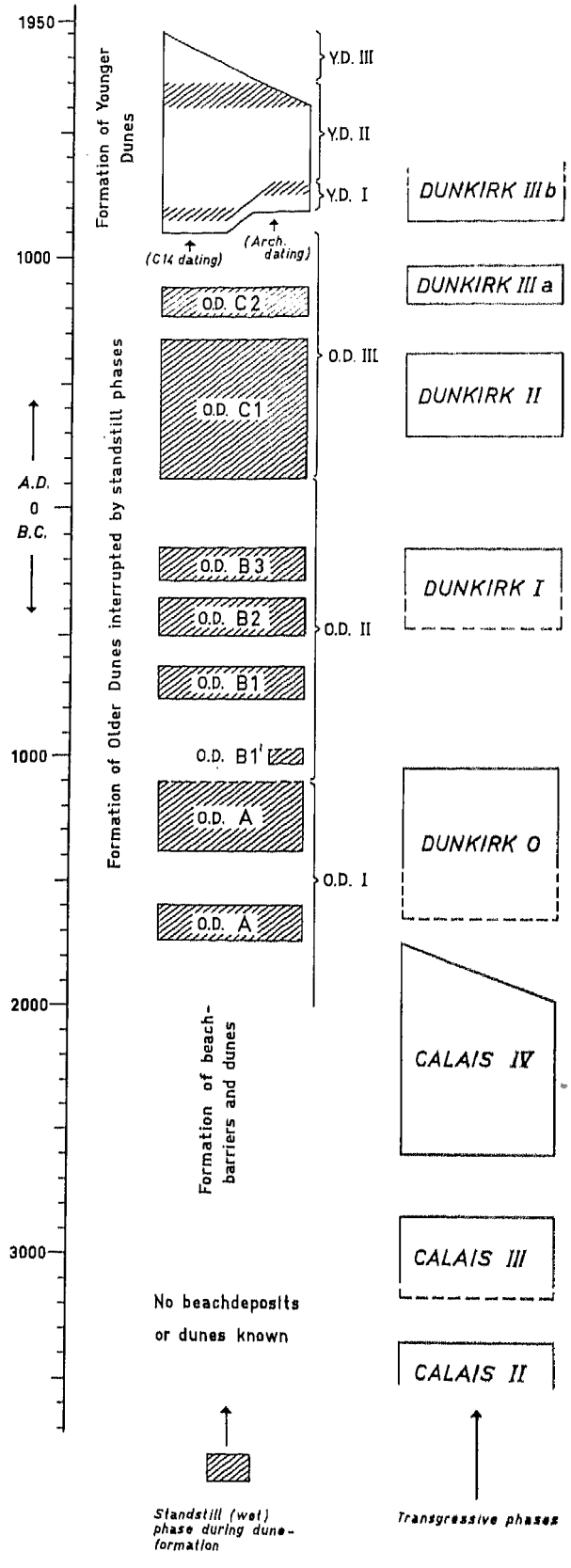

Fig. 5

Diagram: standstill phases during Older and Younger Dunes formation compared with Calais and Dunkirk transgressive phases.

problems arise from this figure:

a. the important barrier formation during the Subboreal,
b. the alternation between standstill and aeolian phases, and
c. the time lag between the formation of the Older and the Younger Dunes.

These problems will be commented upon.

a. The known coastal barriers were formed during the Subboreal in two phases. Before that time coastal barriers were also present but were eroded by the sea (van Straaten 1965). It is surprising that during the Subboreal under rising sea-level conditions such an amount of sand could accumulate into coastal ridges. This enormous quantity of sand probably came from the bottom of the North Sea (transversal transport) and via longshore transport from river deltas. The sediment transport of the rivers Rhine and Meuse will have been of importance; this in contrast to the present situation. It is likely that several factors concerning sea-level changes, sediment supply and the frequency of depression activities are involved, all resulting in an important progradation of the coastline. After the Roman period conditions will have been less favourable: after that time the coast became eroded, the consequent recession continuing up to the present day.

b. The coastal dunes sedimentation, on top of the coastal ridges, was not a continuous but a cyclic process (figure 5). This cyclic recurrent sedimentation could either be caused by human influence or by climatic fluctuations. As mentioned before, habitation traces were found in different soil horizons throughout the dune formation. It is tempting to think that human activities like forest felling, agriculture and animal husbandry (grazing) were responsible for the initiation of the aeolian phases. On the other hand this cyclicity could also have been caused by small climatic fluctuations such as drier and wetter conditions. It is well known that a dune region is a very unstable environment, highly depending upon precipitation. Support for the latter idea has been provided by radiocarbon datings of the intercalated peaty layers in the dune sands; the datings show that the time of formation of these peat layers is synchronous with the transgression phases noticeable in the backswamps (see figure 5). Accordingly, the

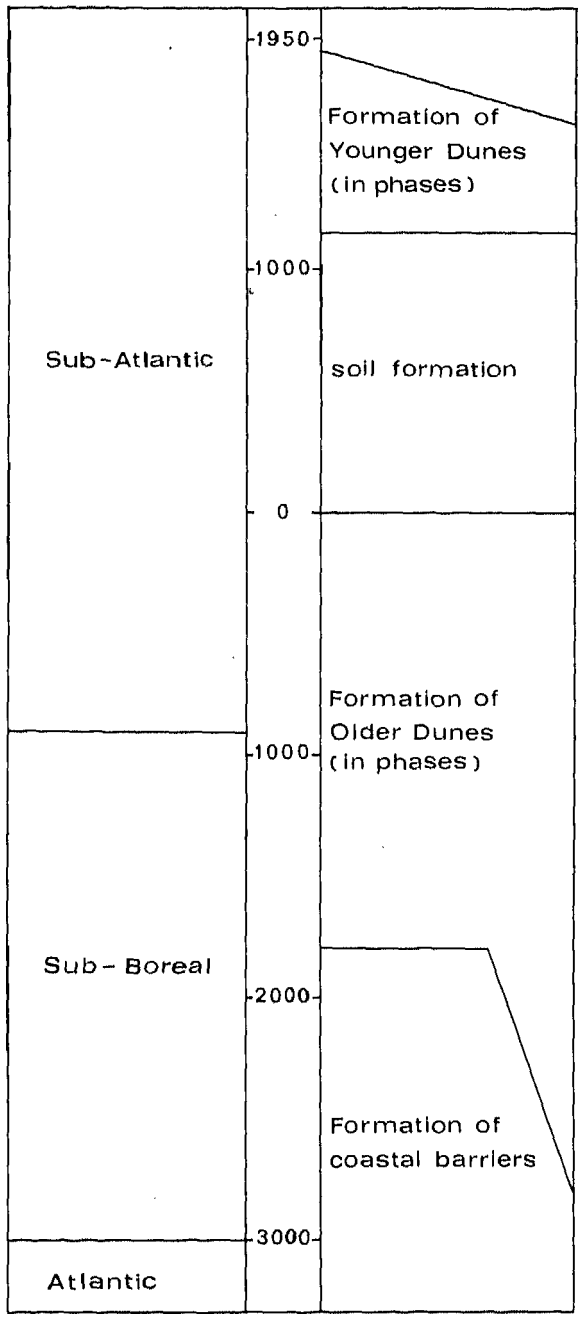

Fig. 6
Diagram: outline of coastal development.

aeolian phases should be correlated with the regression phases.

c. The standstill phase between the Older and the

Younger Dunes lasted a long time, during which conditions were favourable for soil formation: two transgression phases occurred during this period (wet climate) and the coastline was situated much more to the west than at present. Nearer to the coastline belonging to the period under discussion, conditions for continuous soil formation were probably less favourable. From the Dunkirk II transgression phase onwards the coast started retreating. It is thought that the sand that became available after a phase of coastal destruction piled up in foredunes and later on was blown landinwards. Accordingly the coastal erosion of the barrier ridges and the Older Dunes was responsible for the large amounts of sand available for the accumulation of the Younger Dunes.

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