After the deluge, a palaeogeographical reconstruction of bronze age West-Frisia (2000-800 BC)

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2 The history of landscape research in West-Frisia

2.1. Introduction

The soil map of *De Streek*, constructed by Ente (1963) in the early sixties of the nineteenth century, is used as a solid base for present day policy documents for eastern West-Frisia (De Boer and Molenaar 2006). This soil map has been of great influence on the ideas about the genesis and habitation history of the West-Frisian landscape, as mentioned in the previous chapter. In order to understand the strong influence of a soil map on our thinking over the landscape and its habitation, it is important to be aware of the history of its construction and the history of landscape research in West-Frisia in general. Therefore this chapter is dedicated to the history of landscape research in West-Frisia.

Paragraph 2.2 deals with the development of soil science of alluvial sediments in The Netherlands. This is of importance to understand the Dutch focus on coring as the most important technique for landscape research. The following paragraph 2.3 describes the development of landscape research in West-Frisia just after World War II, a period which is characterized by thorough and fundamental landscape research. The ideas developed in this period are reflected in the present day soil, geological and geomorphological maps. Although the ideas on landscape genesis have largely changed (Vos 2015, 8-10), new maps are not (yet) available. In order to understand the compilation of the available datasets, the

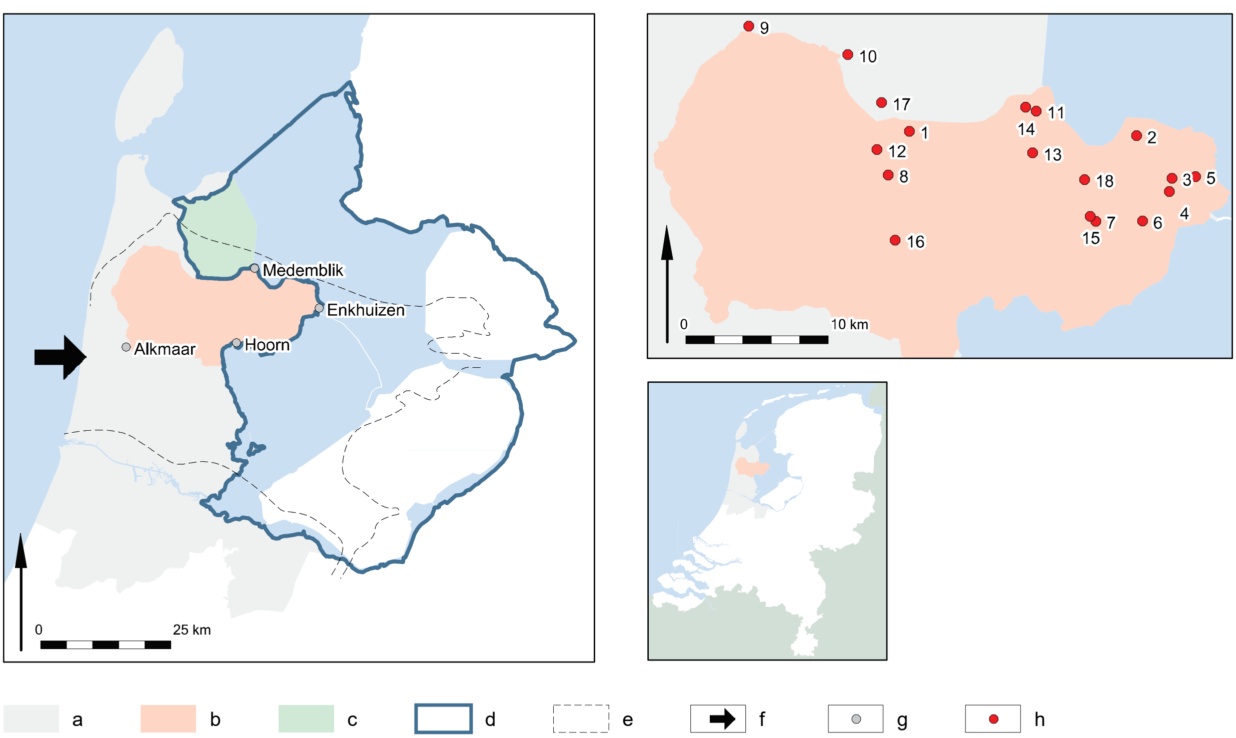


Figure 2.1: Topography and sites mentioned in text. Legend: a Province of North-Holland, b West-Frisa, c Wieringermeer, d former Zuiderzee, e maximum size of Bergen tidal basin, f Bergen inlet, g cities, h sites: 1 Aartswoud, 2 Andijk, 3 Bovenkarspel-Het Valkje, 4 Bovenkarspel-Monument, 5 Enkhuizen-Kadijken, 6 Grootebroek, 7 Hoogkarspel, 8 Hoogwoud, 9 Keinsmerbrug, 10 Kolhorn, 11 Medemblik-Schepenwijk, 12 Mienakker, 13 Oostwoud, 14 Opperdoes-Markerwaardweg, 15 Westwoud II (Noorderboekert), 16 Zandwerven, 17 Zeewijk, 18 Zwaagdijk.

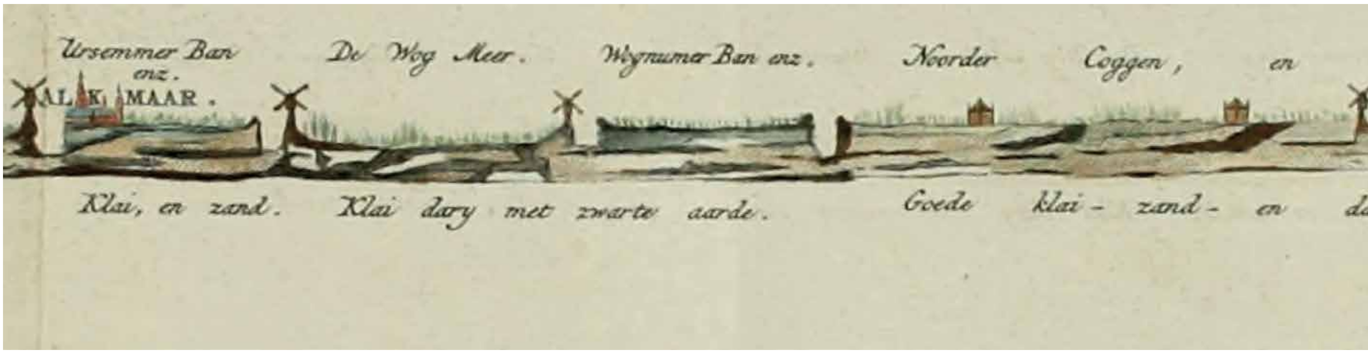


Figure 2.2: Part of a cross-section of West-Frisia as published by Le Franq van Berkhey (1771, plaat III).

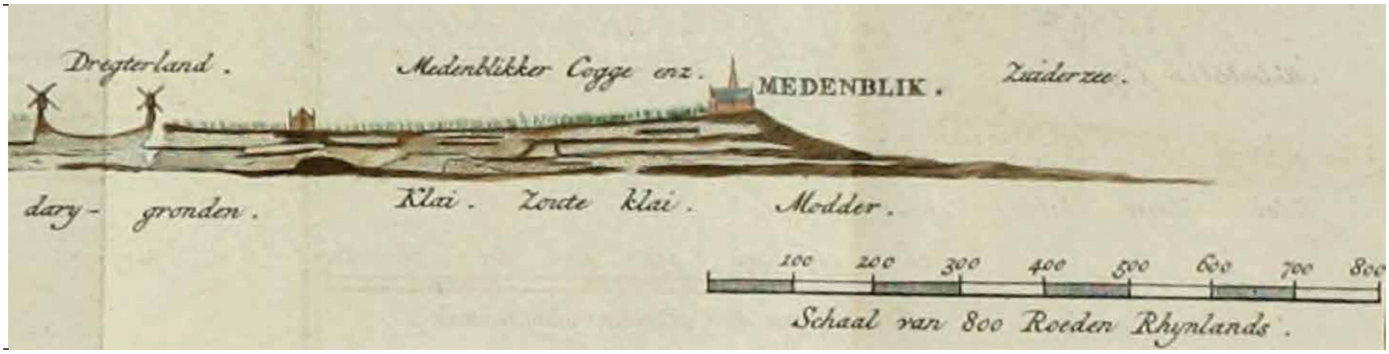
period of land consolidation projects is described in paragraph 2.4. In this period an enormous database of soil sections and a large archaeological database have been created, a treasure chest which we still profit from today. In paragraphs 2.5 to 2.7 the scientific result of the previous research is presented. In these paragraphs, the models for the genesis of the landscape, habitation and palaeogeography are critically evaluated. The last paragraph (2.8) deals with the results of post-Valletta archaeology. The results of this post-Valletta research differ from the results of the previous period and present arguments for the need of a new palaeogeographical model for West-Frisia. In figure 2.1 the topography mentioned in this chapter is depicted.

2.2. Prelude

During the 18th century geology and biology still had to be invented (Zagwijn 2004, 30). Scholars in this century were unaware of geological time (Zagwijn 2004, 27). In this period the Dutch naturalist Johannes Le Franq van Berkhey studied the origin of Holland. Between 1769 and 1811 he published in six volumes his lifework "*Natuurlyke Historie van Holland*" (the natural history of the western part of the Netherlands). In this study a broad variety of topics is dealt with, geography and climate, the deposits and mineral resources, inhabitants of Holland and animals. The second volume on the deposits and mineral resources is partly based on research in sand quarries, gravel pits and descriptions of corings up to 5 meters below the surface (Le Franq van Berkhey 1771). Many of these corings were carried out by the author himself, however he also used archived descriptions of soil sections and corings. Unique in his work is the detailed description of a soil section of approximately 10 meters in a sandpit in the dunes near Katwijk and the description of a coring in the centre of Amsterdam to a depth of approximately 72 meters below the surface carried out in 1605. In the publication a cross-section of North-Holland including West-Frisia is presented (figure 2.2). In the description of the cross-section the interpretation of the different layers is based on observations by the author of the existing landscape. This uniformitarianistic interpretation is quite modern for the 18th century. With this interpretation Le Franq van Berkhey implied successive changes of the landscape in the past. Therefore the publication of this cross-section marks the start of the palaeogeographical research of West-Frisia.

In the 19th century, amongst others, the disciplines of biology, geology and soil science developed (Zagwijn 2004, 30). In 1813 the first geological map of the Netherlands was compiled by d'Omalius d'Halloy and published in 1822 (d'Omalius d'Halloy 1822). In this map, the Netherlands is depicted as a single unit: "*terrains mastozootiques*". This unit represents all the sediments from the later defined Tertiary and Quaternary. Between 1858 and 1867 Staring published a geological map of the Netherlands at scale 1:200.000 (Faase 2004, 129). In this map the Quaternary sediments were subdivided into 21 units. The marine clays and marine sands of West-Frisia are depicted in this map. In the same period Staring published his magnum opus "*De bodem van Nederland*" (The soil of the Netherlands; Staring 1856; Staring 1860). The publication of Staring and the geological map are generally accepted as the start of modern geology in the Netherlands (Zagwijn 2004, 5).

In the first part of the 20th century large parts of the Netherlands were mapped in detail. In 1918 the Geological Survey was established by the government. This service was established in order to



map the geology of the Netherlands at scale 1:50:000 which was almost finished by the end of the project more than 30 years later in 1951 (Faasse 2002, 62). Shortly after the Geological Survey started with the construction of a second series of geological maps at the scale of 1:50.000 which has never been finished. West-Frisia is only partly mapped in this second series (Westerhoff *et al.* 1987).

In the nineteen thirties Oosting developed a modern approach in soil mapping (Oosting 1936). In this method principles from geology, geomorphology, topography, hydrology and archaeology were combined (Hartemink and Sonneveld 2013, 2). Field observations obtained with hand auger equipment constituted the basis for the construction of soil maps. Oosting (1936) applied his method in a relatively small area. After the draining of the Wieringermeer, the first of a series of polders in the former Zuiderzee bordering the northeast part of West-Frisia, the soil scientist Zuur mapped this area using Oosting's method (Zuur 1936). Zuur (1936) systematically mapped this considerable area with a regular grid of corings. In his publication he used the information gathered for an analysis of the genesis of the landscape and an analysis of the soil properties to investigate the optimal use for agriculture of the drained parcels. This approach follows the tradition started by Staring, who stated that: *"…men dient niet te vergeten, dat geologische kennis de agronomische dient vooraf te gaan, dat deze een uitvloeisel is van gene en als 't ware hare toepassing op de praktijk (*Staring 1856, 9)*."*[1] Oosting's method (1936) and the strategy used by Zuur (1936) was followed by other soil scientists and brought to perfection under the direction of Edelman.

1 "…one shouldn't forget that knowledge of geology precedes the knowledge of agronomy, agronomy is a consequence of geology and can be considered as its practical use."

2.3. Pioneers

During World War II Edelman started mapping the soil of the Bommelerwaard, an area in the Rhine-Meuse valley, inspired by the work of, amongst others, Oosting (Edelman 1950, 4). Shortly after, he was followed by several colleagues in other regions. Soil maps constructed in this period, proved to be very useful for agricultural purposes. In 1945 Edelman founded Stiboka in order to construct various soil maps for the Netherlands. Stiboka proved to be a very successful organization, national as well as international. The success of Stiboka was partly due to the timing of its foundation. The last winter of World War II ended in a famine due to food shortages. The first task of Sicco Mansholt, the newly appointed minister of Agriculture, Fishery and Food supply after World War II, was to restore the food production and food supply. Therefore Mansholt presented a plan to stimulate the modernization of Dutch agriculture in order to achieve a self-sufficient food producing economy (Van den Bergh 2004, 48). In his opinion it was necessary to execute an extensive program of land consolidation in combination with up-scaling and soil improvement to achieve this goal. Soil maps were needed to execute this ambitious program. Therefore, in 1952 Stiboka was asked to provide a soil map for the Netherlands at a scale of 1:25.000. This scale appeared to be far too ambitious for the small organization of Stiboka and soon it was changed to a scale 1:50.000. The work of Stiboka provided an avalanche of data and publications on the origin of the Dutch subsoil. Many dissertations, monographs and articles were published using Stiboka's data. The first publication presenting an overview of the genesis of the province of North-Holland including West-Frisia based on these data is the publication by Pons and Wiggers (1959/1960), both leading soil scientists of Stiboka.

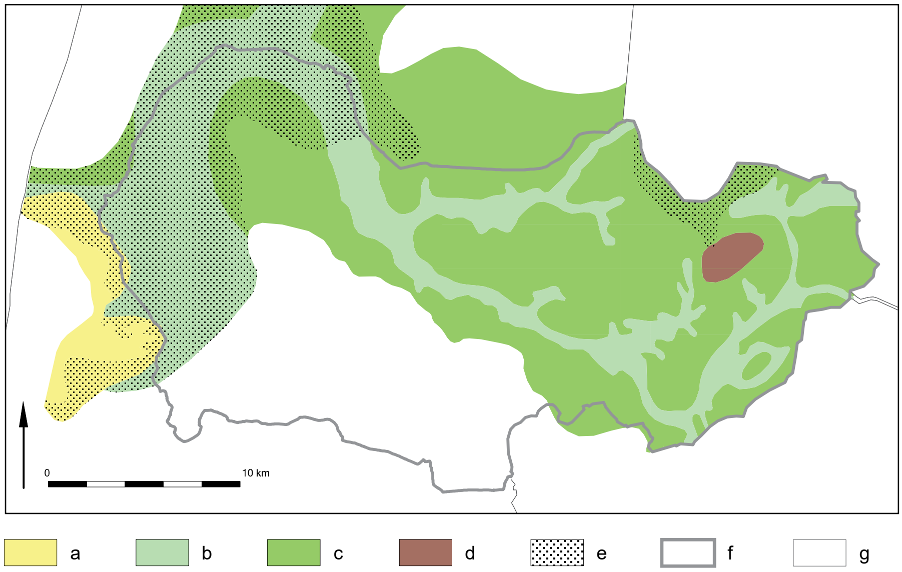


Figure 2.3: The distribution of the Westfrisian deposits in the Bergen tidal basin (After: Pons and Van Oosten 1974, 27, figure 15). Legend: a coastal dunes b mud flat deposits, c tidal marsh and fen deposits, d fen deposits, e Westfrisian deposits covered by younger deposits, f West-Frisia, g North-Holland.

In this publication Pons and Wiggers (1959/1960) present a compendium of the previously published data. A complicating factor to summarize the data was the absence of a neat stratigraphical framework at that time. In their work they put a lot of effort into combining all the available data in a single stratigraphical framework for the province of North-Holland. Pons and Wiggers (1959/1960) reconstruct a tidal inlet near the present-day town of Bergen, the so-called Bergen tidal inlet. This tidal inlet unlocked the hinterland where marine sediments were deposited in a tidal basin, including West-Frisia. The younger marine sediments in this tidal basin are labeled as Wieringermeer and Westfrisian deposits. The Wieringermeer deposits are dated between 2900 BC and 2300/2200 BC, based on archaeological finds and a set of radiocarbon dates (Pons and Wiggers 1959, 152). The Westfrisian deposits are subdivided into Westfrisian deposits I and II and dated between 2100-1900 BC and 1600-1250 BC respectively (Pons and Wiggers 1960, 28). The authors distinguish three successive types of environments within the Wieringermeer and Westfrisian deposits: tidal flats, tidal marshes and fens (figure 2.3) (Pons and Wiggers 1959, 149). The tidal flats present a gradual change in salinity from west (salt) to east (light brackish), which is confirmed by the presence of certain types of molluscs, foraminifera and ostracods (Pons and Wiggers 1959, 150). The tidal flats are situated along a broad (app. 100 m) and deep (app. 15 m) tidal channel (Pons and Wiggers 1959, 150). The sediments of the tidal marshes are characterized by a higher percentage of lutum and decalcification (Pons and Wiggers 1959, 135). The tidal marshes, as well as the fens, are intersected by creeks. The fens are characterized by unconsolidated or partly consolidated clay with reed remnants and thin layers of peat. The foraminifera in these sediments represent a brackish environment changing over time into an environment with less available oxygen and less influence of the sea (Pons and Wiggers 1959, 150). Due to relief inversion the former tidal channels are well visible in the landscape as creek ridges. Away from the influence of the sea, bogs developed represented by peat layers. After the closure of the Bergen inlet the bogs expanded rapidly over the fens, tidal marshes and tidal flats.

Apart from soil scientists and geologists, archaeologists also conducted research into the origin of the subsoil. In Dutch archaeology a tradition of bio-archaeological research had been developed before World War II by Van Giffen. In 1942 Van Giffen excavated a barrow near Zwaagdijk (Van Giffen 1944). After the excavation several soil samples were examined on his request for pollen, foraminifera, ostracods and diatoms. The results turned out to be as expected. The base of the soil had been formed in a salt to brackish marine environment gradually developing towards a freshwater environment at the top on which the barrow had been constructed. The soil sample on top of the infill of the ditch around the barrow turned out to be of anthropogenic origin (Van Giffen 1944, 177-182). In 1947 Van Giffen conducted an excavation of a barrow in Grootebroek (Van Giffen 1953; Van Giffen 1954). This time

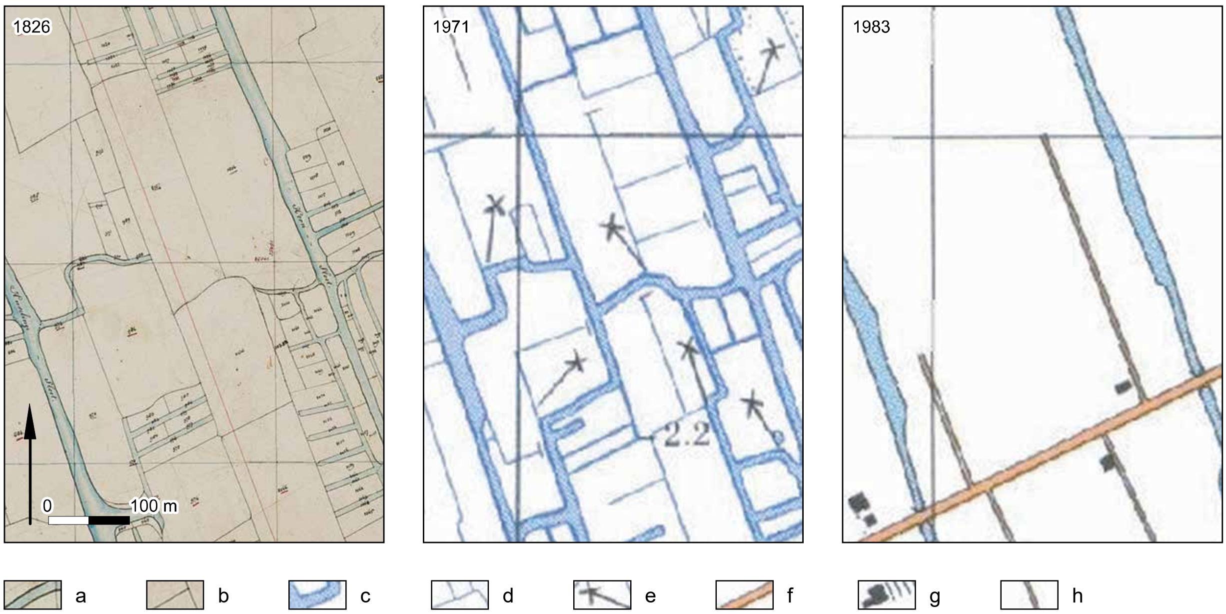


Figure 2.4: Topography of a parcel in the community of Andijk, situation in 1826 (left) 1971 (middle) and 1983 (right). Legend: a canal, b legal boundary or ditch, c canal, d ditch, e windmill, f road, g building and greenhouses, h dirt road.

he sampled the soil section underneath the barrow stratigraphically for pollen, ostracods, foraminifera, diatoms and molluscs. The foraminifera samples suggested a gradual change from a salt/brackish environment towards a light brackisch environment (Van Giffen 1954, 114). Van Giffen interprets this as a change from a tidal flat into a tidal marsh (Van Giffen 1953, 40). In the supplements Van Voorthuysen (the geologist involved in the project) suggests, based on this single analysis, a regional change of a transgression into a regression which is not adopted by Van Giffen. It demonstrates the different approach and scale between both disciplines, a topic which will be addressed in chapter 4. Van Giffen concludes his excavation report with an observation on the relative height of the present day surface level. He wonders why the present day surface level is almost the same as the surface level during the Bronze Age, approximately 150/170 cm -OD. He assumes that the present day surface level should equal mean high water (MHW). Subsidence due to drainage can explain a surface height under MHW as observed at many other places. However, it does not explain why the Bronze Age surface is situated more or less at the present day surface. He concludes the article with the comment:

> *"Het is dus zonder nader in te gaan op dit probleem, wel duidelijk, hoezeer het gewenst is het begonnen onderzoek voort te zetten (Van Giffen 1953, 40)."* [2]

This remark is the start of a perennial debate on the existence of a peat cover in West-Frisia in an attempt to explain this peculiar phenomenon.

2.4. Land consolidation

Many excavations would follow that of Van Giffen (1953) due to rapid intensifying of agriculture preceded by land consolidation. Land consolidation is an instrument for improving the agrarian sector. From 1850 until 1922 the agrarian sector in the Netherlands flourished. Innovation and export thrived. Small farms were especially successful in this period. In 1922 the world market was flooded by cheap cereals from Canada and the United States and dairy products from Australia and New Zealand. This situation lead to a crisis in Dutch agriculture. The government reacted with several laws to facilitate and improve the agrarian sector. One of these laws was the Land Consolidation Act which was accepted by parliament in 1924 (Van den Bergh 2004, 25-36). In advance of land consolidation projects, soil maps

2 "Without going into detail, additional research is obviously needed."

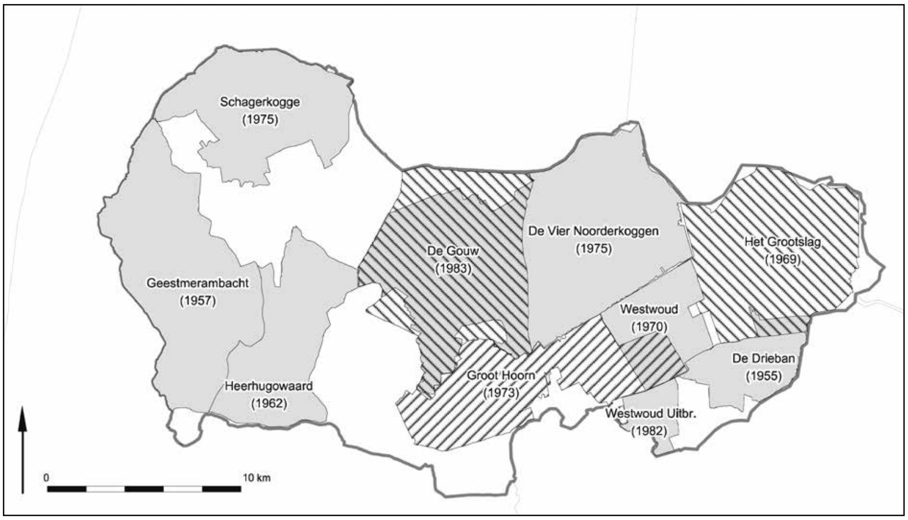


Figure 2.5: Overview of published soil maps within the framework of land consolidation projects in West-Frisia. The soil maps of De Gouw, Het Grootslag and Groot-Hoorn partially overlap earlier published soil maps.

Land consolidation area	Year	Area (ha.)	Soil map
De Drieban	1955	± 1865	Du Burck 1955
Geestmerambacht	1957	± 6601	Du Burck 1957
Heerhugowaard	1962	± 3893	Van den Hurk 1962
Het Grootslag	1969	± 6167	Ente 1963
Westwoud	1970	± 2203	Bles and Rutten 1972
Groot Hoorn	1973	± 4812	Bles and Steeghs 1973
Schagerkogge	1975	± 4472	Kleinsman, Stoffelsen and Van den Hurk 1975
De Vier Noorder Koggen	1975	± 11930	Du Burck and Dekker 1975
Westwoud uitbreiding	1982	± 706	Kiestra and Rutten 1982
De Gouw	1983	± 7057	Mulder, Van Berkum and Van Pruissen 1983

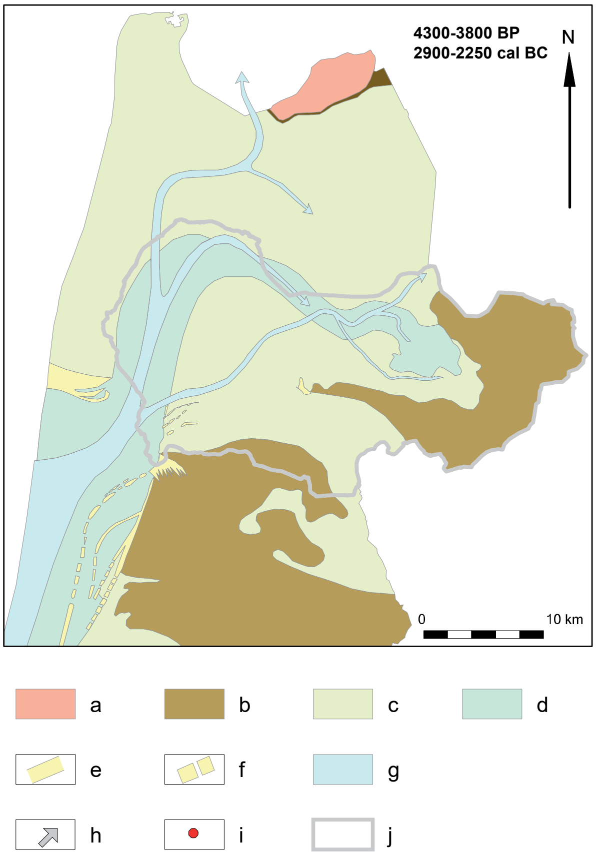
Table 2.1: Overview of published soil maps within the framework of land consolidation projects in West-Frisia.

were constructed in order to redistribute parcels fairly amongst the land owners. Therefore these projects resulted in series of detailed soil maps. In West-Frisia it would take until 1940 before the first project under this Act was effectuated (Van den Bergh 2004, 208).

Improvements for a more efficient agricultural system were strongly needed in West-Frisia. Parcels belonging to a single farm were small, scattered over large areas and only accessible by boat (Ente 1963, 3). The last large scale improvements in this area dated from the Dutch Golden Age (16th and 17th century). During this period the economy flourished, lakes were drained and the overall drainage was improved by an ingenious system of windmills, spill-ways and sluices (Borger 1975, 21). Only small scale changes in land division can be seen in topographical maps from the 18th century onwards until the period of land consolidation projects (figure 2.4).

The first small scale project in West-Frisia was carried out in 1940 (Van den Bergh 2004, 208). The area affected by this project was only 42 hectares. After World War II plans were made for extensive land consolidation programs in West-Frisia which were carried out between 1963 and 2012. To improve the efficiency of the individual farms in West-Frisia, one of the goals of the land consolidation projects was to transform the area in such a way that every parcel could be reached by motor vehicle (Ente 1963, 3). These projects covered almost the entire region (table 2.1 and figure 2.5). The impact on the subsoil was huge, old canals were (partly) filled, new canals were dug, parcels were leveled and extensive areas were ploughed up to a depth of 80 centimeters. On top of these physical disturbances of the subsoil, the mean groundwater level was lowered by one to two meters. Remarkably, soil scientists, not archaeologists, were the first to understand the implications for the archaeological archive of the intended activities (Oosting 1940).

After World War II soil surveys were undertaken by Stiboka prior to the land consolidation projects. The first soil maps, like for instance the soil map



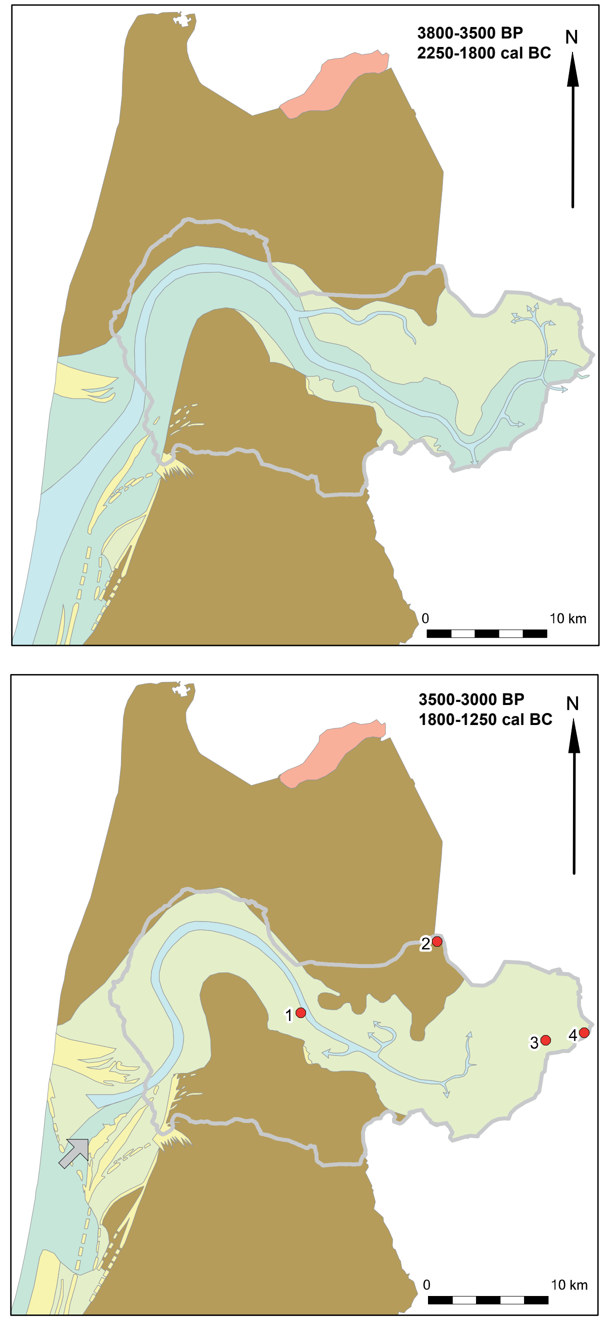


Figure 2.6: The palaeogeographical development of West-Frisia (After: De Mulder and Bosch 1982, 144-147, figure 20-22). Legend: a Pleistocene deposits at surface, no deposition of Holocene sediments, b Continuous peat growth and/or absence of clastic deposition, c end of clastic deposition and/or peat growth, d continuous marine sedimentation throughout the period, e beach barriers/sand ridges, f idem assumed, g orientation of the main tidal channel, h location of Bergen inlet, i settlement site (1 Hoogwoud, 2 Medemblik-Schepenwijk, 3 Bovenkarspel-Het Valkje, 4 Enkhuizen-Kadijken), j West-Frisia.

of the land consolidation area *De Drieban*, present the unit "*oude cultuurgronden*" (old cultivated soils) (Du Burck 1955). This unit represents deep humic soils originated by an intensive antropogenic use and includes settlement soils dating to the Bronze Age. The soil scientist Ente was aware of the presence of Bronze Age sites in West-Frisia due to the excavation reports by Van Giffen. He and his co-workers undertook the first systematic archaeological survey between 1953-1955 during the soil survey of the land consolidation project *Het Grootslag* (Ente 1963, 5-6). In his map he presents the unit "ancient settlement soils" which represent settlement sites dating to the Bronze Age or Iron Age (Ente 1963, 156-159).

In 1966 the first large scale excavation was conducted at the site *Hoogkarspel* in West-Frisia by archaeologists of the University of Amsterdam (IPP) (Bakker *et al.* 1977 188-189). The excavation revealed a well-preserved Bronze Age settlement site and several burial mounds just beneath the plough layer. It was only in this project when archaeologists began to realize the enormous impact on the archaeological archive of the upcoming land consolidation in this area (IJzereef and Van Regteren Altena 1991, 61). Alarmed by these finds and the expected destruction due to activities for soil improvement, the Dutch State Archaeological Service (ROB) started an intensive field survey and a first excavation in Andijk. Based on the survey and the experience during the excavation in Andijk, the State Service decided to excavate an area of 18 hectares in Bovenkarspel and to preserve a comparable area for future research (IJzereef and Van Regteren Altena 1991, 61-62). A synthesis of these excavations will be published by Roessingh (Roessingh in prep.). Articles and dissertations on the palaeobotany, palaeozoology and landscape were published relatively shortly after the end of the excavation of the Bronze Age settlement site *Opperdoes-Markerwaardweg* in 1985. This excavation was the last large scale excavation of a Bronze Age site in West-Frisia within the framework of a land consolidation project. It was assumed that little or no remains from the Bronze Age were left due to the soil improvements after such projects.

In the last large scale land consolidation project in West-Frisia, *De Gouw*, archaeologists focused on newly discovered well preserved Late Neolithic sites. Between 1979 and 1986 the Late Neolithic site of *Kolhorn* had been excavated by archaeologists of Groningen University (BAI; Van der Waals 1989). Based on the excavation results an archaeological survey was carried out between 1985 and 1986 in advance of the project (Manning and Van der Gaauw 1987). During this survey the traditional "*archäologische landsaufnahme*"[3] was combined with aerial photography and manual corings. Several new Late Neolithic sites were discovered leading to the excavations of *Keinsmerbrug* (1986), *Mienakker* (1990) and *Zeewijk* (1992-1994) (resp.: Smit *et al.* 2012; Kleijne *et al.* 2013; Theunissen *et al.* 2014). Other Late Neolithic sites were preserved for future research opportunities (Van Heeringen and Theunissen 2001, 43-44). With the completion of *De Gouw* in 2012 the period of large scale land consolidation projects in West-Frisia came officially to an end.

3 An "*archäologische Landesaufnahme*" is a regional field survey consisting of a desktop study, inventory of collections and systematic field walking.

2.5. The palaeogeographical model

The land consolidation projects and excavations resulted in much information on the genesis of the subsoil. This information was used for the construction of a palaeogeographical model. In 1982 a well-documented study on the development of the Bergen Inlet was published by the Geological Survey of the Netherlands (De Mulder and Bosch 1982). In this publication the development of the physical landscape is described from a lithostratigraphical point of view. The palaeogeographical maps in this publication present the distribution of the lithostratigraphical units at a certain period in time (figure 2.6). The clastic lithostratigraphical units are not subdivided into, for example, tidal flat deposits and tidal marsh deposits. Due to the lack of such a subdivision and the map scale, the publication was little used in archaeological projects afterwards.

A time-framework was added to the lithostratigraphy, based on an extensive overview of available radiocarbon dates including a wide range of dates from archaeological excavations.[4] The quality of the dates used for the stratigraphical framework is, in retrospect, of a poor quality. The radiocarbon dates are all conventional dates from the seventies or older. Most dates concern gyttjas, molluscs, clayey peat and bone. Conventional dates on gyttjas are suspected to be too old due to the hard water effect. These dates display substantial age differences up to several hundreds of years compared to AMS dates of selected macrobotanical remains from gyttjas (Törnqvist *et al.* 1992, 573). Conventionally dated bulk samples of clayey peat remnants also differ from AMS samples due to mechanical and botanical contamination depending, amongst other things, on the accumulation rate and the clastic sediment content (Törnqvist and Van Dijk 1993, 133). Bivalves are known to date too old due to the reservoir effect. Molluscs in the Bergen tidal basin lived in a brackish environment, a mixture of freshwater from the hinterland with an unknown ageing effect and salt water from the North

4 The time-framework is published in dates BP as is the tradition in geology instead of cal BC or BC as is the tradition in archaeology. In this text dates based on actual radiocarbon dates are presented as a 2σ cal BC date. The documentation on the original dates is included in Appendix 1. Archaeological dates based on multiple radiocarbon and/or other dating techniques are presented as BC dates. The BP dates used in the publication by De Mulder and Bosch (1982) are presented between brackets. In chapter 3 this problem is dealt with in detail.

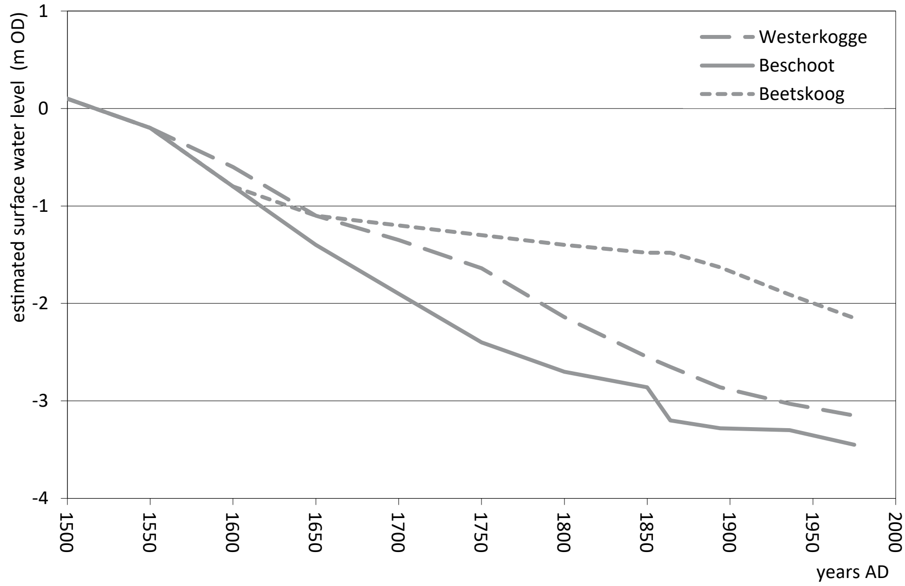


Figure 2.7: Graph of the estimated surface water level in three polders in West-Frisia based on data assembled by Borger (After: Borger 1975, 74).

Sea with a known ageing effect. Bone is susceptible to ageing due to a partly marine diet (Barret *et al.* 2000). Due to these problems the time-framework has to be handled with care.

Three observations in this study by De Mulder and Bosch (1982) are of interest in relation to the habitation history. The first observation concerns the closure of the Bergen inlet. The second observation in the article of De Mulder and Bosch (1982) concerns the development of a peat cover. The third observation in the article of De Mulder and Bosch (1982) concerns the transgression-regression model. These observations will be discussed below.

2.5.1. Closure of the Bergen Inlet

De Mulder and Bosch (1982) provide a date for the closure at 3000 BP, which corresponds with a date around 1250 cal BC. This date is based on a conventional ^{14}C-date on a clayey gyttja obtained from a gully close to the inlet and supported by a conventional radiocarbon date for the start of accumulation of organic matter (clayey gyttja) in the western part of the tidal basin.[5] These two dates are supported by several conventional radiocarbon dates for the start of peat growth in the eastern part of West-Frisia between 1500 and 1322 cal BC (3150 BP) and two dates for the start of peat growth close to the inlet at some distance from the tidal channel between 1628-1523 cal BC (3300 BP) (De Mulder and Bosch 1982, 147).[6] Therefore a closure of the Bergen inlet shortly before 1250 cal BC (3000 BP) seems likely according to the authors. The authors state clearly that after the closure: "*Minor quantities of marine deposits might have been deposited behind a chain of beach barriers in front of the inlet* (De Mulder and Bosch 1982, 147)." In other words, the inlet was geologically closed because almost no sedimentation took place in the remaining tidal basin. Geologically closed is therefore not the same as literally closed. In an archaeological sense it means that after the geological closure fish and boats were still able to enter the remaining tidal basin through the inlet.

The date of the closure of the Bergen Inlet was, after this publication, discussed by Roep and Van Regteren Altena (1988, 219). Roep and Van Regteren Altena (1988) date the closure before 1516-1297 cal BC at least, which marks the start of peat growth in the vicinity of the city of Alkmaar and after 2198-1641 cal BC, a date of a bivalve from a beach deposit close to the city of Alkmaar.[7] In order to pinpoint the closure of the Bergen inlet more exactly, the authors reasoned that permanent settlements on top of the former tidal channels were only possible after relief inversion of these tidal channels, ergo: after closure of the Bergen inlet. The start of Bronze Age habitation in the eastern part of West-Frisia is marked

5 Appendix 1, date 163 and 164; GrN-6763 3360 ± 50 BP and GrN-823 2950 ± 85 BP.

6 Appendix 1, date 165-170; GrN-5554 3440 ± 90 BP, GrN-6603 3150 ± 35 BP, GrN-7782 3270 ± 35 BP, GrN-8094 3265 ± 40 BP, GrN-611 3155 ± 110 BP, GrN-9067 2690 ± 60 BP.

7 Appendix 1, date 171 and 172; GrN-5217 3140 ± 50 BP, GrN-6309 3560 ± 40 BP.

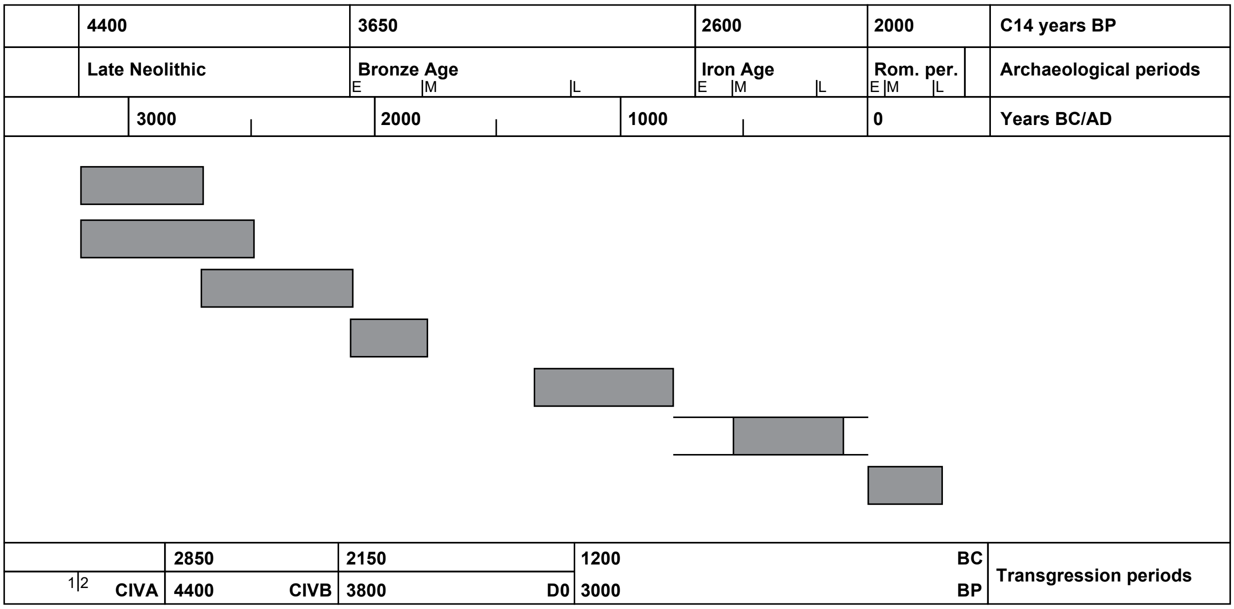


Figure 2.8: Habitation phases in West-Frisia in relation to transgression periods (C = Calais, D = Dunkerque, E = Early, M = Middle and L = Late) (Woltering 1985, 210, figure 8).

by the date of charcoal from a ringditch associated with a burial mound from the site *Bovenkarspel-Het Valkje* at 1634-1454 cal BC (Roep and Van Regteren Altena 1988, 219).[8] This "oldest" date from a settlement site supported the argument for an early closure of the Bergen inlet at 1570 cal BC (3300 BP). Consequently, after the publication of this article, 1570 cal BC has been reproduced repeatedly as the date for the closure of the Bergen inlet (Van der Spek 1994; Beets *et al.* 1996; Kok 2008).

The uncritical adoption of this date is remarkable. First, there were several older dates available in 1988 from settlement sites in West-Frisia. For example the site of *Oostwoud* is considerably older compared to the site *Bovenkarspel-Het Valkje* (Lanting and Van der Plicht 2002, 86-87). In several articles it has been argued that the northern branch in the Bergen tidal basin ceased approximately 2100 cal BC (3700 BP) (Van Heeringen and Theunissen 2001, 52). Apparently it was thought that after relief inversion the tidal channel deposits of the northern branch became exploitable. Second, Havinga, one of the leading soil scientists in the Netherlands, published in 1986 an article on the mechanism of relief inversion (Havinga 1986). In this article he argued that the archaeological community used the mechanism of relief inversion the wrong way (Havinga 1986, 395). His title is a pretty clear statement: "*Op dwaalwegen met de omkering van het bodemrelief*", which means something like: "*On the wrong track with relief inversion*" (Havinga 1986, 393). In his article Havinga explains in detail the process of relief inversion and explains why relief inversion is not applicable to the situation in West-Frisia. The main argument is the absence of bogs prior to the formation of marine sediments in this area (Havinga 1986, 399). Third, Pons and Wiggers (1959/1960) discussed the different landscapes simultaneously available within West-Frisia during the formation of the Wieringermeer and Westfrisian deposits; tidal flats, tidal marshes and fens. The authors specifically mention the presence of creeks and the influence of differential subsidence on the relief in the different landscapes. In retrospect it is curious that these publications have been neglected.

2.5.2. The development of a peat cover

In the article of De Mulder and Bosch (1982) the development of a peat cover is simply mentioned as a fact. The authors write: "*When the former sedimentation area had been drained, differential compaction set in. In the lowest parts swampy conditions caused the development of peat. These environmental conditions gradually extended over the entire area, and finally the whole of West-Frisia was covered with peat* (De Mulder and Bosch 1982, 146-147)." Obviously

8 Appendix 1, date 162; GrN-7472 3275 ± 35 BP.

the discussion started by Van Giffen (1953, 40) with his remark on the relatively low surface height was solved with the invention of a peat cover, an idea that was generally adopted at the time of publication.

After the publication of the excavation of the barrow of Grootebroek by Van Giffen (1953) several authors addressed the problem of the low surface height. Several years after the publication by Van Giffen (1953), Edelman suggests that the low surface height and the absence of younger clastic sediments can be explained by the existence of a peat cover for entire West-Frisia (Edelman 1958). Pons and Wiggers (1959/1960), as well as Ente (1963), rejected this idea. Pons and Wiggers (1960, 31-32) accepted a partial cover in the lower parts of West-Frisia but rejected the idea of a complete coverage. Ente (1963) rejects the entire idea. In his opinion the low surface height is caused by compaction due to a long tradition of intensive drainage since 1200 AD. In addition he noticed the presence of a thin cover of lake sediments known as "*kiekklei*" which had been overlooked by Van Giffen (Ente 1963, 188-189).

A new element was introduced in this discussion when in 1972 a peat layer was found under the church of Hoogwoud (Roldaan 1972; Havinga *et al.* 1992). The church is situated in central West-Frisia on top of a creek ridge. The base of this peat remnant was dated at 1500-1320 cal BC.[9] This find ended the discussion, the existence of a peat cover of entire West-Frisia was generally accepted. In 1975 the peat cover of West-Frisia was studied by the historical geographer Borger. Based on historical sources he reconstructs the change of the surface water level over time from 1500 AD onwards for three polders in West-Frisia (figure 2.7) (Borger 1975, 75). He argues that the peat cover has mainly disappeared due to oxidation (Borger 1975, 219-223). The original thickness of the peat cover was estimated at approximately four meters by Pons (Pons 1992, 48).

2.5.3. The transgression-regression model

The dates presented by De Mulder and Bosch (1982) do not fit in the transgression-regression model. Trans- and regressions were supposed to vary with changes in the pace of the relative rise in sea level and changes in sediment supply. Progradation or retrogradation therefore depended on small changes in the rise of the relative sea level, fluctuations in precipitation causing changes in river discharge and fluctuations in storm surge frequency and magnitude (Vos 2015, 8). During transgressions retrogradation took place and clastic deposits were formed. During regressions progradation occurred, parts of the tidal area emerged, soil formation took place and organic deposits were formed (Vos 2015, 9). This model was used by archaeologists to explain the occupation dynamics of the coastal area (Vos 2015, 9). It was widely believed that during regressions the risk of flooding diminished and land became inhabitable. During transgressions the risk of flooding enlarged and land became uninhabitable (figure 2.8). Due to the large amount of available radiocarbon dates De Mulder and Bosch (1982) observed a different staging of the trans- and regression phases in the Bergen tidal basin compared to other parts of the Dutch coast. In the article it is carefully suggested that the size and morphology of the tidal basin were possibly of influence on the sedimentation history next to changes in sediment supply, isostatic and eustatic sea level movements (De Mulder and Bosch 1982, 149).

Not only in the Netherlands was the simultaneous cycle of trans- and regressions along the coast questioned. Baeteman published in 1983 a critical overview of the Belgian coastal development and observed local differences in the various tidal basins (Baeteman 1983). This publication marks a turn in thinking over the development of coastal environments. Local factors like accommodation space, morphology of the tidal basin and so on were thought to be of importance in the development of a tidal basin. In the nineties these new ideas were applied to the development of the Bergen tidal basin by Van der Spek (1994, 152-180). Surprisingly these new ideas were not adopted by the archaeological community.

2.5.4. A new model for coastal development

In the previously mentioned publication by Van der Spek (1994) the erosion and sedimentation history is explained by three components: accommodation space, tidal asymmetry and tidal range. The accommodation space of a tidal basin is determined by the morphology of the subsurface and the relative sea level rise. A tidal basin enlarges when the accommodation space is larger than the sediment supply and vice versa (Coe *et al.* 2003,

9 Appendix 1, date 166; GrN-6603 3150 ± 40 BP.

56-61). The morphology of the subsurface of the Bergen tidal basin is determined by the morphology of the Pleistocene surface, the former river valley of the river Rhine. The valley is confined by ranges of ice pushed ridges. In the north ice pushed ridges occur along the line Texel-Wieringen-Gaasterland-Steenwijk-Coevorden. In the south these ridges are present along the line Haarlem-Utrecht-Nijmegen (De Mulder *et al.* 2003, 219). Approximately 28.000 BP the river Rhine changed its course to the central parts of the Netherlands, the present day Rhine-Meuse delta. From 28.000 BP onwards the valley was drained by the river Overijsselse Vecht and smaller tributaries like the Tjonger, Eem and the predecessor of the river IJssel (De Mulder *et al.* 2003, 208-209).

The tidal asymmetry is the difference between the length of the flood and ebb tidal current. Tidal asymmetry is influenced by several factors. Along the Dutch coast the ebb tidal current is larger compared to the flood tidal current due to the morphology of the North Sea basin. Due to the stronger flood tidal current in comparison with the ebb tidal current a net sediment supply will occur in the tidal basins along the Dutch coast (Dronkers 1986, 121-122). The morphology of the tidal basin and the presence of tidal flats are of influence on the asymmetry. If the surface covered by tidal flats within a tidal basin enlarges the flood tidal current is obstructed and the length of the flood tidal current enlarges (Van der Spek 1994, 14). An enlargement of the flood tidal current results in a loss of energy and thus sediment transport.

The tidal range is the difference between high tide and low tide. Within a tidal basin the tidal range can change from location to location, depending on the length of the tidal basin with respect to the tidal wave (Van der Spek 1994, 169-170). The former Zuiderzee is a good example of the influence of the basin length at the tidal range. In the former Zuiderzee the length of the tidal basin equaled a half tidal wave. The outgoing ebb tidal current met the incoming flood tidal current resulting in a minimal tidal range and a raised mean sea level (Elias 2006, 55).

The development of the Bergen tidal basin between 4350 cal BC (5500 BP) and 1570 cal BC (3300 BP) as described by Van der Spek (1994) is relevant to this study. Approximately 4350 cal BC (5500 BP) the Bergen tidal basin could be characterized as a flood dominated tidal basin. Behind the Bergen inlet a multi-channel system was present. The channels were flanked by tidal flats and enclosed shallow lagoons. The tidal range decreased from the inlet in an eastward direction whereas the mean water level increased and the flood period shortened. Around 2100 cal BC (3700 BP) a remarkable change occurred. The eastern part of the tidal basin area was disconnected from the western part and turned into a freshwater lake. This resulted in a substantial decrease of the accommodation space in the tidal basin. The surface reduction of the tidal basin was estimated at approximately 85%. As a result the sediment balance in the tidal basin changed dramatically. The basin consisted after 2100 cal BC (3700 BP) of a single channel flanked by tidal flats and salt marshes. As a result of the reduced accommodation space, tidal wave length and mean water depth, the tidal range increased for the area between the inlet and Hoogwoud. In the area between Hoogwoud and Enkhuizen the tidal range decreased. Simultaneously the mean water level east of Hoogwoud was strongly increased. In addition west of Hoogwoud the tidal basin changed from flood dominated into ebb dominated. As a result, the basin west of Hoogwoud

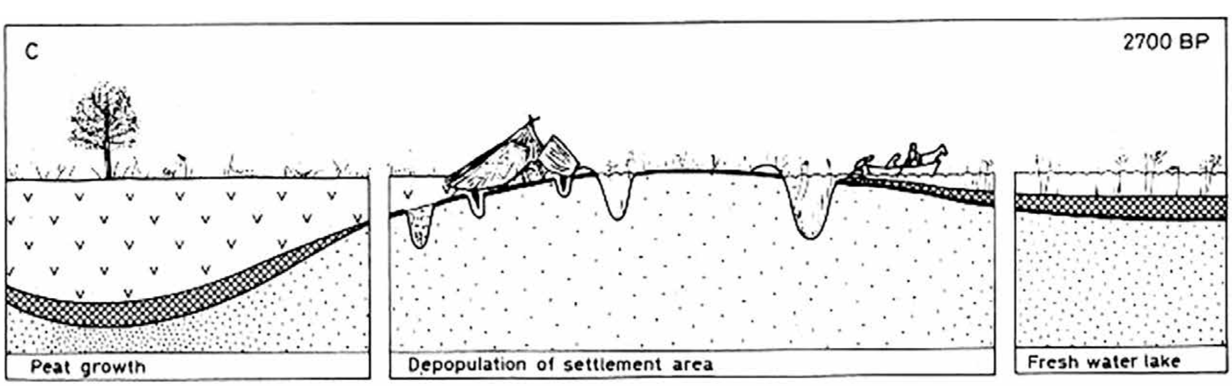


Figure 2.9: The abandonment of West-Frisia at the end of the Late Bronze Age (Van Geel et al. 1982, 306, figure 7c).

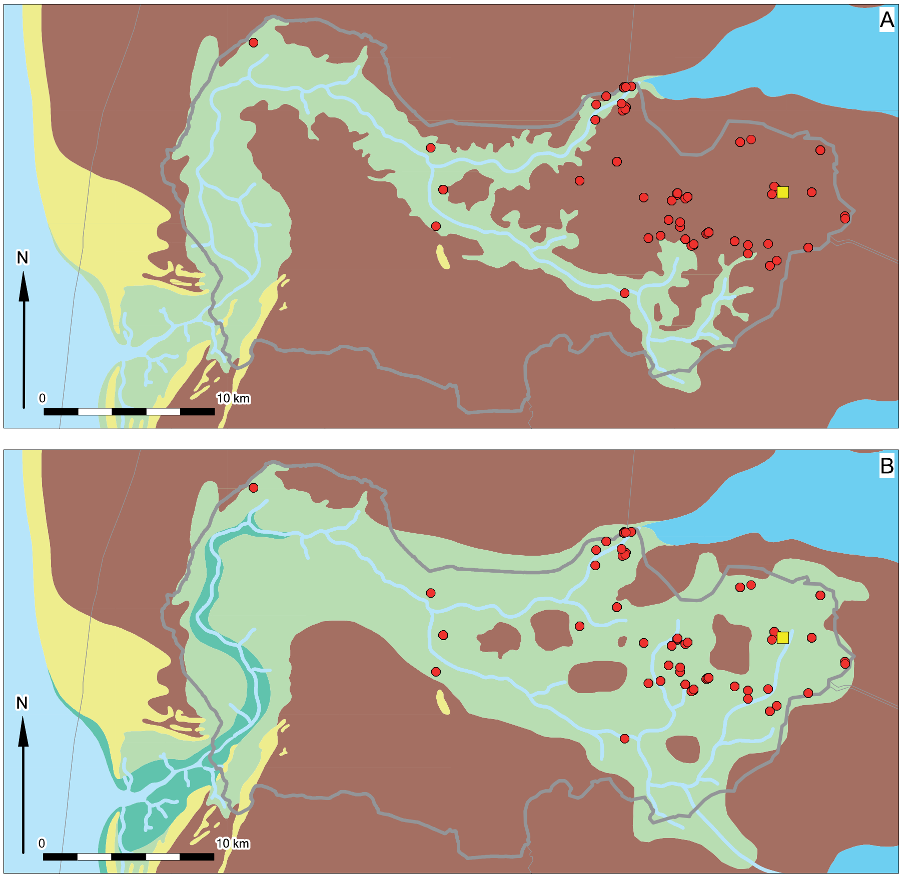
silted up rather quickly and the area east of Hoogwoud silted up to a level above mean sea level (Van der Spek 1994, 169-180). However the ideas on the why and how of the sedimentation and erosion history in this area changed, the proposed date for the closure at 1570 cal BC (3300 BP) was unaffected.

2.6. The habitation model

The landscape development models presented before the publication by Van der Spek (1994) have been of great influence on the development of a habitation model. The archaeologists involved in the 1966 excavation of the *Hoogkarspel* site used amongst others the soil map of Ente as a palaeogeographical map. A relationship was observed between the sandy and loamy soils mapped by Ente and the location of the settlement sites (Bakker *et al. 1*977, 192-196). The sandy and loamy soils were interpreted as former tidal channels. To explain the exploitation of these former tidal channels it was argued that these channels were completely silted up prior to the colonization of West-Frisia and transformed into creek ridges as a result of relief inversion (Van Geel *et al.* 1982, 273; Roep and Van Regteren Altena 1988, 219). After this transformation these ridges were colonized. The first house plans situated on these ridges were thought to date between 1500 and 1400 BC. There was no evidence for permanent settlements on these ridges in the area prior to this date. Only one settlement site dating prior to the Middle Bronze Age was known in West-Frisia until the nineties. This site, *Zandwerven*, was excavated in 1929 (Van Giffen 1930). This site was situated at a former coastal dune instead of tidal marsh deposits. Other types of sites dating prior to the Bronze Age were some ard marks and burials dating to the Late Neolithic which were found during an excavation at the site of *Oostwoud* in 1956 and the site of *Aartswoud* excavated in 1972 (Van Giffen 1961; Van Iterson Scholten and De Vries-Metz 1981). All Late Neolithic sites were interpreted as sites where activities had taken place temporarily. The few sites in West-Frisia dating in the period 1800-1500 BC, the burial mound of *Bovenkarspel-Het Valkje* and the poorly excavated site *Westwoud II*, confirmed the ideas of the colonization of a "virgin soil" in the Middle Bronze Age (IJzereef 1981; De Vries-Metz 1993).

The archaeologists who excavated in West-Frisia assembled data on site for detailed landscape reconstructions. Based on multi-proxy evidence from several excavations it was argued that the vegetation could be characterized as an open, almost treeless area from the start of the colonization phase to the end of the Late Bronze Age (Buurman 1996, 186). During the Bronze Age the environment became wetter resulting in the enlargement of fens and the development of bogs (Van Geel *et al.* 1982, 304-308). Based on algae derived from multiple excavated ditches, the landscape was characterized as a pure freshwater environment throughout the Middle and Late Bronze Age (Van Geel *et al.* 1997, 159-161). The fish bone assemblages of the excavations also indicated a freshwater environment, excluding the possibility of brackish water in the vicinity (IJzereef 1981, 126). The samples of cultivated cereals dating to the Middle Bronze Age settlement phase contained mainly wheat. The samples dating to The Late Bronze Age contained mainly barley. This shift from wheat to barley was interpreted as an indication for wetter environments (Buurman 1999, 134-135). This shift coincided with a rise in the amount of weeds that prefer more humid conditions. Moreover molluscs, mostly snails derived from excavated ditches, indicated a more humid environment at the end of the Bronze Age compared to the start of the Bronze Age (Buurman 1999, 134-135). In addition it has been suggested that the attested change from meat to dairy production is an indication of wetter conditions (Runia 1987, 190; Buurman 1996, 192). A last indication of wetter conditions is derived from small mammal habitats. Small mammal remains from late contexts represent a wider range of habitats compared to the start of the Bronze Age. According to the researchers this implies that the habitats of small mammals were smaller i.e. in closer proximity of each other in the Late Bronze Age (Buurman 1999, 134).

The end of Bronze Age habitation is marked by a change in settlement construction. The youngest house plans of the Bronze Age settlements in West-Frisia are dated between 900 and 750 BC. In this youngest period the houses were situated on small artificial mounds on the creek ridges, suggesting a wetter environment. The ongoing rise of the relative sea level was thought to cause a wetter landscape, a substantial enlargement of the fens and the start of the formation of peatbogs. After 750 BC West-Frisia was thought to have become uninhabitable and the settlements sites were abandoned (figure 2.9) (Van Geel *et al.* 1982).



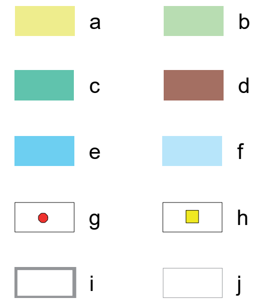


Figure 2.10: Palaeogeographical map of West-Frisia 1500 BC with all known settlement sites dating to the Middle Bronze Age (After: Vos, et al. 2011, 55 (A) and Vos 2015, 73, figure 2.8 (B). Legend: a dunes and beach ridges, b tidal marshes (2.10 b) tidal marshes and tidal flats (2.10 a), c tidal flats, d peat, e freshwater, f salt and brackish water, g settlement site Bronze Age, h Bovenkarspel-Het Valkje, i West-Frisia.

In the nineties the theory of solar forcing as the explanation for the sudden abandonment of settlement sites in West-Frisia was introduced (Van Geel *et al.* 1996, 453-454). Based on a peat remnant under the Westfriese Omringdijk and the Engbertdijksveen in the eastern part of the Netherlands a change was attested from *Sphagnum* species which favour dry summers to species favouring cooler, wetter and cloudier circumstances. This change in *Sphagnum* species coincides with a change in the delta ^{14}C-value, indicating a period with a substantially smaller amount of solar flares. It is suggested by the authors that this change in solar radiation led to a small climatic change analogous to the Maunder minimum during the Little Ice Age. This change in climate led to a higher pace of peat formation and suddenly increasing wetter conditions in West-Frisia. Therefore a direct link was suggested between the abandonment of West-Frisia around 750 BC and the change in solar radiation (Van Geel *et al.* 1996, 453-454).

Although this habitation model seems to fit the data very well, there are two anomalies in this well documented and thorough research project. The first is the find of an Early Iron Age (750-500 BC) settlement site near the village of Opperdoes in 1985. This site, *Opperdoes-Markerwaardweg* is the only known excavated settlement site with features dating to the Bronze Age and Early Iron Age. The date of the Iron Age site is based on the presence of Ruinen-Wommels I type of pottery (Diederik 2011). Only one radiocarbon date is available from this site but it is unclear what this date (charcoal from a feature) represents.[10] Settlement sites dating to the Middle Iron Age and Late Iron Age are rare but not unknown. The presence of the site *Opperdoes-Markerwaardweg* was explained by the relatively high altitude (-0.25 m O.D.) of the excavated location compared to the sites *Hoogkarspel* and *Bovenkarspel-Het Valkje* (-1.25 m O.D.) (Woltering 1985, 225).

The second anomaly is the find of several Neolithic sites in the last land consolidation project *De Gouw* (figure 2.5). The presence of the Late Neolithic sites in *De Gouw* is explained by the shift of the main tidal channel to the south eastern part of the tidal basin.

10 Appendix 1, date 139: GrN-10015 2210 ± 55 BP.

Due to this shift the area of *De Gouw* was relatively stable and therefore suitable for exploitation (Van Heeringen and Theunissen 2001, 54). The eastern part of West-Frisia was thought to be uninhabitable during this period. Therefore the idea of the exploitation of a virgin soil during the Bronze Age was unaffected. The recent find of two Late Neolithic sites in the eastern part of West-Frisia in advance of the construction of a motorway proves differently (Knippenberg in prep.).

2.7. The palaeogeography of the Netherlands

The changing ideas on the development of the landscape and habitation possibilities are well reflected in the series of palaeogeographical maps at a national scale which have been published over the years. The first national palaeogeographical map series was published by Pons *et al.* (1963). This map series is a joint effort of the soil scientists of Stiboka and the geologists of the Geological Survey. These maps were improved by Zagwijn (1986) mainly based on the newly published geological maps, palaeobotanic data and radiocarbon dates. This series contains 10 maps of the Netherlands during the Holocene. In 2003 a series of palaeogeographical maps was published by De Mulder *et al.* (2003). These maps were an improved version of the maps constructed by Zagwijn using regional studies of Zeeland and the Rhine-Meuse delta and the results of the Coastal Genesis Project by Rijkswaterstaat. The published maps were schematic and the palaeodrainage pattern was not at an exact scale. In 2005 TNO published a set of seven maps (Vos and Kiden 2005), commissioned by the Cultural Heritage Agency. These maps were drawn at a scale of 1:500.000. An important difference with maps published before is the use of a selection of archaeological sites. In 2011 an improved and extended version of these map series was published consisting of 11 sheets (Vos *et al.* 2011). A new source used in the construction of this series was the elevation model of the Netherlands (AHN). In this series the relationship with archaeology was amplified. All the palaeogeographical maps published after 1986 were subject to debate, due to a lack of a description of the methods used for the compilation of these maps.

The research project "*Farmers of the Coast*" started just after the publication of the latest national palaeogeographical map in august 2011. In this series a map presenting the palaeogeography in the Middle Bronze Age is incorporated (figure 2.10A). A quick glance at the distribution of the Bronze Age settlement sites, plotted on the newly published map, shows the imperfection of the national reconstruction for the palaeogeography in West-Frisia around 1500 BC. Almost all known settlement sites dating to the Middle or Late Bronze Age are plotted in an area covered by peat, whilst in reality all excavated sites were situated on top of clastic sediments.

During the research project an improved set of 11 palaeogeographical maps was published in "*Origin of the Dutch coastal landscape*" (Vos 2015). A big improvement by this publication is the presentation of a methodological base for the construction of the maps. The maps have been compiled at scale 1:100.000 and show, therefore, a larger degree of detail. In this 2015 reconstruction the "peat problem" as described above is mainly solved (figure 2.10B). Although in this reconstruction another problem occurs. In this reconstruction Middle and Late Bronze Age sites are situated along active tidal creeks despite the absence of any indication for the habitation of tidal marshes along tidal creeks. The landscape of eastern West-Frisia is characterized by archaeologists as an entirely freshwater landscape during the Middle and Late Bronze Age. This idea is based on a large amount of data from many different proxies and is confirmed in many excavations. Specifically, the situation for the site *Bovenkarspel-Het Valkje* is peculiar. During the excavation a cross-section through the entire main tidal channel was made. This tidal channel was silted up completely in the Middle Bronze Age, even house plans dating to the Middle Bronze were situated on top of the infill of the residual gully. This implies a complete abandonment of the tidal channel prior to the habitation in the Middle Bronze Age. In chapter 3 an alternative palaeogeographical reconstruction will be proposed.

2.8. After "Valletta"

The publication by Van Geel *et al.* (1996) completed the entire habitation model and did not conflict with both previously presented landscape development models. The ratification of the Valletta Treaty in 1998 by the Dutch government provided an opportunity to validate the presented models. In anticipation of the new Monuments Act based on the Valletta Treaty, archaeological research was obligatory in advance of ground disturbances. This change of legislation and policy led to the start of a new archaeological practice where excavations were undertaken by commercial companies. Far more important was the change in focus. Archaeological excavations were no longer research led projects but became development led projects, exploring larger areas and areas which were previously thought of less importance. Thomas (2013) deals with this topic in his publication "*Bridging the gap?*" in which he emphasizes the different nature and results of these two research foci in Great Britain. Due to the new legislation in the Netherlands transparent procedures were needed for the obligatory archaeological research. One of the tools for achieving these transparent procedures are policy documents and their accompanying maps which have been published by the local government.

In 2006 a policy document and map were presented by the local government for eastern West-Frisia (De Boer and Molenaar 2006). In this document the landscape and habitation model by Van Geel *et al.* (1982) and De Mulder and Bosch (1982) are repeated. The known Bronze Age sites from the ArchIS database and the sites mapped by Ente (1963) were plotted on the detailed soil map of the land consolidation project. In order to distinguish areas with a high, medium or low risk for the presence of archaeological values dating to the Bronze Age, the method presented by Deeben *et al.* (2002) was applied. In this method the number of sites per soil unit is counted. Soil units with a more than average amount of sites are classified as an unit with a high indicative archaeological value. Soil units with an average amount of sites are classified as a unit with a medium indicative archaeological value. Soil units with a less than average amount of sites are classified as a unit with a low indicative archaeological value. Using this method three classes were distinguished for the policy document of eastern West-Frisia. The sandy and silty soil units turned out to contain a more than average amount of sites compared to clayey, humic and peaty soils and therefore represent the high and medium units. For these high and medium units the local government is advised to conduct an intensive survey in advance of planned ground disturbances. For areas with a low indicative value the local government is advised to conduct an extensive survey in order to validate the low value (De Boer and Molenaar 2006, 48-49).

Three critical remarks can be made on this policy document. Although the authors mention explicitly the effect of land use on the visibility of sites, they ignore the fact that there is a strong relationship between land use and subsoil. The sandy and silty soils were mainly in use as arable fields whereas clayey and especially humic and peaty soils were in use as pastures during the large scale archaeological surveys. The site visibility is higher in the former compared to the latter. A second topic which is briefly addressed is the sedimentation and the peat formation after the Bronze Age. However, little sediment is supposed to have been formed after the Bronze Age. This post-Bronze Age sediment layer is supposed to be thicker at locations with soils more vulnerable to compaction, i.e. clayey, humic and peaty soils. A third topic which is not dealt with in the document is the process of churning in relation to preservation of archaeological remains. Especially soils with a high lutum and/or organic matter content are vulnerable to churning. The survival opportunity for pottery is therefore greater in sandy and silty soils compared to the other soil classes. Therefore there is a causal relationship between the observed site distribution and observed soil classes. However, this does not imply a relationship between the actual site distribution and observed soil classes! In chapter 6 this problem will be dealt with.

In West-Frisia several excavations were undertaken based on the new legislation and policy. Three large scale excavations revealed Middle Bronze Age (1600-1100 BC) and Late Bronze Age (1100-800 BC) settlement sites: *Hoogwoud*, *Medemblik-Schepenwijk* and *Enkhuizen-Kadijken* (Lohof and Vaars 2005; Schurmans 2010; Roessingh and Lohof 2011). The site of *Hoogwoud* dates between 1300 and 1000 BC. The site of *Medemblik-Schepenwijk* dates between 1450 and 800 BC. Features and pottery dating between 1100 and 900 BC seem to be absent at this site. The site of *Enkhuizen-Kadijken* dates between 1600 and 800 BC. These three sites all provided data contradicting the existing palaeogeographical and habitation models. For example the site *Enkhuizen-Kadijken* is not situated at a creek ridge but at a former tidal marsh, an area which is supposed to be uninhabitable according to the presented models.

Pollen is poorly preserved in all three sites due to the alkaline soil and deep artificial drainage (Dimbelby 1957, 18). Despite the poor conservation palynological research of samples from ard marks in *Medemblik-Schepenwijk* presents pollen percentages for alder up to 25%, indicating the presence of alder carr in the immediate vicinity of the settlement site. Palynological research of several coprolites from dogs present in addition a relatively high percentage (7%) of willow which is a poor pollinator. This indicates the presence of willow woodland or willow shrubs in the vicinity of the settlement site (Schurmans 2010, 162-165).

In all three sites the preservation of uncharred macrobotanical remains is poor due to the deep artificial drainage of the soil. Despite the poor conservation all three settlement sites provide macrobotanical remains representing different habitats ranging from freshwater environments with nutrient rich dry arable soils to very wet pastures in the direct vicinity of the settlement site for the entire period. Indications for an enlargement of wetter habitats in the Late Bronze Age are clearly present. This is in accordance with both models. Contradictory is the presence of poorly preserved wood from oak, alder and willow in features dating to the Late Bronze Age in *Medemblik-Schepenwijk* and indicators for shrubs (or possibly woods) like seeds of bramble and elder (Van Zijverden 2013). The range of wood species found in *Enkhuizen-Kadijken* is even larger compared to *Medemblik-Schepenwijk* and comprises oak, alder, ash, birch, willow and pine (one object) (Roessingh and Lohof 2011, 247). Apparently woodlands or at least patches of woodland and shrubs have been present, which contradicts both models.

All three sites provide fish bones due to a-select sieving of features and the good preservation of bone due to the alkaline subsurface. The fish remains of *Hoogwoud* comprise specimens indicating full marine environments (Atlantic cod and sting ray), brackish environments (European flounder and thinlip mullet) and freshwater specimens (cyprinids and northern pike). Approximately 75% of the remains at this site represent a brackish environment (Van Amerongen 2015). The fish remains of *Medemblik-Schepenwijk* indicate a full freshwater environment with mostly northern pike, cyprinids and several other species. In the Late Bronze Age a few remains of European flounder and mullet are present indicating brackish environments or at least a distant connection with a marine environment (Van Amerongen 2015). Remains from *Enkhuizen-Kadijken* are almost similar compared to those of *Medemblik-Schepenwijk*: mainly "freshwater" fishes, a few mullets and large numbers of eel (Van Amerongen 2015). The presence of marine and brackish species in the western part and species indicating a distant connection with the sea contradict the habitation model as well as the palaeogeographical model (Van Amerongen 2015). The presence of species indicating a distant connection with the sea in the Late Bronze Age is especially hard to understand within the current palaeogeographical model.

Mammal and bird remains are well-preserved at all three sites due to the alkaline soil. The large faunal remains from *Medemblik-Schepenwijk* represent animals like goose, elk, deer, wild boar, fox and beaver for the Middle Bronze Age. In the Late Bronze age wild cat and otter are also represented in the assemblage (Schurmans 2010, 86). The assemblage of large faunal remains of *Hoogwoud* is small and represent red deer and roe deer (Lohof and Vaars 2005, 37). The faunal remains from *Enkhuizen-Kadijken* comprise wild boar, brown bear, elk, deer, and beaver (Roessingh and Lohof 2011, 203-204). Of interest from the small faunal remains of this site are northern goshawk and the woodcock both indicative of woodland and shrubs (Roessingh and Lohof 2011, 204-205). Both these landscapes are supposed to be absent according to the habitation model and palaeogeographical model (Van Amerongen 2014).

At some locations within the site *Enkhuizen-Kadijken* the original stratigraphy was intact. At two locations a soil sample was studied using micromorphology. Based on this research it was noticed that, after the abandonment of the settlement site, renewed sedimentation took place Roessingh and Lohof 2011, 46). Distinct layers of charcoal particles alternate with very small silt particles after the abandonment. Apparently man burned the vegetation regularly, indicating a continuing presence in the area after the abandonment of the settlement area. After a while sedimentation took place in a back swamp environment, uninterrupted by burning activities and without any indications of peat growth which contradicts both models.

The new data confirms the enlargement of wet habitats in the Late Bronze Age without any doubt (Roessingh and Lohof 2011, 268). However *Enkhuizen-Kadijken* proves that the rise of the water table didn't always lead to peat formation at the end of the Bronze Age. The situation of this settlement site at tidal marsh deposits influenced by differential subsidence, combined with the absence of raised mounds in the Late Bronze Age contradicts the disastrous events sketched by the models. This new data also presents indications of a much more differentiated landscape than previously thought. A patchwork of lakes, marshy grasslands, dry arable fields alternating with patches of woodland and shrubs like alder carrs, willow woods or willow shrubs could have been present in the eastern part of West-Frisia. Apart from these types of shrubs and woodlands, riparian forests with ash and oak could have been present as well. The game assemblage with animals like wild boar, brown bear, Northern goshawk and woodcock is consistent with the presence of these specific woodland biotopes. In chapter 4 this topic will be dealt with in more detail.

2.9. Concluding remarks

In this chapter the palaeogeographical and habitation models for Bronze Age West-Frisia have been introduced and placed in a historical perspective. The framework for both models was built using the work of the soil scientists of Stiboka. These soil scientists practiced the genetic approach during soil surveys, carried out in advance of land consolidation projects. The maps and models generated by Stiboka were of great use to understand the development of the environment in the past and the nature of Bronze Age archaeology in West-Frisia. It was widely thought that with the exception of the monument at Bovenkarspel all features from Bronze Age West-Frisia were destroyed due to the land consolidation projects. Therefore little to no research has been carried out in West-Frisia after 1985. New development-led research, carried out as a consequence of the Valletta Treaty, proved different. Not only well-preserved Bronze Age sites appeared to be present, but also the generated data contradicted the existing models.

Several problems in the palaeogeographical and habitation model have been addressed in this chapter. According to the present model, the start of Bronze Age habitation is marked by the closure of the Bergen Inlet. The early closure of the Bergen inlet at 3300 BP is, despite the geological evidence as presented by De Mulder and Bosch (1982) and the archaeological evidence from the site *Hoogwoud*, not yet ruled out. A later closure implicates a salt to freshwater gradient and the influence of tidal movement during at least part of the Bronze Age. A dynamic environment with changes in salinity has a radical influence on the biotic and physical environment. Furthermore, it also has implications for the geographical position of West-Frisia during (a part of) the Bronze Age. An open coast line with a sheltered tidal inlet is an attractive location for fisherman and traders. The end of habitation in the Bronze Age is marked by the development of a complete peat cover in West-Frisia. At at least at one excavated site (*Enkhuizen-Kadijken*) a peat cover is absent which raises discussion of the degree of completeness of this peat cover. The new model for the coastal development of West-Frisia as presented by Van der Spek (1994) has not yet been translated into a new palaeogeographical reconstruction. Chapter 3 will cover these topics in detail and a new regional palaeogeography, which is in accordance with the archaeological evidence, will be presented.

In this chapter the strong "belief" in a preferred settlement site location at creek ridges has been discussed. On one hand the explicit article by Havinga on this topic is systematically ignored as is the evidence from a site like *Enkhuizen-Kadijken*. On the other hand, without any doubt, creek ridges are present in the landscape of West-Frisia. There is indeed a distinct correlation between find distribution and soil units suggesting a correlation between these creek ridges and settlement sites. In this chapter it has been argued that this statistical correlation is not the same as a causal relationship between settlement sites and creek ridges. Furthermore, in the models it is suggested that the vegetation of West-Frisia can be characterized as a treeless, almost open landscape. In this chapter it has been argued that the broad spectrum of wood species combined with a broad spectrum of animals preferring cover in the find assemblages, is at least an indication for the presence of woodlands. In chapter 4 the problem of the creek ridge and the almost treeless landscape will be dealt with.