

Archaeology and Coastal Change in the Netherlands

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I. Introduction

The archaeology and coastal change of the Netherlands are best seen from an ecological point of view. Governed by the rise of sea-level, sediment was laid upon sediment and a vast stratigraphy originated, in which all environmental changes are documented: a sequence of changing landscape-patterns. A major framework of this sequence is embodied in cyclic processes, known as transgression/regression cycles. The balance between land and sea was now in favour of the sea, a transgression phase during which estuarine creek systems were gradually extended and tidal flat areas were enlarged. This was followed by periodical sedimentation, during which creek systems were silted up and tidal flats changed into salt marshes. Mostly this sedimentation phase is included in the transgression part of the cycle, but it represents, in effect, the first part of a regression phase, which culminated in widespread peat formation. The transgression/regression cycle is a major topic in the present study: to what extent is this cyclicity periodical (with regular intervals) or aperiodical (with more or less random intervals)? Are there other processes that show a similar cyclicity, such as fluvial sedimentation or dune formation? What are the agencies governing these cyclicities, and a practical consideration: are predictions for the near future possible?

In this study the earth-sciences and palaeobiological disciplines combine forces: the vegetation is reconstructed by a palaeobotanist with the help of pollen, while macrofossils (seeds, wood), molluscs, foraminifera and diatoms help to reconstruct water conditions (tidal ranges, stream velocity, presence of mud and salt). Sometimes skeletal material of fishes and mammals permit a glimpse of the macrofauna.

The chronological framework is formed, together with stratigraphy, by many hundreds of C14 dates of a high standard, all determined by the Groningen Isotope Physics Laboratory.

II. Geological Differentiation of the Delta

The area under discussion is not homogeneous at all, but comprises widely different landscapes. I only want to give here a short sketch and refer for more detail to my earlier description (Louwe Kooijmans 1974) and the literature listed below. Better than words can do, the map and section illustrate the way the area is built up of different types of sediment, under the influence of the rising sea-level (figs. 47, 48).

Deposition started with a basal peat and was followed by tidal flat and salt marsh deposits behind coastal barriers as the sea encroached farther. East of the marine and estuarine environments the peat growth continued and behind this zone a fluvial sedimentation district was established along the main rivers. A major change took place around 3000 bc, when the gradual eastward shift of the coastal barriers came to an end. New coastal barriers were subsequently formed seaward of the old ones. The 'intracoastal zone' (i.e. the land between the coastal barriers and the Pleistocene hinterland) became better protected from marine incursions and changed into an extensive freshwater swamp. Only behind the inlets through the barriers did marine and estuarine deposits of more restricted extent form during 'transgression phases'. In relatively recent (i.e. post-Roman) times considerable destruction of the land and renewed marine deposition took place in those parts, where the coastal barriers extended the farthest to the west:

in the South-West, the province of Zeeland and adjacent regions
in the North, the northern parts of Holland and in the IJssel Basin behind.

In these regions remnants of the old deposits and traces of occupation in the old landscapes have only accidentally survived.

In the northern Netherlands (the provinces of Friesland and Groningen) the conditions were rather different. No coastal barrier remains are known there and from the facies of the intracoastal deposits it can be concluded that throughout the Holocene the coastline must have been interrupted with inlets, as nowadays. Deposition took place mainly as tidal flats and salt marshes. Peat formation took place in only a small belt and no major rivers flowed to this part of the coast. The coastal district is made up of salt marsh deposits from 600 bc and later, behind the present islands and Wadden Sea.

So we can distinguish a number of zones between the actual coast line and the hinterland, characterised by decreasing marine and increasing freshwater influences:

1. The sandy coastal barriers, covered by dunes
2. The tidal flats
3. The salt marshes
4. Estuarine creek systems
5. Peat zone
6. Districts with fluvial sedimentation.

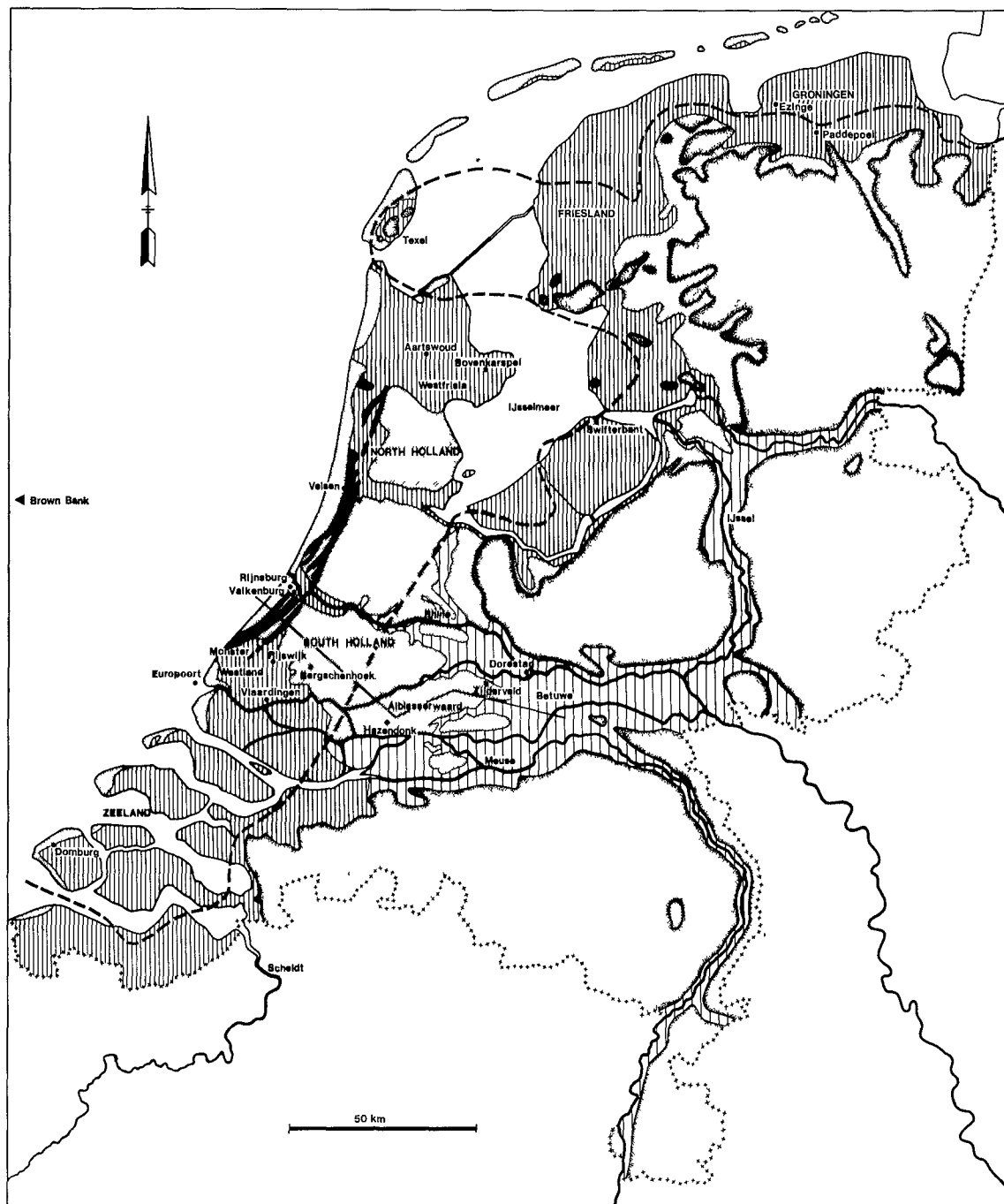
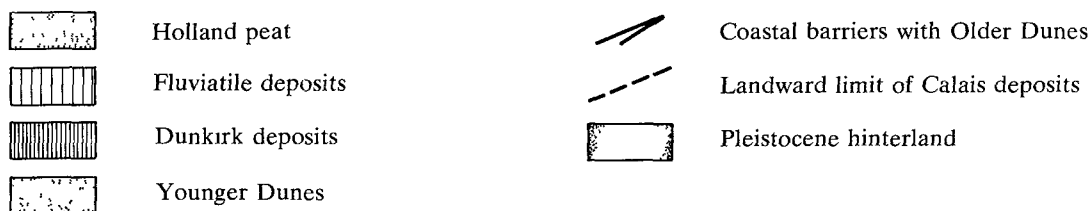


Fig. 47. Generalised geological map of the Netherlands with the major archaeological sites and districts mentioned in the text. Geology after S. Jelgersma *et al.* 1970.



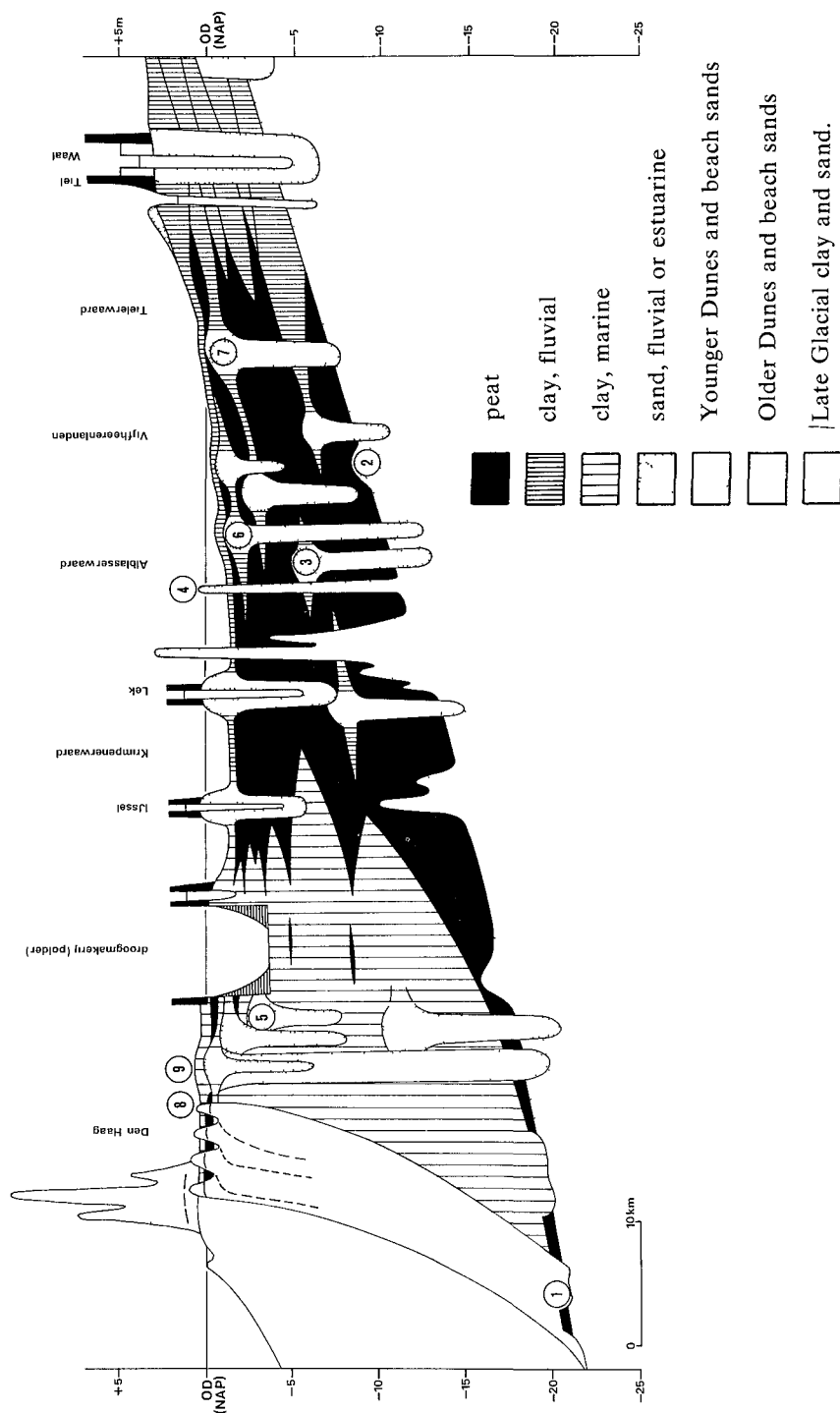


Fig. 48. Schematic west-east section through the Rhine/Meuse delta; for its position see fig. 47. Height exaggerated 1400×. Indicated are a number of sites (or their projection onto this section) of which the present levels were used in the construction of the sea-level curve of fig. 50.

Indicated sites:

1. Europoort
2. Willemstad
3. Swifterbant S3 (projected)
4. Hazendonk
5. Vlaardingen, Hekelingen
6. Molenaarsgraaf
7. Zijderveld
8. Voorschoten, Loosduinen, Arentsburg
9. Valkenburg, Rijswijk

The position and width of these zones fluctuated over time and their widths show considerable variations along the coastline. As regards these variations the intracoastal district can be divided into a number of sections from south to north:

1. The estuary of Scheldt and Meuse
2. The Holland plateau
3. The Lake IJssel basin
4. The northern salt marshes.

The river clay area may be distinguished as a fifth district.

Although one is inclined to speak of the combined 'delta' of a number of rivers, especially the Scheldt, Meuse, Rhine and Vecht, there are in fact only some minor parts in the area as a whole where true delta deposits were laid down. The 'Rhine/Meuse delta' consists of a complex of marine, estuarine, fluvial and organic deposits.

References: Hageman 1969; Jelgersma *et al.* 1970; Jong 1967; Jong 1971; Pons *et al.* 1963; Roeleveld 1974.

III. Human Occupation: Where and When?

In which areas did people settle in these landscapes before the embankments were constructed in the Middle Ages (from c. A.D. 1000)? To what extent was this choice of terrain governed by their subsistence economy and/or to what extent did they adapt themselves in this respect?

- (a) On the coastal barriers and the Older Dunes, settlement traces are found from the Vlaardingens culture (2400 B.C.) onwards. No occupation is found from barriers at the time they formed the actual coastline. The settlements are situated on the older ones more inland. There are no gaps of considerable importance in the occupation sequence.
- (b) No remains are known, nor are they to be expected, from the former tidal flat regions.
- (c) On salt marshes and comparable deposits, the slightly higher and more sandy parts were chosen, like surf ridges, creek levees and completely silted-up creeks. In Westfrisia extensive occupation is dated 1200–700 B.C., in Groningen and Friesland from 600 B.C. onward.
- (d) In the estuarine districts people founded their settlements on the silty levees of tidal creeks or on the sand-bodies of those that were silted up.
- (e) In the peat districts occupation did not take place on the peat surface until the general reclamation of the eleventh–twelfth century A.D., with the exception of some native settlements of the Roman period. But where sandy stream ridges and outcropping dune-tops were available, i.e. in the extension of the fluvial clay districts of IJssel and Rhine/Meuse, these were settled throughout prehistory, from the Mesolithic to the Iron Age.
- (f) In the river clay area the levees of active (and perhaps also former) rivers were occupied from the Late Iron Age till recent times. Older (Late Neolithic and Bronze Age) settlements were found on older systems and especially on so-called crevasse-deposits. In general, these are the well-

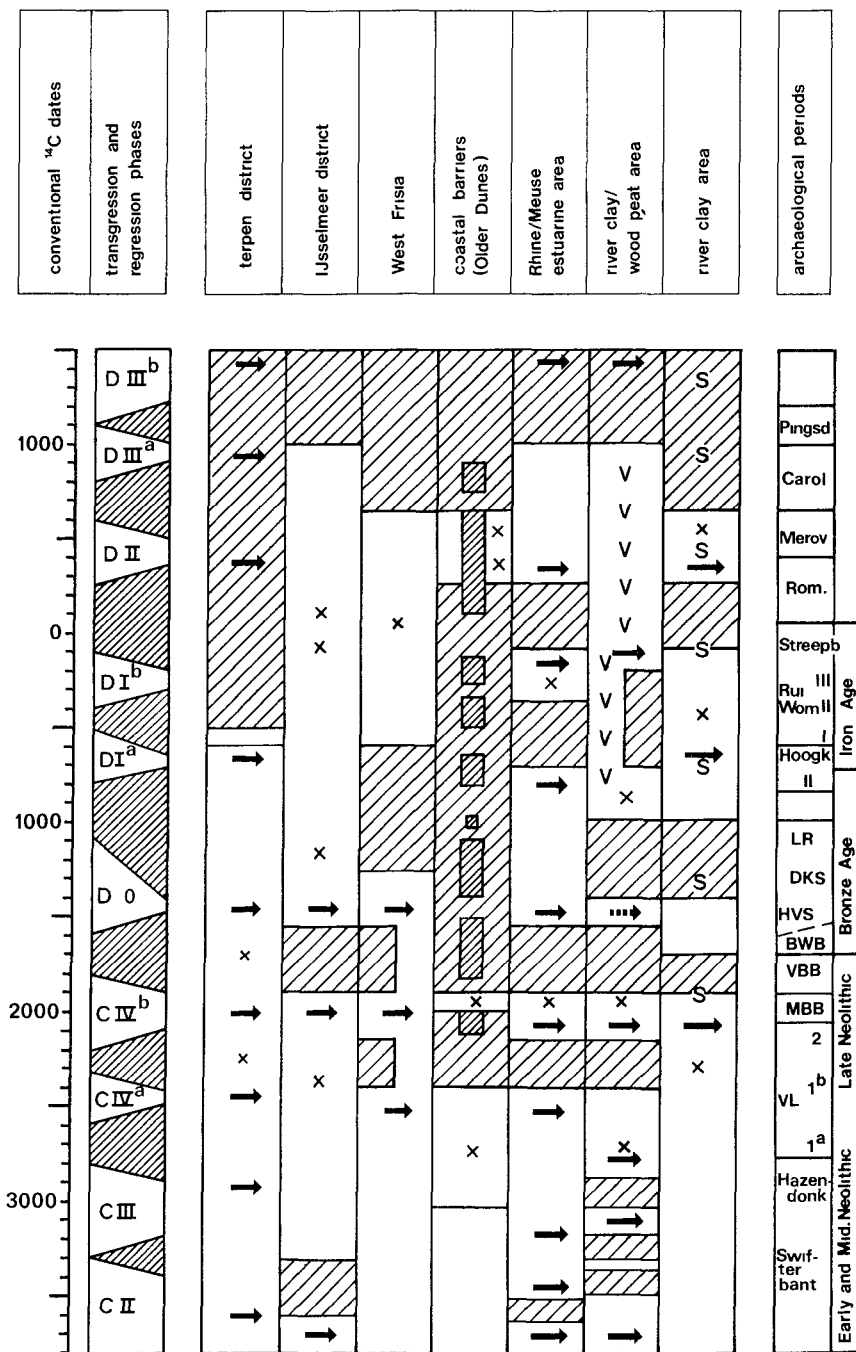


Fig. 49. Schematic representation of the occurrence of settlement traces in the various physiographic landscapes of the Rhine/Meuse delta between 4000 B.C. and A.D. 1500, compared with the transgression/regression-cycles. After L. P. Louwe Kooijmans 1974, with some modifications.

drained and relatively sandy deposits formed next to open watercourses of some importance, up to local MHW level or even slightly higher, and then preferably the higher parts of these. The coastal Older Dunes and the out-cropping dune-tops in the peat district form special cases, where the interaction of environment and occupation, although certainly present, is of a more restricted degree.

From this inventory the criteria that played a role in the choice of terrain for settlement can be extracted. The major factors for all communities, irrespective of the way of life, are:

- (a) As little inconvenience as possible from water, which means adequate drainage and a height above the level of regular flooding.
- (b) The economic possibilities of the site and its direct surroundings. Fresh water had to be available and, for rural communities, enough land for cattle and crops. Where these conditions are not fulfilled hunting, fowling, fishing and collecting played an important role, as at Swifterbant, Bergschenhoek, Hazendonk and even in the late Neolithic Vlaardingen. On these sites one must try to answer an important question: was the occupation perhaps seasonal or connected with a special, season-bound activity? This seems to be the case at Swifterbant. The sites are probably summer fishing camps. At Vlaardingen, however, permanent occupation is the most likely. The Hazendonk research is not yet far enough advanced to answer this question.

As stated above, the quantity of data has increased so much that we can safely say that landscapes were inhabited whenever and wherever possible. We must now turn to chronology and ask when and why occupation starts and ends. In the sedimentary phase of a transgression/regression cycle high levees, etc., could be formed, especially where the high waters were raised, when collateral flow was restricted, for example because of the silting-up of small side creeks during this phase. When subsequently a drainage pattern changed—and this was often the case at the end of the sedimentation phase—it could easily happen that these high deposits were outside the reach of (or at least far away from) normal high water, be it marine, estuarine or fluvial. In this way, by the lowering of the local MHW (i.e. often a decrease of the local tidal amplitude), a favourable situation for settlement came into existence. In our opinion this was the case, for instance, with Bell Beaker occupation in the Alblasserwaard peat district, Middle and Late Bronze Age occupation in Westfrisia, Iron Age and later colonisation of the Groningen and Friesland salt marshes and ‘indigenous’ Roman occupation in the Zaanland peat district north of Amsterdam, in the estuary of the Meuse (Westland) and in the Betuwe river clay area.

The major cause for the ending of a period of occupation was the general rise of sea-level, which counteracted the temporary gain of the sedimentation process. In due course the favourable conditions that led people to settle down disappeared; drainage became worse, flooding more frequent, arable land and natural pasture land marshy. A new transgression phase might have accelerated this process.

This process was more pronounced in earlier prehistory, when the rise of sea-level was rapid, during the Neolithic, for instance, about 20 cm/century (8 in.); in the Roman period about 5 cm/century (2 in.). At the end of the Late Bronze

Age people of Westfrisia were the first to fight back, by retiring to the highest points, digging ditches around the farms and by raising the yards with the excavated soil. But it was not a success. Sea-level rise, or more correctly the resulting rise of ground water level, won. Slightly later the northern salt-marshes were settled and there, about 500 B.C., people managed to resist flooding by raising small artificial mounds of sods, called *terpen* or *wierden*. The *terpen* were raised when necessary and also extended after the Roman period, in order to provide land for crop farming, when the old salt marsh surface became too wet.

When the embankments and artificial drainage were constructed, between A.D. 1000 and 1300 in most of the low districts, natural conditions played only a minor role when new settlements were founded. Many of the present-day villages in Holland are of medieval origin and lie in the middle of the peat bogs. But the individual farms often had raised yards. Until recently the dykes proved to be no safe guarantee against flooding.

References: Clason 1967; Louwe Kooijmans 1974; van Regteren Altena *et al.* 1962-3; van Zeist 1968; van Zeist 1974.

IV. Sea-level Records

A special topic is that of the rise and possible fluctuations of sea-level: the study of dated levels and the construction of a time-depth curve (fig. 50). It is the mechanism governing the main line of geological history, for which archaeological research may produce very reliable and extensively controlled data. The research concentrates on the collection of such data, on the estimation of the margins of error and the factors of local and regional importance that must be taken into consideration, on the establishment of variations along the coast and on the question whether and to what extent the transgression/regression cycles are reflected in the time/depth curve.

I explained in a special paper (Louwe Kooijmans 1976c) the line of reasoning that must be followed to attain a dated MSL from a dated sample-height. There are four steps in this line, each with its margins of error, that accumulate in the end-result.

The first step is from the present altitude of the sample to the original level. Sources of error are: the margin of error of the measurement itself, the relation of the sample to the presumed level and, above all, compaction. Preferably samples must be compaction-free. Otherwise compaction must be estimated, which is often impossible with any degree of accuracy. The importance of compaction-free samples cannot be overstressed.

The second step is to establish the position of a former local water level from this (present) height. The relation between the sedimentary height and a certain water level must be evaluated for this purpose. This can be done by comparison with recent situations. A salt marsh level lies at about 40 cm (15.5 in.) above MHW and estuarine creek levees are silted up to MHW level. But much basic study still must be done in this field.

The third step is that from the local water level, which mostly is the MHW, to a more general valid value; how representative is the sample-point for the whole

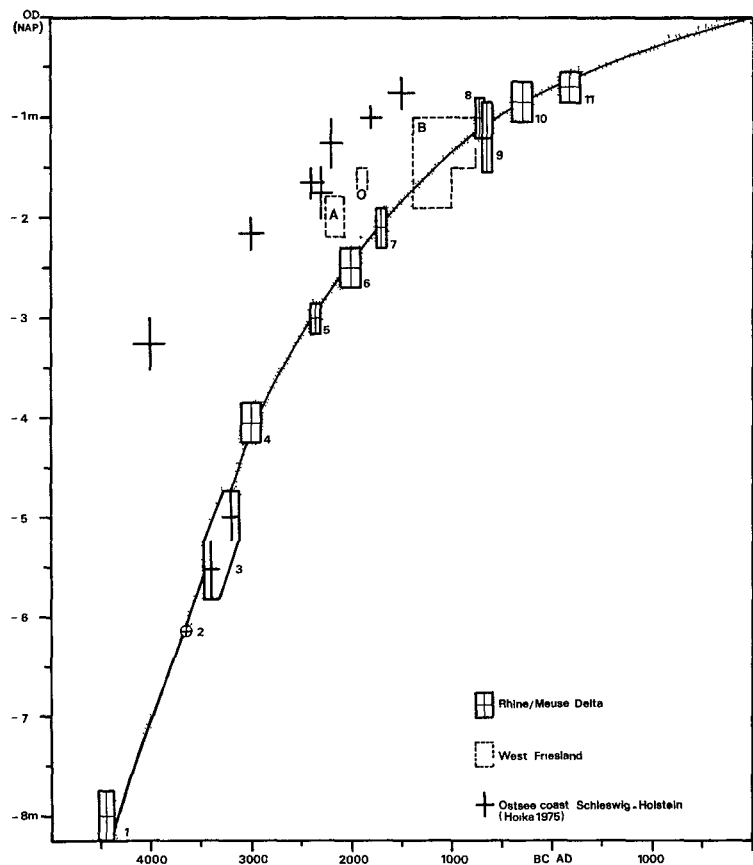


Fig. 50. Time/depth diagram of dated MHW-levels in the Rhine/Meuse delta, derived from the depths of archaeological sites, and the curve for the rise of mean sea-level that is obtained in this way. The dotted zones give an indication of the variation due to locally or regionally varying conditions.

Also indicated (but not taken into account) are some data from Westfrisia, where sedimentation during the Calais IV phase reached very high levels.

The curve of the eustatic rise of sea-level must lie somewhere between the data from the area of tectonic depression at the mouth of the river Rhine and the area of glacio-isostatic upheaval of the east coast of Schleswig-Holstein.

area? There are many factors that cause regional and local variation of MHW, namely:

- Extinction or enlargement of tidal amplitude by flood depression (in wide basins) or stowage (in narrow channels) respectively.
- Rise of all water levels when we go upstream along the lower courses of small and big rivers (gradient effect).
- Rise of the groundwater table in extensive sand bodies, like the coastal barriers, caused by restricted velocity of drainage.
- When relatively large areas are studied, like the whole of the Netherlands, MHW-variations along the coast cannot be neglected.

The fourth step is that from MHW to MSL. The former tidal amplitude must be estimated.

It will be clear that the best points for sampling are those where only a limited number of factors played a role, or situations where the effect of different factors can be compared, or thirdly, regions where the comparison of samples of which all factors are equal is possible.

I tried to construct a curve based on archaeological sites, selected according to this principle and following the line of reasoning above (Louwe Kooijmans 1976c). A much more thorough study is being made at present by van der Plassche, based on a long series of dated peat samples taken from carefully selected sites, controlled by very detailed geological mappings.

As to the results the following remarks can be made:

- (a) The main path of the time/depth curve is now firmly established, with a rise of about 20 cm/century (8 in.) during the Neolithic, diminishing to about 5 cm/century (2 in.) since the Roman period.
- (b) This curve gives the relative rise of sea-level. The post-Roman rise may be for the greater part the result of tectonic sinking of the land (calculated to 2–4 cm/century (0.8–1.6 in.)); the earlier rise is mainly caused by the eustatic rise of sea-level.
- (c) There are minor differences between Zeeland, Holland and Groningen, caused by differences in tectonics, morphology and tidal amplitude.
- (d) MHW-fluctuations established on archaeological sites, especially temporary lowering of MHW, can be explained for the greater part (if not completely) by local changes in drainage patterns. We can presume that these, running parallel to the transgression/regression cycles, are reflected in an ideal time/depth curve (Louwe Kooijmans 1974, fig. 14), but to measure these small fluctuations seems beyond our capabilities in the field. If ever possible, this should be the case in van der Plassche's investigations.

References: Bennema 1954; Jelgersma 1961; Jelgersma 1966; Louwe Kooijmans 1976c; van der Plassche (forthcoming).

V. Some Examples

In the following paragraphs an introductory description will be given of recent research in some widely different regions of the area dealt with in this paper, to illustrate the diversity of the problems and information gained there.

1. EARLY MESOLITHIC IMPLEMENTS FROM THE NORTH SEA AND EUROPOORT, ROTTERDAM

In addition to the well-known barbed point from the Leman and Ower Banks off the Norfolk coast, more bone tools were retrieved from depths between 35 and 45 m (115–150 ft.) west of the Brown Bank in the North Sea. They give a depth of -40 ± 5 m (-131 ± 16.5 ft.) at 7000 ± 400 bc, where (in view of the preservation of bone) peat formation took place. This is in good agreement with C14 and pollen-dated moorlog samples. They offer, moreover, information about

affinities between the material cultures of the Mesolithic hunter–fisher–gatherer communities of Great Britain, the Netherlands and Denmark.

Small bone implements, dredged up during harbour construction of Rotterdam-Europoort and found at the surface of the new artificial sand plain called 'Maasvlakte', give additional information in the last respect, but not about former sea-levels. The 'gradient-effect' plays a role and the substantial margin of error in the dating.

Together with modest finds on sandy outcrops (some of them covered) as at Swifterbant and Hazendonk, they document an occupation of unknown character, when peat formation started, i.e. in the 'North Sea Land' during the Early Boreal, and on the sands in the subsoil of the Western Netherlands in the later part of this period.

The rapid rise of the sea-level (c. 2 m/century (6.5 ft.)) had an enormous horizontal effect in the flat North Sea Basin and people living there must have been driven back by the encroaching sea. The appearance in some parts of the Netherlands in the beginning of the Atlantic of the flint assemblages of the De Leien–Wartena Complex must reflect these people settling in more inland areas. There are now more arguments for this supposition. Firstly, the material equipment of both (the Boreal and the Atlantic) groups, although very different in character, has distinct Nordic traits. Secondly, in both cases a marshy environment was preferred.

References: Louwe Kooijmans 1970–1; Newell 1973.

2. SWIFTERBANT — EARLY NEOLITHIC SETTLEMENTS ALONG FRESHWATER TIDAL CREEKS, c. 3300 B.C.

In the newly reclaimed IJsselmeer polders an estuarine creek system of Calais II age, part of the then IJssel estuary, was found preserved a little way below the present surface, which is at about –5 m O.D. (–16.5 ft.). On the levees settlement sites were discovered, dating from the final stage of the sedimentation period. These were investigated during the last years by the Biological–Archaeological Institute, Groningen.

In a fresh or only slightly brackish environment, with a very small tidal range (10–20 cm (4–8 in.)) the narrow, clayey levees were only incidentally flooded. They were covered with a deciduous forest of oak, elm and lime; in the swamps behind mainly alder brushwood was found, with willow-reed marshes further behind. The small early Neolithic settlements measured less than 30 m in cross-section and were intermittently occupied during a period of about one century. There are geological arguments for the absence of winter occupation and palaeobotanical evidence points even to non-annual (summer-) returns to one site, which might imply the alternate use of different sites by one community. But there are other arguments for longer stays.

A small cemetery has been found, cattle and pig were kept and slaughtered at the site, and Naked six-row barley and Emmer wheat were grown in the restricted space that was available. Apart from this, beaver, otter, red deer and wild boar were hunted. Future identifications of the bones of moor- and water-birds (which were also hunted) might give valuable information about the seasonal occupation

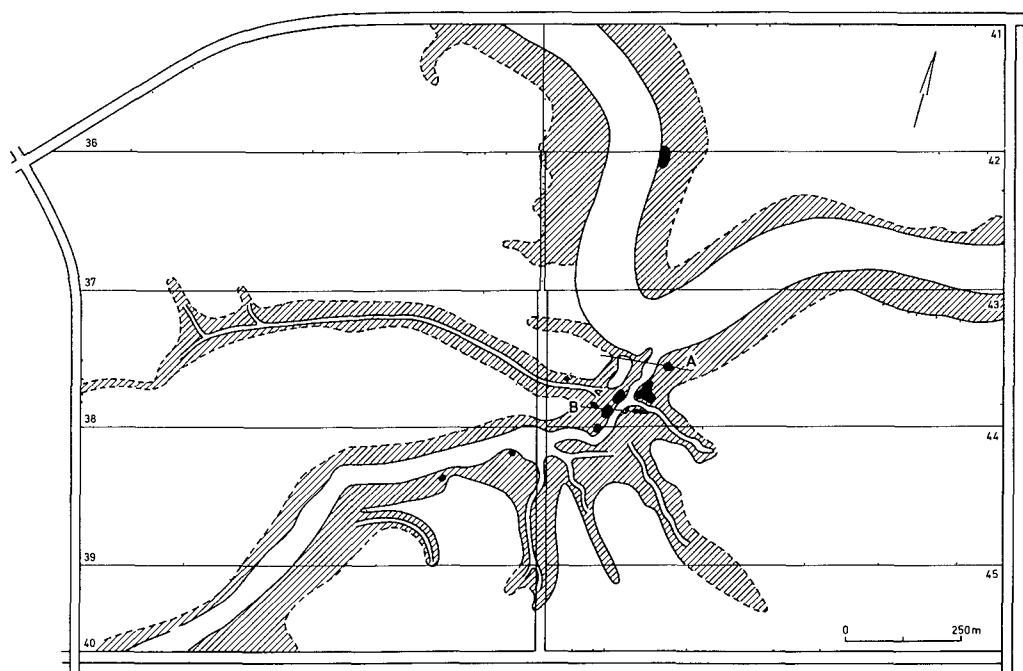


FIG. 2. — The Calais II deposits in the environment of the Swifterbant levee sites.







-  compact levee clay
-  soft creek clay
-  soft backswamp clay
-  settlement
-  sharp transition between deposits
-  gradual transition between deposits

Fig. 51. Detailed palaeogeographic map of a part of a Calais II estuarine creek system with a top at -5 m O.D. (-16.5 ft.) in the new Flevoland polders and the Early Neolithic settlement sites on its banks. After L. Hacquebord, Swifterbant contribution 3, *Helinium*, **16**, 1976, 38.

of the site, by the presence or absence of migratory birds. The fruits found (hawthorn, apple, hazelnut, rose hips and blackberry) must have been collected in the late summer/early autumn, while some of the fish (especially sturgeon, salmon and grey mullet) were only present in these waters in spring and early summer. In view of the position of the sites, at a crucial point of the creek system, fishing must have been of major importance.

The material culture reflects a local evolution from Mesolithic communities, with a pottery in a Nordic (Ertebølle) style and (trade) relationships with late Rössen communities, proved by the presence of fragments of true *Breitkeile*. The sites must have been left when the creek system silted up and this area lost its special attraction. From the occupied levels an MHW at -5.55 ± 30 cm O.D. (-18.2 ± 1 ft.) around 3300 B.C. could be calculated.

To what extent are these data representative of the occupation of the total area of the then 'delta'? No coastal barriers from this period are preserved and so all possible coastal sites are lost. Major parts of the intracoastal area are eroded and the remaining parts are deeply covered. By lucky accident a few glimpses of the former occupation are permitted: at Swifterbant, where the later cover has been eroded in historical times; at the Hazendonk, a sandy out crop of only 2 ha (5 acres), where grain was grown (Einkorn and Naked barley) and large amounts of fish refuse indicate an important fishing activity; a third site was discovered recently near Bergschenhoek, north of Rotterdam, in an artificial pond, dug to -8 m O.D. (c. -26 ft.). This site, excavated in 1978, appeared to be a very small (winter?) fishing camp, used 5–11 times within a period of only 5–7 years as could be concluded from the microstratigraphy. Both sites lie in a freshwater peat landscape, not dissimilar to Swifterbant.

It seems that the occupation pattern of the later Mesolithic, with maintenance camps and extraction camps, persisted into the Early Neolithic, while hunting, fowling, fishing and gathering were combined with animal husbandry and crop farming. At this stage nothing can be said about the velocity and pattern of this change; was it gradual or abrupt, did it happen in stages, and are there regional variations? Informative sites are so rare, that one may wonder whether answers to these questions may ever be found.

References: Louwe Kooijmans 1976b; Swifterbant Contributions 1–8; van der Waals 1972.

3. HAZENDONK AND MOLENAARSGRAAF—NEOLITHIC OCCUPATION IN THE PEAT DISTRICT, 3400–1700 B.C.

Where the Late Glacial Rhine/Meuse Valley underlies the peat district, many tops of river dunes are found, dated to the Pleistocene/Holocene transition, and for the greater part submerged by the peat formation. Through the millennia they were dry islands in the marshes and ideal places for prehistoric people to settle down. The small Hazendonk, measuring only 50×200 m (160×650 ft.) and in an isolated position, had attracted people in at least nine successive phases of the Neolithic and once or twice earlier still.

This district is a freshwater, eutrophic peat area, outside tidal and marine influences, but open to fluvial incursions from the east. There is a sequence of phases with general peat growth alternating with wide spread flooding and clay deposition along creeks and in lakes. The marshes were covered by an alder brushwood and reed, while the sand dunes had a cover of deciduous trees such as oak, elm and lime.

Traces of the successive Neolithic settlements on the top of the Hazendonk are completely lost, but old surfaces with domestic refuse on the slope of the dune and in the covering peat are preserved in excellent stratigraphy. This refuse was sampled by hand and by sieving during three excavation campaigns (1974–76), led by the author. Apart from pottery, stone and flint tools, bone implements, worked wood, charred seeds, grain and fruits, animal bones, fish remains and some human skeletal material were also collected. Pollen samples and series of C14 samples were selected. The detailed geological mapping of the complete Holocene deposits (about 10 m) of the immediate surroundings (c. 4 km² (c. 1.5 sq. miles)) of the Hazendonk is a special project to obtain palaeogeographic maps of each occupation phase. This is being undertaken by the Institute for Earth Sciences, Free University, Amsterdam. Traces of both earliest occupations of the site were discovered in this project and were not reached in the excavation.

Although finds and samples are very unevenly distributed over the various occupation phases, due to the restricted or superfluous traces that are left of these, it will be possible to follow the changes in material culture, food economy and landscape and their mutual relationships on this site in detail over seventeen centuries, covering the entire Neolithic period. All occupation phases are separated by periods in which the disturbed vegetation had completely recovered. For some phases the character of the occupation (incidental, seasonal or permanent) and an impression of its duration can be obtained. The 'attachment-points' of the refuse layers to the sandy dune slope give very reliable sea-level data, only to be corrected for the 'gradient-effect'. It is remarkable that the sequence of occupation seems to have no distinct relationship with the sedimentation sequence of the surroundings, which is in sharp contrast to other areas and to expectation.

It would be premature to give explanations or to make estimations of the results that will be available in some years. Work is in progress on all aspects of this. The coordinates and codes of 40,000 individually mapped finds are at present being fed into the computer, drawings are being made, C14, seed-, pollen- and fish-samples are being analysed; the bone refuse is being studied by Dr A. T. Clason. But some comments can be made.

In the lowest levels (3400 B.C.) the settled area seems to be small (c. 500 m² (c. 5400 sq.ft.)). The density of finds increases from the lower layers upward. In every phase crop cultivation has been proved (pollen), but charred grain occurs mainly in the lower layers. In every period fishing was important, in view of the abundant fish remains; sturgeon fishing and hunting (especially of beaver and roe deer) were of considerable importance as late as 2100 B.C. (Late Vlaardingen/AOO Beaker).

We have no explanation why people at a given moment stopped using the site; there might be different explanations for the various periods. During the Late Vlaardingen occupation a large stream crossed the peat about 1 km (0.6 miles) north of the site. We can imagine that sturgeon was caught there and that the Hazendonk lost its attraction when this stream sanded up. The modest Late Bell

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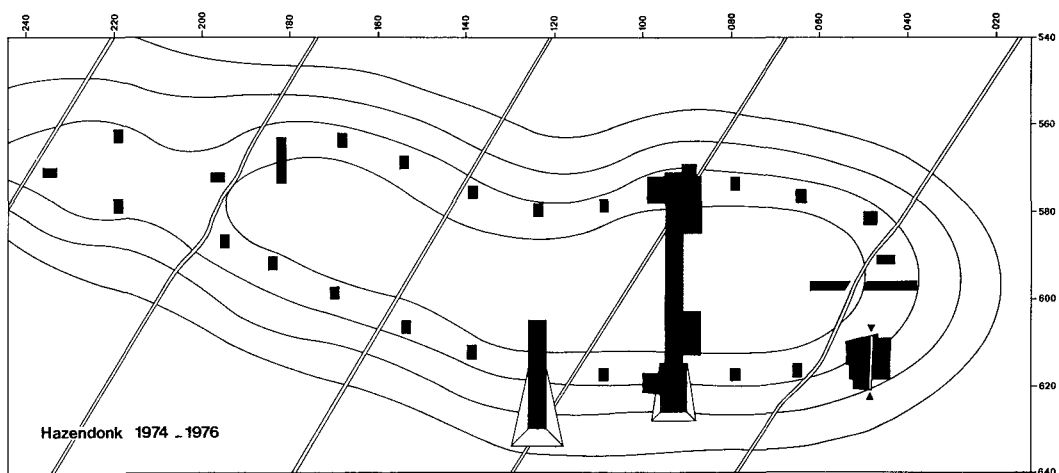


Fig. 52a. Hazendonk, generalised contour map of the surface of the sand dune with contour lines at 0, 2, 4 and 6 m (0, 6, 13, 20 ft.) below the present surface, which itself is at -1.30 m O.D. (-4.3 ft.). Excavation trenches and sampling pits in black. Grid of 20 m squares indicated along the margins.

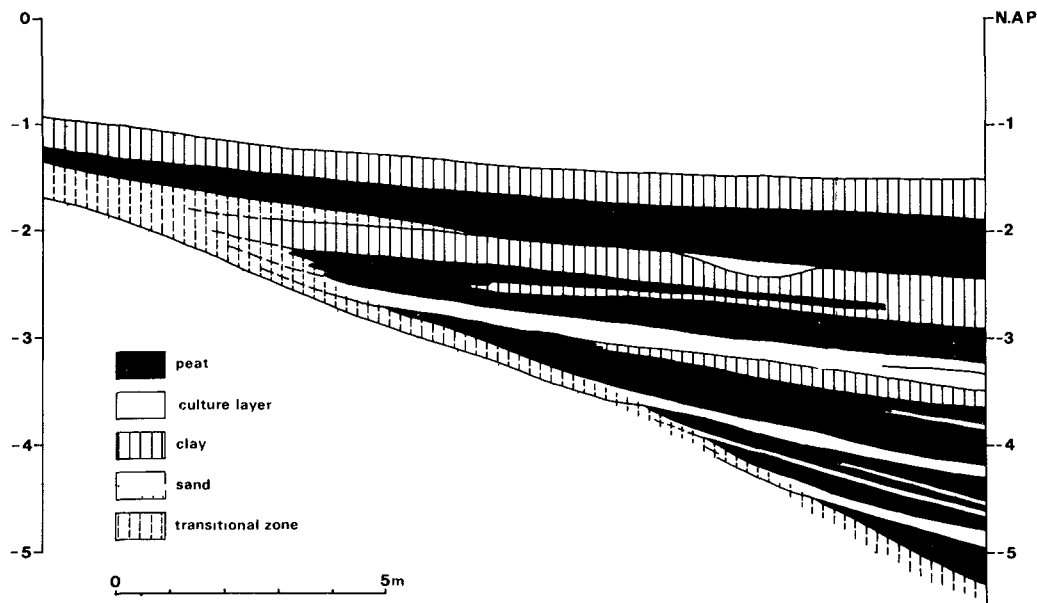


Fig. 52b. Simplified section through the deposits that cover the sand slope in the SE-trench. This is the most complete stratigraphy on one point of the site. Missing culture levels (VL2^{b1} and ^{b2}) are projected from other sections. Height exaggerated 2 \times .

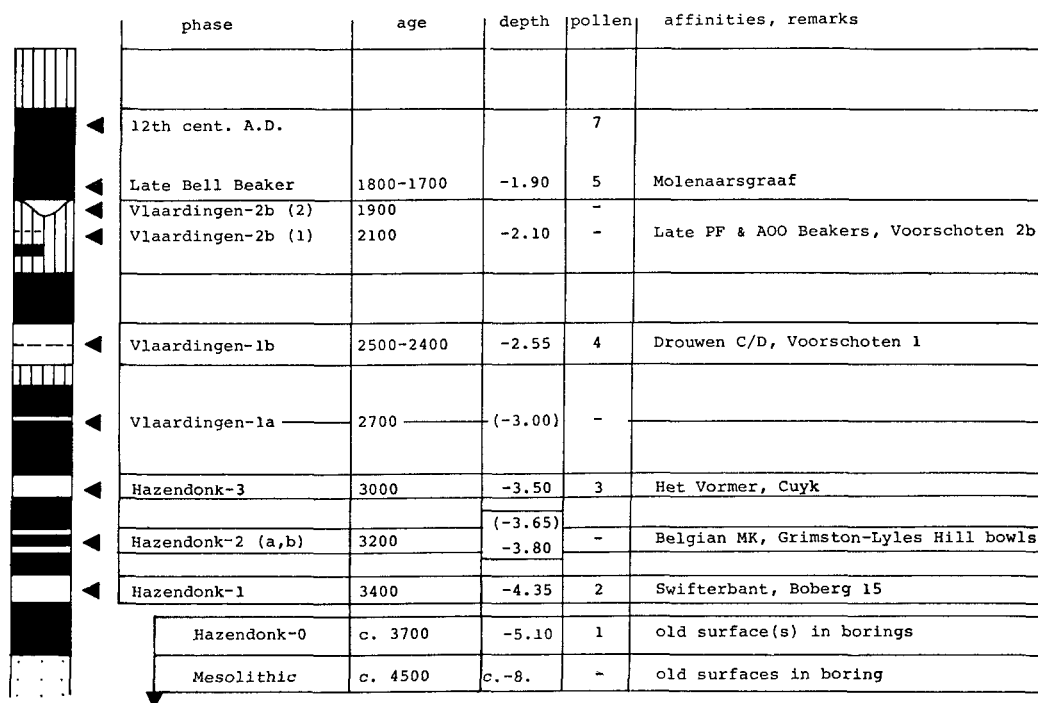


Fig. 52c. Stratigraphic column, similar to the extreme right part of fig. 52a, with archaeological comments.

Age: preliminary C14 dates bc.

Depth: local mean water-level (= sea-level + (50 ± 20 cm)).

Pollen: local pollen zone.

Beaker occupation and the absence of later refuse can be easily explained by the presence of a sand body, a few kilometres long and about 100 m wide (330 ft.), left by this stream. Intensive prospecting combined with three excavations on this so-called Schoonrewoerd Streamridge offered a detailed picture of the occupation around 1700 B.C. Over c. 5 km (3 miles) small sites are spread at intervals of 300-800 m (1000-2500 ft.), representing the positions of single farmsteads. Crops were grown on the deforested sand ridge, and cattle were grazed on natural pasture land on both sides.

Hunting was unimportant (enough arable land being available), but fish might still have been a prominent source of food. The long houses were spindle-shaped (if my interpretation is correct). In a temporarily abandoned settlement some burials were made.

Peat growth continued and the absence of new mineral sedimentation made the region less attractive and this became the major cause of a gradual eastward shift of the occupation. In the Roman period the region was completely abandoned and people returned only in the eleventh century when the present day villages were founded and the peat marshes were reclaimed.

References: Louwe Kooijmans 1974, 1976a, 1976b.

4. THE DUNE LANDSCAPE OF THE COASTAL BARRIER BELT: A SUCCESSION OF WIND-BLOWN DEPOSITS AND OCCUPATION FROM 2400 B.C. UP TO HISTORIC TIMES

In the earlier part of the Holocene a narrow coastal barrier was pushed landward by the encroaching sea, but around 3000 B.C. this movement came to an end and from then on new coastal barriers were formed on the sea side of the older ones, separated from these by strand flats. Rather low dunes (the Older Dunes, not higher than 10 m (33 ft.)) were formed on the barriers; in the fossil strand peat formation began when the groundwater reached the surface. The coastal aggradation was a rapid process. A belt of barriers of *c.* 6 km (4 miles) width was formed during the Subboreal and the process continued probably during the early Subatlantic. In Roman times the coastline lay some kilometres farther to the west than at present. The causes of the change in coastal processes at about 3000 B.C. are still rather obscure. The decrease in the rise of the sea-level is certainly one factor in this, but another must be the increase in the amount of sand available at the coast, either derived from the North Sea bottom (changed current patterns) or from the rivers, or both. The same factors must have played a role in the coastal degradation after the Roman period, which resulted in a smoothing of the coastline and the formation of the Younger Dunes.

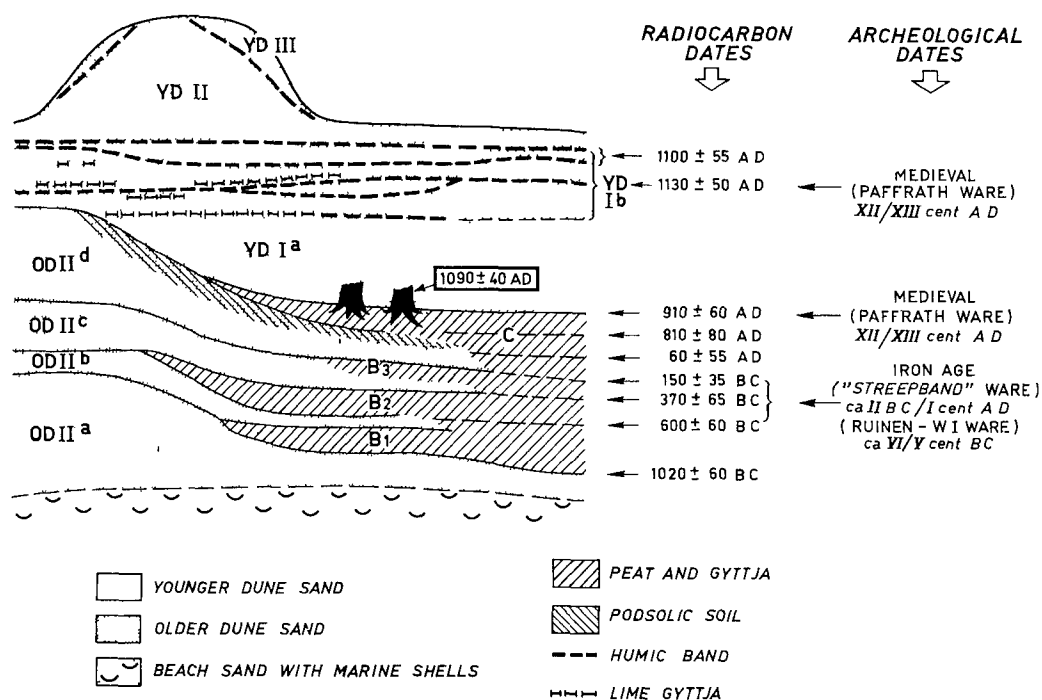


Fig. 53. Schematic representation of the succession of wind-blown sands, peat and soil formations in the dune area south-west of Haarlem. After S. Jelgersma and J. F. van Regteren Altena, *Geologie en Mijnbouw*, 48 (1969), 339.

The coastal barrier belt was broken into sections by some wide inlets at the mouths of the main rivers, where curved spits were formed. The coastline itself must have been rather open with a low halophytic vegetation, but the rows of Older Dunes further inland were covered with a deciduous forest, in which the oak dominated. On the peat-covered strand flats alder brushwood was found.

The dunes formed an attractive landscape for settlement. The main rivers and the levee deposits along their banks formed the routes through the immense peat bogs, by which they were accessible from the sandy hinterland.

The conditions for archaeological research are widely different within the district. Much has gone, since the dense present-day occupation is concentrated on the same dunes; the bulb fields were made (i.e. levelled and dug) on these sands before the time of archaeological interest. Most organic material decayed, because of the position of most culture layers well above the ground water table. But prehistoric sites can, on the other hand, have been beautifully preserved, when covered with wind-blown sand, and at low points conditions for preservation can be favourable, as in the Velsen area, excavated by J. F. van Regteren Altena. These sites enable us to sketch the following picture.

Traces of coastal occupation from the period before 3000 B.C. are irretrievably lost. Only one isolated axe might belong to the period 3000–2400 B.C. Our picture of the occupation starts with some Vlaardingen settlements on the dunes of the oldest barrier. These were already covered with forest, and the actual coastline lay 2 km (1.3 miles) farther west. This seems to be characteristic for all coastal occupation: there are no settlements known from the actual coastlines. Nor are they to be expected there, and if any were ever present there is little chance that their remains were preserved in that unstable environment. I will not go into detail about the subsistence economy in these settlements. At all sites cattle raising was most important in all periods, with pigs and sheep in widely varying ratios in the second and third positions. Hunting, especially of roe deer and red deer, was of minor importance in the Neolithic and early Bronze Age, and of no importance at all in the Iron Age and later.

The geological history is documented in the stratigraphy of the Older Dunes. A sequence of wind-blown sands has been observed, separated by soil profiles, peat or gyttja layers, that represent dormant phases, well-dated by a great number of C14 dates and by domestic refuse of prehistoric settlements.

The three oldest 'A' levels are only present in the older, eastern parts of the dunes and correlated with Vlaardingen—All Over Cord Beaker, Late Bell Beaker—Early Bronze Age, and Middle Bronze Age material respectively. The two lower 'B' levels contain Late Bronze Age sherds (1000–700 B.C.) and Middle Iron Age pottery (Ruinen/Wommels I–III ware, 600–450 B.C.). The upper B-level was formed before Roman times.

From this it seems preferable to speak of continuous occupation in spite of short breaks. The periods of sand displacement, although dominating the sections, were relatively brief. It seems best to infer continuous occupation, interrupted by intervals of one or two centuries of general dune formation. The sequence is in fact one of periods with a high ground water table, a vegetational cover and human occupation, alternating with periods with a lower ground water level, destruction of vegetation and a lack of archaeological finds, which in view of the environmental situation, is of no great surprise. There seems to be a correlation with the

transgression cycles in a general sense. Does this mean that the marine sequence is governed by a climatic sequence? One can only answer in the affirmative when one can prove that the groundwater changes in the dunes, reflecting variations in the precipitation–evaporation ratio, are caused by natural processes. But prehistoric and early historic man seems to have played an important role, by his deforestation, grazing of cattle and other agricultural activities. In a dune landscape, covered by a natural vegetation, minor variations in precipitation would not have been disastrous. But the dunes are a vulnerable district and, when the vegetation is disturbed, dune formation is easily started. In this way man may have had a considerable influence on the occurrence of phases of dune formation, and especially in later prehistory and early history when more extensive areas were occupied and cultivated. I estimate human influence on this process before the Iron Age to be very low.

With regard to the transgression/regression cycles it is suggested that the coastal inlets might have been (partially) blocked by wind-blown sand during a phase of dune formation and that this might be a cause of the start of a regression phase, which is, in fact, primarily a restriction of marine ingressions into the intracoastal area. This explanation cannot be applied, however, to the occurrence of transgression/regression cycles along other coasts.

Summarising all data and considerations, I think we can state that the cyclicity in the dunes is primarily the result of variations in precipitation, while in later prehistory and early history the effect will have been enlarged as a result of human destruction of the natural vegetation. The same climatic changes are responsible for the transgression/regression cycles, with a higher storm and stormflood frequency and a higher precipitation in the transgression phases.

References: Glasbergen and Addink-Samplonius 1965; Glasbergen *et al.* 1967–8; Jelgersma and van Regteren Altena 1969; Jelgersma *et al.* 1970; Modderman 1960–1; van Straaten 1965; Zagwijn 1965.

5. WESTFRISIA — BRONZE AGE OCCUPATION ON SALT MARSH DEPOSITS 1300–700 B.C.

The district of Westfrisia is built up of salt marsh and creek deposits, that were formed during the transgressive phases Calais IV and Dunkirk O in a system of tidal creeks, all connected with a main sea-arm, which had penetrated far inland behind the inlet in the belt of coastal barriers near Egmond. These sediments were deposited up to a relatively very high level, and can be ascribed to an elevation of high waters in this system, especially when the minor creeks were blocked at the beginning of the sedimentation phase. Bronze Age remains (barrows) were already known in 1942, and later settlements from the same age were discovered during the soil survey by Ente (1963). New discoveries since that time demonstrated the richness of the region in this respect, but this has been threatened in recent years by a large scale reallocation. Extensive fieldwork and excavations were carried out by the Institute for Pre- and Protohistory, Amsterdam, and by the State Service for Archaeological Investigations. Amersfoort: a survey ('Landssaufnahme') of 3600 ha (8700 acres) was made, an 18 ha (45 acres) excavation completed near Bovenkarspel and a monument of 70 ha (175 acres)

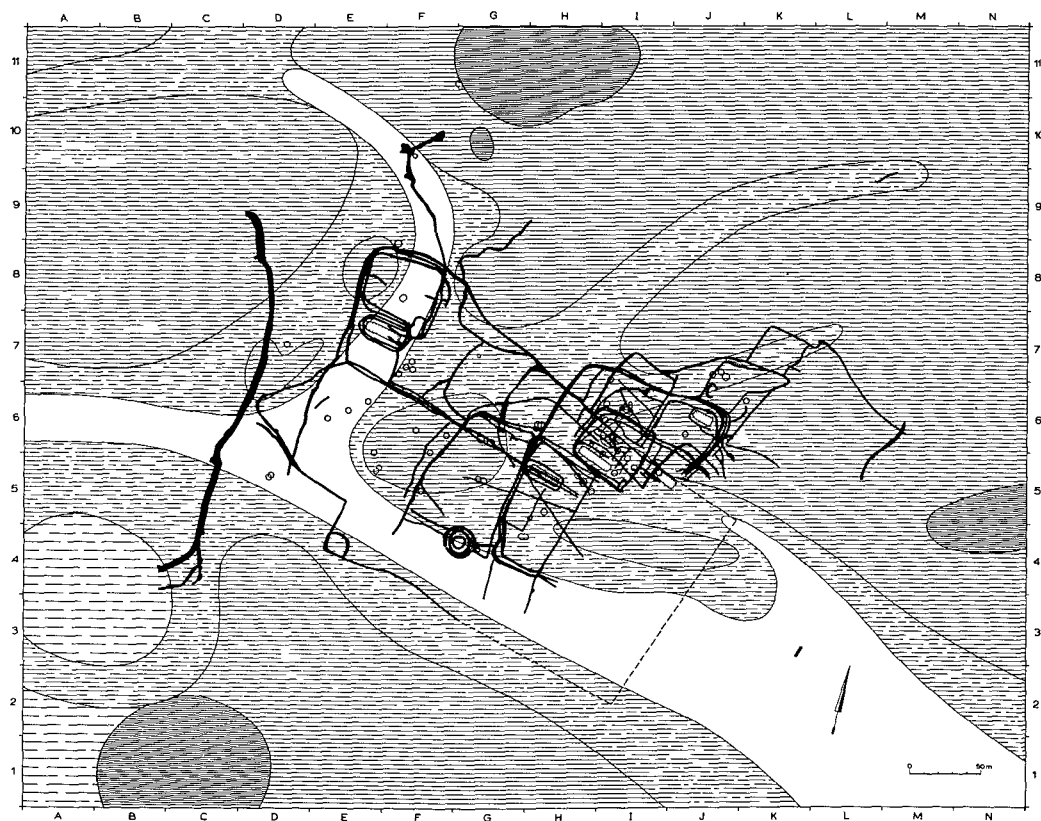











Fig. 54. Hoogkarspel-Watertower, Westfrisia. Idealised excavation plan, projected on the soil map, showing numerous successive ditch systems in close relationship to the soil conditions. The settlement, dated c. 1000 B.C., comprised probably one or two farmyards, rebuilt from time to time during the occupation, which itself lasted a few centuries. After J. A. Bakker *et al.* 1977.

-  sand
-  sandy clay
-  sandy clay or clay
-  clay or sandy clay
-  clay
-  housesite
-  main ditches and drains
-  granary drains
-  largest possible extent of one holding

saved from destruction. A fairly complete picture of Bronze Age Westfrisia has been obtained.

There are a few beaker settlements on deposits of Calais IV^a—age to the west of the district proper: Aartswoud (zigzag beaker, c. 2100 B.C.) and Oostwoud (Early Bell Beaker, c. 1900 B.C.). Bronze Age occupation concentrated more to the east, in the higher part of the region, and started not before 1300 B.C. The inlet at Egmond was probably narrowed or even closed at that time, and drainage conditions in eastern Westfrisia improved. Moreover, a change to freshwater conditions took place and an initial compaction, resulting in a landscape with a very low (less than 1 m (3 ft.) relief. The fields, measuring $\frac{1}{4}$ –1 ha ($\frac{1}{2}$ –2½ acres) were laid out on the sandy creek ridges (the main ones were more than 100 m (330 ft.) wide) and were surrounded by ditch systems which were frequently cleaned and altered. They were not very deep and had a drainage function only in times of a high water table. These fields were ploughed with the *ard*, as is revealed by extensive plough marks. The farms were built next to the fields, high on the flanks of the ridges. Some dozens of house plans are known, all of the three-aisled type, measuring, on average, 25 m (80 ft.), with a maximum width of 6 m (20 ft.). In one half, cattle stalls are presumed by analogy with similar houses at Elp, but they were not preserved. Most houses were surrounded by a ditch, to give better drainage to the yard in the wet season. In the lower terrain, vegetation had changed only slightly: treeless natural pasture lands were available for grazing, with lakes at the lowest places. Numerous small circular ditches and rings of pits mark places where most probably fodder, such as marsh-hay or straw, was stored, or perhaps even the harvest. No traces of wooden granaries were found. The expensive timber for the houses must have been brought from a great distance.

Permanent settlement and a fully agrarian, self-supporting economy seem evident. Cattle, a small breed, are represented by c. 75% in the refuse and were most important, with sheep second and pigs third. Grain (Emmer wheat and Six-row barley) and flax were grown. Some shellfish were collected at some distance in the tidal area. An occasional wild animal (elk, red deer, beaver, otter and others) was killed; these might have accidentally wandered into the area, or have been hunted elsewhere.

A Middle Bronze Age occupation phase, dated between 1300 and 1000 B.C. and characterised by simple, bucket-shaped pottery, can be separated from a Late Bronze Age phase between 850 and 700 B.C. No cause for this occupation hiatus has yet been found. In this second phase groundwater conditions worsened. People retreated to the highest points of the area and raised the yards with soil, dug from systems of surrounding ditches, which at the same time improved drainage. But in due course, as the sea-level and also the water table continued to rise, the land proved to be too low and, especially, too wet for cultivation and the raising of a yearly crop.

References: Bakker *et al.* 1959–68; Bakker *et al.* 1977; Buurman and Pals 1974; Clason 1967; Ente 1963; van Giffen 1944; van Giffen 1961; Modderman 1964; Modderman 1974; van Regteren Altena 1976; van Regteren Altena *et al.* 1977.

6. THE 'TERPEN' DISTRICT OF GRONINGEN AND FRIESLAND — IRON AGE AND
LATER OCCUPATION OF SALT MARSHES, 500 B.C.—A.D. 1000

As a result of the progressive decrease in the rise of sea-level the salt marshes of the end of the Dunkirk I transgressive phase were the first that ceased to be marshy shortly after their formation. No peat cover was formed. This must be the main reason for the occupation of the northern coastal district starting at this time, i.e. about 500 B.C. In the first half of the Iron Age settlements were founded on the higher, sandier, and better drained ridges (the marsh bars) and creek (curs.) levees, in Groningen as well as Friesland. It has been asked where the colonists came from, and why they left their regions of origin. Waterbolk demonstrated that in this phase the conditions for agriculture on the Drenthe plateau deteriorated; the Celtic field systems suffered from wind erosion, although this now appears not to have been in such a catastrophic sense as was originally suggested. The pottery of the oldest marsh settlements is similar to that of the settlements in the sand district: the Ruinen-Wommels I/II ware of the Zeijen culture. The region of origin of some others might have been Westfrisia, which became uninhabitable just prior to this period.

The marshes lay in a relatively protected situation, behind extensive tidal flats, which very probably were separated from the open sea by a row of barrier islands, very similar to the present geography. Palaeobotanic research has revealed that the vegetation was entirely halophytic, with *Salicornia maritima* and *Juncus gerardii* as the dominant plants, which indicates regular, but non-destructive, floodings. The rushes offered rich, natural pasture lands: cattle breeding was the main activity, to provide milk, meat, hides and tractive power. Sheep were second in importance in their livestock, and only a few pigs were kept. This sheep/pig ratio is (as for earlier situations in Westfrisia) characteristic for the treeless landscape. Some hunting took place of aurochs, elk, bear, red deer and other animals, either on the wooded sands to the south, or whenever they wandered into the marsh district. Seals were caught along the coast. Crop cultivation was rather hazardous: barley, *Linum* (flax) and other crops, such as *Brassica campestris*, *Camelina sativa* and *Daucus carota* (carrot) could withstand the floodings, but no wheat and pulses could be grown.

The occupation certainly was permanent and the people self-supporting. Serious difficulties had to be overcome: apart from the adaptation of the agricultural system, there was the lack of water, fuel and timber. Rainwater was collected in small ponds, on top of artificial mounds (see below), and timber was found on the sands to the south where fuel could also be collected; otherwise dried dung could serve as fuel. The major limiting factor on occupation was not in the settlement itself, but in the possibilities of raising an annual crop and grazing cattle, on land not too frequently flooded with salt water.

Shortly after the first colonisation a new transgressive phase started (Dunkirk Ib¹), which, although of modest extent and not destructive, had its effect on the living conditions. Some settlements were left (Middlestum, Hatzum, Jemgum), at other sites people demonstrated their remarkable adaptability by the construction of the first *terpen*, artificial mounds of sods, on which the farms were built (Ezinga).

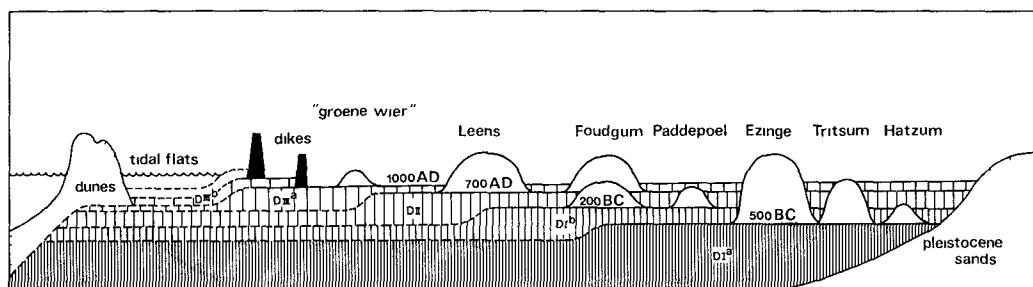


Fig. 55. Schematic north-south section through the Groningen *terpen* and salt marsh district, showing the successive marsh deposits, the shift of newly founded '*terpen*' northward and the extension or abandonment of the older ones. Redrawn after H. T. Waterbolk, in J. W. Boersma ed. 1970.

The formation of salt marshes continued, linked to the transgression/regression cycles. Four major phases can be distinguished, each followed by new colonisation of the slightly higher, fresh pasture lands on the seaward side of the old ones, and mark the beginning of a new generation of *terpen*. The older ones were raised and extended and sometimes fused, to make room for more houses and for crop cultivation on the slopes. But at the same time the oldest and lowest marshes, far inland, sometimes became too marshy. Settlements in the Roman period are known to have been abandoned for this reason at the end of the third century and subsequently covered by sediments (Paddepoel). The following general sequence of events in the northern coastal district can now be made out:

- (a) Dunkirk I^a salt marsh formation, followed by surface settlements on marsh bars and levees, dated by Ruinen/Wommels I/II pottery, 500 B.C.
- (b) Dunkirk I^{b1} transgressive sub-phase. Settlements are left or small initial *terpen* are constructed. Ruinen/Wommels III pottery of the 'protofrisian culture', 400–200 B.C. First generation of *terpen*.
- (c) A short regressive interval c. 200 B.C. with extension of occupation and start of second generation of *terpen* during the following Dunkirk I^{b2} transgressive subphase. '*Streepband* pottery' of the Frisian Culture, with its continuation into Roman times.
- (d) Friesland and Groningen were not occupied by the Romans, but there existed trade relationships with the Roman provinces south of the Rhine. In the following centuries the sequence of events is rather obscure. Occupation continued during the Dunkirk II transgressive phase, but in view of the modest number of finds there may have been a decrease in population.
- (e) A third generation of *terpen* was founded on the Dunkirk II marshes after c. A.D. 700.
- (f) Shortly before the embankments started some small *terpen* were raised on Dunkirk III^a marshes: a fourth generation. But the embankment of the salt marsh area made further raising and extension of the *terpen* unnecessary. Their growth stopped and farms were founded on the surface of the flat country, near their fields.

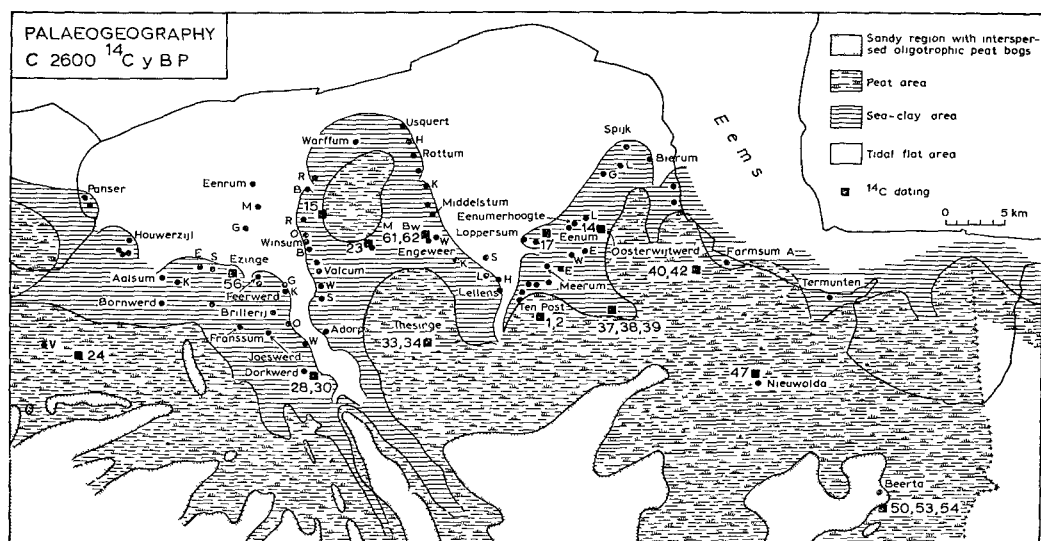


Fig. 56. Palaeogeographic map of the Groningen coastal area shortly after the Dunkirk I^a phase of salt marsh formation and the first colonisation of the fresh deposits by the farmers of the 'proto-Irisian' culture, who shortly afterwards must have built the first *terpen*. After W. Roeleveld 1974 (fig. 63).

References: Boeles 1951; Boersma 1970; van Es 1968; van Giffen 1936; van Giffen 1940; Roeleveld 1974; Waterbolk 1965-6; van Zeist 1974.

7. THE OCCUPATION SEQUENCE IN THE WESTERN NETHERLANDS AFTER THE ROMAN PERIOD

In the Roman period a widespread occupation took place over the whole of the western Netherlands (the peat districts excepted), and also on the barriers. At the end of the third century there was a sharp decline in number of sites, which certainly reflects a decline in population, but the lack of datable (imported) material may be partly responsible for this impression. From the fifth and sixth centuries no finds at all are known and the population must have been very thin, or even absent, but from the end of the sixth century onward the number of finds and sites increases.








The oldest are situated at the mouths of the rivers Scheldt (Domburg), Meuse (Naaldwijk, *Monster inter alia*) and Rhine (Rijnsburg, *inter alia*). The main reason for this occupation hiatus was formerly found in the transgression phase Dunkirk II, but it appears that many of the deposits dated to this phase are in fact later (Dunkirk III^a), since twelfth-century house sites were found below these clays at several points. So political reasons and an economic collapse after the Roman departure are now considered to be a better explanation and a major cause.

From the Carolingian period onwards a steady increase in the number of sites













Fig. 57. Geological map of the coastal area between Leiden and Rotterdam and its Roman occupation. Scale 1:200.000. After Bloemers 1978.

Geology

-  channel deposits, marine and fluvial, post-Roman
-  tidal flat deposits, marine, and bank deposits, fluvial, pre-Roman
-  channel deposits marine and fluvial, pre-Roman
-  Holland Peat, mainly excavated
-  Older Dune and Beach Sands
-  waters, some of which were present in the Roman period
-  modern built-up area

Archaeology

-  Roman fort
-  Civitas capital
-  settlement, mainly finds of Roman material
-  settlement, finds of Roman and native-Roman material
-  settlement, mainly finds of native-Roman material
-  site, c. five finds or less, Roman material
-  id. Roman and native-Roman material
-  id. native-Roman material
-  Roman cemetery
-  location uncertain

reflects a rapidly growing population. The colonisation and reclamation of areas, unoccupied for centuries or even millennia, as in the case of the peat districts, was stimulated for political reasons by the Count of Holland and the Bishop of Utrecht and in the thirteenth century practically the whole of Holland was taken into (agricultural) use, embanked and artificially drained in a modest way. From this time onwards a sequence developed of improved drainage, raised embankments, and an increased danger of flooding. The natural equilibrium was broken. Transgression phases are obscured by other phenomena, such as the quality of the maintenance of the dykes, the sedimentation along the rivers between the dykes and the raising of floods between the embanked sea arms.

In the south-west, the province of Zeeland, the greater part of the peat district was destroyed by the sea between the Roman period and the eleventh century. Only minor parts of the 'old landscape' are preserved in the central parts of some of the islands, which came into existence by the embankment of fresh salt marsh deposits. A similar, and even more complete, destruction took place in the same period in the northern part of Holland. It may not be accidental that in both districts the belt of coastal barriers curved farthest seaward, while we know from the Holland Older Dunes landscape that in this period coastal degradation took place, resulting in a straightening of the coastline.

In the dune landscape occupation started again after the hiatus of the fifth and sixth centuries. This is confirmed by pollen diagrams, which show a complete vegetation recovery of the dunes, followed by fresh reclamations gradually leading to a disappearance of the forest vegetation. This might be one of the causes of the formation of the Younger Dunes.

The main cause must, however, be a change in coastal processes (a change of the currents?), resulting in the degradation mentioned above and the straightening of the coast, so making available the huge quantities of sand, from which the Younger Dunes were formed. These changes must have started sometime between the fourth and twelfth century A.D., since sherds dating from the twelfth century were found in a fossil arable land over which the sands of the oldest phase of the Younger Dunes was blown. Where these dunes were blown landward, habitation and agriculture became impossible, and people had to retreat landward.

References: Besteman 1974a; Besteman 1974b; Bloemers 1978; Jelgersma *et al.* 1970; Sarfatij 1971; Trimpe Burger 1973.

*I am indebted to Miss Linda Whitaker for struggling with the original English text. MS. closed May 1978.

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