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POLLEN AND DIATOM ANALYSIS OF A SHORE SECTION OF THE FORMER LAKE WERVERSHOOF

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ABSTRACT

A pollen- and diatom analysis of a shore section of the former Lake Wervershoof was carried out to investigate the history of occupation and vegetation in the region. The section is dated to between 1800 BC and 850 AD; a dating near the end of this period is probable. The presence of human occupation near the lake shore is shown. At this time the lake contained fresh water. The occupation changed its agricultural emphasis from the growing of wheat and barley to the growing of rye. The occupation is ended by a marine transgression. During a break in this transgression there is a renewed inhabitation.

1. INTRODUCTION

In 1967 an excavation of Carolingian settlement traces on the shore of the former Lake Wervershoof at Medemblik (N.H.) was undertaken by the "Instituut voor Prae- en Protohistorie" of the University of Amsterdam (van Regteren Altena and Bakker, 1968). A map of the region is shown in fig. 1. In addition to this investigation the pollen- and diatomanalysis were carried out by the above authors respectively. The material used for these analyses originated from a section through the shore sediments of the former Lake Wervershoof, located near the settlement traces. The aim of the pollen- and diatom analysis was to connect the changes in water composition and level of Lake Wervershoof with the history of vegetation and occupation in this region.

2 THE SECTION; ITS SEDIMENTATION, DATING AND THE ORIGIN OF ITS POLLEN- AND DIATOM CONTENT

The section is shown schematically in fig. 2. It consists of six layers, of which the middle four have been used for the analyses.

Layer O, consisting of fine silty sand, is a Calais IV B deposit, the top of which can be dated to around 1800 BC (du Burck and Dekker, 1968). Investigation of top material of this deposit shows, at least in this region, a nearly total absence of pollengrains and diatoms. The state of conservation of what few remnants there are shows that the originally deposited organic materials have nearly all been oxidized.

Layer 1, consisting of sandy clay, is considered to be reworked Calais IV B material (van Regteren Altena and Bakker, 1968). The top layer of the lake bottom, consisting of the already mentioned top material of the Calais IV B deposit, is brought into suspension by water movements and redeposited again. During this process the finer fraction will have been redeposited predominantly at the lee side of the lake, i.e. the south and west side. Taking into account the absence of organic remains in the Calais IV B top material, the pollengrains and diatoms in layer 1 can be considered to be synchronous with the redeposition of the original material and therefore can be used for the investigation of the situation during this redeposition.

Layer 2, consisting of humic clay, differs from layer 1 mainly by its more humic character. This points to more vegetation at the spot during its sedimentation.

Layer 3 consists of fine marine clay and is deposited both over the lake and shore sediments as well as over the wider surroundings. This clay, in Dutch named "kiekklei", is a Dunkirk III deposit, dated to between 800 and 1400 AD (Dekker and de Weerd, 1973). The pollen content of this clay can not be trusted as an indicator of the vegetation in the region, as this pollen will, for the most part, have been transported and laid down together with the clay.

Layer 4 is a thin level with a more or less burnt character. Traces of occupation show a break in the sedimentation of the marine clay. According to the archeological remains this break can be dated to ca. 850 AD (personal communication drs. J.C. Besteman).

Layer 5 is the cultivated topsoil.

A close dating of the section proved to be impossible. However, the weathered character of the top of the Calais IV B deposit might show that this material has been the top soil for some time. This, together with the occurrence of

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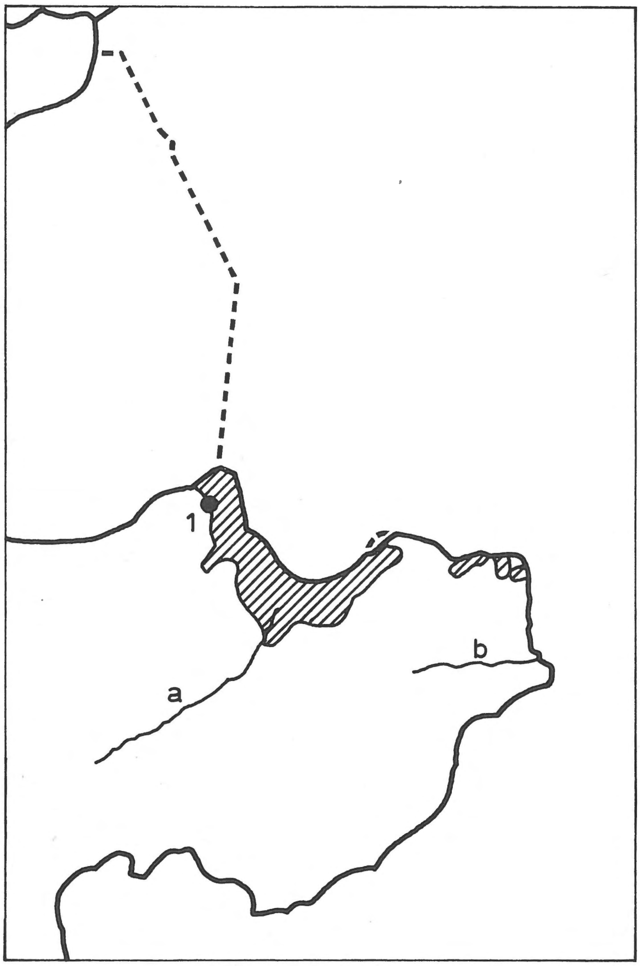

Fig. 1
Map of the region

1.	:	Medemblik
a.	:	Kromme Leek
b.	:	Oude Gouw
////	:	Lake Wervershoof sediments

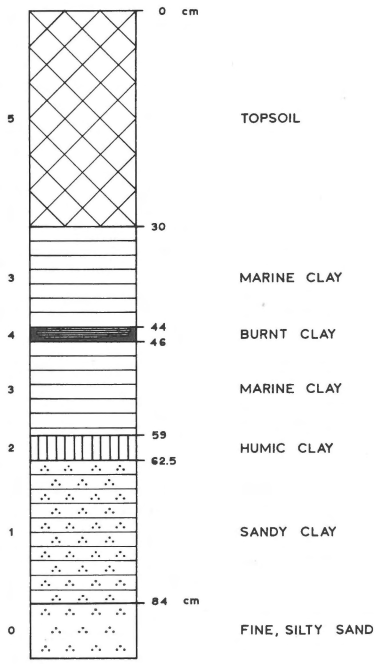

Fig. 2
Lithostratigraphy of the section

pollengrains of *Secale* in layer 2 (see 3.2.3) might point to a dating near the end of the period between 1800 BC and 850 AD.

3 THE POLLENANALYTICAL INVESTIGATION

3.1 Methods and presentation of the results

The samples for the pollenanalytical investigation were treated according to the method for clayey and sandy soils, described by Faegri and Iversen (1964). However, instead of boiling for some minutes in a 30% HF solution, the samples were placed for 24 hours at room temperature in a 40% HF solution. Before and after this part of the treatment the samples were rinsed with a 35% HCL solution. No staining was employed after the acetolysis. The material was mounted in 100% glycerine.

Pollencounts were done at a magnification of a 400 times. The total number of counted pollengrains per sample is shown in table 1. As the aim of the investigation was the history of human occupation, it was neccessary to select a pollensum unambiguously showing the occupation phases. As differences in level are small in this area and occupation will most probably have been concentrated on the highest parts (see 3.2), all pollentypes that represent plant species which

Table 1: Numbers of counted pollengrains

spectrum	total	sum	upland trees and shrubs
– 45 cm	2112	283	172
– 50 cm	2819	362	276
– 54 cm	1879	325	256
– 56 cm	2521	345	261
– 58 cm	1580	303	235
– 59 cm	2668	428	331
– 60 cm	1974	295	214
– 61 cm	3062	308	208
– 62 cm	1759	205	146
– 63 cm	1966	274	207
– 64 cm	2079	372	262
– 65 cm	1990	310	233
– 66 cm	1569	266	215
– 69 cm	1048	201	155
– 72 cm	1770	296	229
– 75 cm	1739	276	230
– 78 cm	1180	257	227
– 81 cm	1023	168	141
– 83 cm	1325	266	225

grow on relatively dry soils are taken into the pollensum, together with pollentypes that represent plant species which are linked to human occupation. The results of the investigation are partially shown in fig. 3. Only those graphs that are important for ecological or stratigraphical reasons are reproduced. Pollentypes taken into the pollensum are marked with a cross.

The individual graphs are arranged within groups as follows.

Group 1: pollentypes representing upland trees and shrubs;

Group 2: pollentypes representing water- and marsh vegetations;

Group 3: pollentypes representing plant species connected with human occupation;

Group 4: pollentypes with their main or only occurence in layer 3.

The groups 1 and 2 are ecologic-physiognomic groups (J a n s s e n, 1967, 1972).

Group 3 simplifies the survey of human activities. Group 4 combines pollentypes representing marine plant species with water-transported material. Within each group the pollentypes are arranged stratigraphically. The borders between the lithostratigraphically defined layers are clearly reflected in the pollendiagram. The transition between the layers 2 and 3 especially is characterized by major changes in the values of nearly all pollentypes. A zonation of the diagram in accordance with the lithostratigraphy is obvious. The zones to be distinghuished in the pollendiagram are as follows.

Zone 1: identical with layer 1, -84 to -62.5 cm;

Zone 2: identical with layer 2, -62.5 to -59 cm;

Zone 3: identical with the lower part of layer 3, -59 to -46 cm;

Zone 4: identical with layer 4: -44 to -46 cm.

The pollendiagram has been computed and printed at the academic computing centre of Amsterdam. A computer program written by the first author has been used (V o o r r i p s, 1973, 1974). The original data are stored on magnetic tape.

3.2 Ecology

An outline of the physiognomy of the landscape can be gained from geomorphological data (d u B u r c k and D e k k e r, 1968). During the deposition of the Calais IV B material the region was a complex system of sandy tidal channels and clayey tidal flats. After this deposition, which ended about 1800 BC, inversion of the relief took place. This inversion wrecked the drainage of the area. The landscape at this point can be described as a network of sandy ridges on which a forest vegetation becomes possible when the salinity diminishes. In between the ridges the basins develop into marshes because of the lack of sufficient drainage. The differentation in altitude between ridges and basins is less than two metres. Human occupation restricts itself to those ridges which, notwithstanding the bad drainage, offer a relatively dry soil.

The groups into which the pollendiagram has been divided now will be discussed, bearing this outline in mind. Names for vegetational units are in accordance with the nomenclature by W e s t h o f f and d e n H e l d (1969).

3.2.1 *Group 1: Upland trees and shrubs.* – First of all it should be noted that the number of pollengrains of the members of this group is in each sample very small as compared with the total number of pollengrains. This means that vegetations of upland trees must have been sparse in this region. Deforestation by human agency is obvious and the drop in the values of *Quercus* and *Tilia* in the upper part of zone 1 and in zone 2 shows the last phase of this process. For this reason it is impossible to decide from the pollentypes in this group what kind of forest remnants were growing on the sandy ridges. The soil conditions, young sandy soils with a rather high water table, are favourable for associations belonging to the *Alno-Padion,* the river-gravel woods ("*Hartholzaue*"). The local presence of species like *Fagus* and *Pinus* is, in this case, impossible. The source of the pollengrains of these – and probably other – species may have been the coastal dune area, ca. 30 km away.

3.2.2 *Group 2: Water and marsh vegetations.* – The pollen types in this group form a rather heterogenous mixture, the plant species represented being linked together mainly by their preference for a fresh, wet environment. Four subgroups can be defined. The first one consists of the microspores of *Pilularia globulifera* and the pollentype *Ranunculaceae* non *Thalictrum*. The second subgroup consists of the pollentypes *Myriophyllum verticillatum, Menyanthes, Mentha, Cyperaceae, Sparganium erectum, Sparganium emersum* and *Dryopteris*. The third subgroup consists of the pollentypes *Filipendula, Thalictrum* and *Valeriana*. These three subgroups have their main occurrence in zone 1. The fourth subgroup consists of the pollentypes *Alnus* and *Salix* and has its main occurrence in zone 2.

The first subgroup, characterized by the many microspores of *Pilularia globulifera*, shows clearly the presence of a vegetation in which this species was important. This vegetation must have been one of the associations in the *Littorellion uniflorae* which can be characterized synecologically as: vegetations of small herbs in shallow water; periodically uncovered; on varying soils, but mainly on sand; oligotrophic to – more rarely – eutrophic conditions. The reason for putting *Ranunculaceae* non *Thalictrum* into this subgroup is the correlation between its graph and that of *Pilularia*. Moreover, the combination *Pilularia* and a *Ranunculus* species – viz. *R. flammula* – exists in an association within the *Littorellion uniflorae*, the *Ranunculo-Juncetum bulbosi*. Part of the habitats of this association are lake shores, enriched by cattle grazing or human occupation, This coincides very well with the presence of human occupation

Fig. 3, see appendix

at the lake shore in zone 1 (see 3.2.3).

The pollentypes within the second subgroup represent plant species which mainly occur amongst fresh-water shore vegetations either in succession stages or as connected spatial zones. These vegetations belong mainly to the *Phragmitetea*. Important synecological features are: occurrence in shallow to rather deep water; at least incidental uncovering in most cases possible; mainly on humic substrates; mesotrophic to eutrophic conditions. The very high values of *Dryopteris* point to the existence of a *Thelipterido-Phragmitetum* near the place of the section. This association, characterized by marsh ferns and reeds, often succeeds more wet vegetations, but only in cases where the development of an alder carr is prevented by men. This agrees with the relatively low values of *Alnus* in zone 1.

The pollentypes within the third subgroup represent plant species which have their optimal occurrence in the *Valeria-neto-Filipenduletum*, an anthropogenic vegetation belonging to the *Molinio-Arrhenatheretea*, the wet meadows and other herbaceous vegetations. This association occurs in places where the development of alder carr is prevented and the amount of nitrogen compounds in the soil is enlarged, for instance by cattle grazing. The rather low values of the pollentypes in this subgroup indicate to some distance between the place of this vegetation and the place of the section. The fourth subgroup contains some pollentypes that represent swamp forest vegetations. The very high values of *Alnus* in zone 2 doubtless show the presence at the spot of one of the associations within the *Alnion glutinosae*, the alder carrs. Some synecological characteristics: water table about the surface level; mainly on humic substrates; meso-trophic to eutrophic conditions. The maximum of *Salix* in zone 2 may indicate the presence of some association within the *Franguletea*, the willow-buckthorn carrs, that have about the same synecology as the *Alnion glutinosae*.

3.2.3 *Group 3: Plant species connected with human occupation*. – In this group the pollentypes Cerealia non *Secale* and *Secale* are of main importance. The Cerealia non *Secale* – representing pollengrains of *Triticum* type and *Hordeum* type – have their main occurrence in zone 1, whilst *Secale* mainly occurs in the zones 2 and 4. A change in agricultural behaviour is obvious. The placing of *Poaceae* in this group is rather arbitrary. Many authors consider the *Poaceae* as ecologically indeterminate because this pollentype contains many species which vary widely in ecological conditions. However, though this is quite true, high values of *Poaceae* in pollendiagrams are very often connected with human occupation and for this reason they are added to this group. *Polypodium* has been taken into this group for an ecological reason. In this area there are nearly no places where species of *Polypodium* could occur, except on pollard-willows (Meinders-Groeneveld and Segal, 1967; Westhoff, 1970). If this assumption is true, the *Salix* maximum in zone 2 can be explained as the appearance of pollard-willows into the landscape.

3.2.4 *Group 4: Marine plant species and water-transported material.* – The pollentypes *Plantago maritima* and *Chenopodiaceae* show clearly the presence of some marine vegetation in zone 3. The high values of *Sphagnum* and *Ericaceae* in this zone and, as a matter of fact, of *Corylus*, *Carpinus* and *Dryopteris* too, are remarkable. There are no marine vegetations in which plant species represented by these pollentypes occur. The explanation must be that during the deposition of the Dunkirk III clay reworked material, from sediments and peat-bogs elsewhere, was redeposited, together with pollengrains of marine plant species. This mixture of pollengrains from different sources makes ecological comments impossible.

4 THE DIATOM ANALYSIS

4.1. Method and presentation of the results

The samples to be analysed on diatom content were successively boiled with concentrated hydrogen peroxide and concentrated hydrochloric acid (both 30%). After this, the entire sand content was removed, along with any clay smaller than two microns. The residue was placed on slides and the diatoms were counted by species under a magnification of a 1000 times till a total of 300 specimens per preparation.

The results are partially reproduced in fig. 4. Only those parts of the diagram which show essential differences in sedimentation and which were, consequently, counted for both whole and broken specimens are reproduced. In common with pollendiagrams, the relative values, expressed as a percentage of the total counted per sample, are shown here. This method would seem to illustrate more clearly whether the diatoms are autochtonous or not, this criterion being the only basis on which all conclusions concerning the conditions under which the sediments were deposited can be founded.

The horizontal scale of the diagram is the same for all species with the exception of *Melosira granulata*, which, because of its frequencies, is reduced to a tenfold scale. The base line of the diagram shows, from left to right a transition from marine via marine-brackish and brackish-marine to brackish types, and from brackish via brackish-fresh and fresh-brackish to fresh species of diatoms.

4.2. Interpretation of results

The diatom content in the top of the Calais IV B deposit proved to be as scanty as that of the pollen. Thus only a small number of almost exclusively marine and marine-brackish species could be counted. Only fresh-brackish and fresh species occur in the deposit of clay in fresh water (layer 1, spectrum 1 in fig. 4). Over half the counted specimens belong to the fresh-brackish type *Melosira granulata*. In addition, *Fragilaria construens*, also a fresh-brackish species, occurs rather frequently. These two prove to be the most important species throughout the entire section. Their optimum growth is obtained in water containing chloride

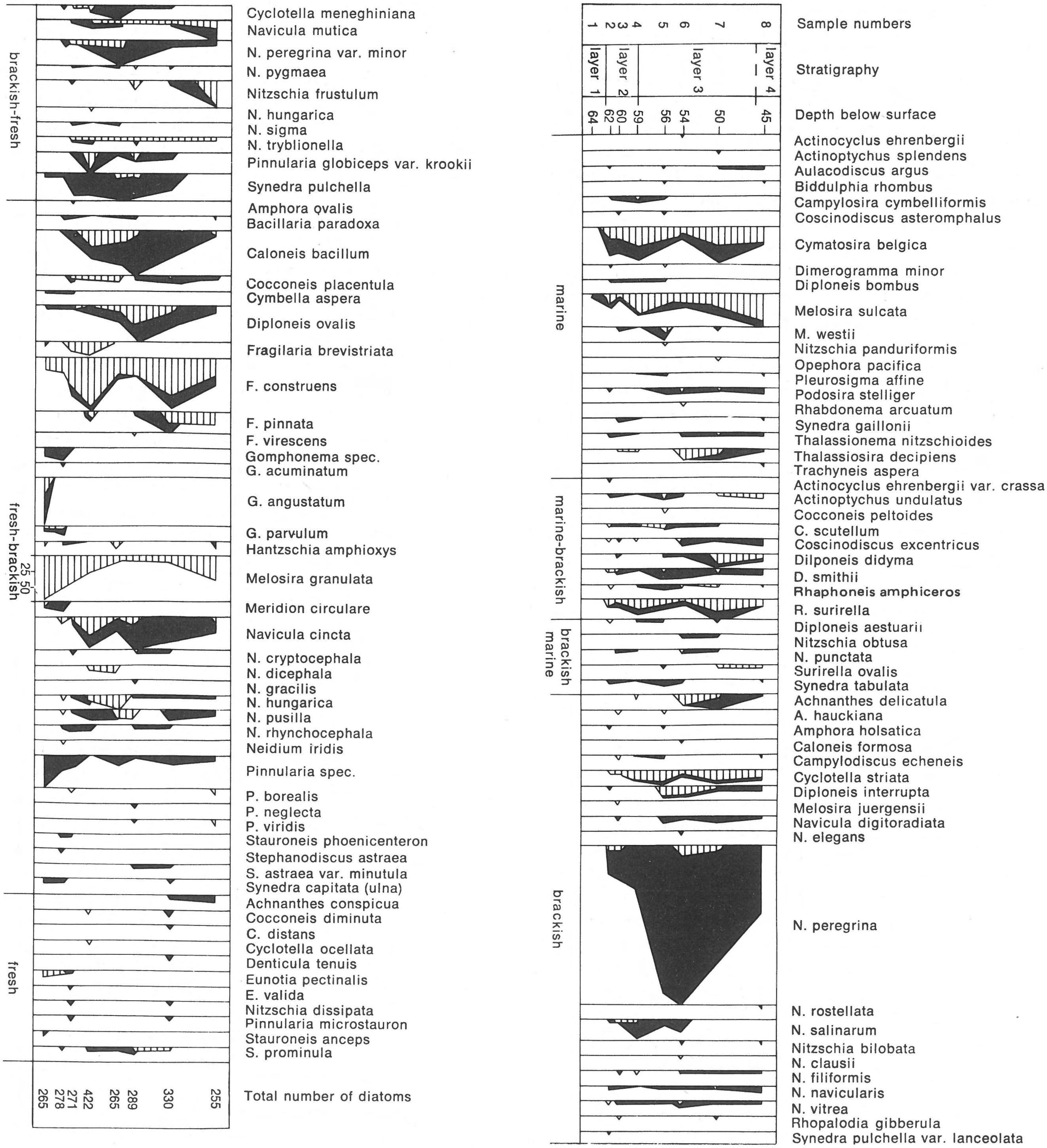

fig. 4
Diatom diagram Medemblik 1967

salts in a concentration varying from 100 to 500 mg per liter (v a n d e r W e r f f and H u l s, 1957-1970). Broken individuals were absent, so it is justified to assume that these species lived on the spot. Since *Fragilaria construens* also displays a slight preference for stagnant oxygen-rich water (C h o l n o k y, 1968), sedimentation in an environment with calm, fresh water seems an obvious conclusion. The occurrence of exclusively broken specimens of *Pinnula-*

ria would seem to be contrary to this, save that this genus has long frustules which are easily broken by the slightest transport. Of the purely fresh water types, *Eunotia pectinalis* is represented by specimens, which, if few, are all unbroken. In layer 2 (spectra 2 – 4 in fig. 4) a large number of marine, marine-brackish, brackish-marine, brackish and brackish-fresh diatoms appear. *Cymatosira belgica* and *Melosira sulcata* are the most common of the marine species. Both are represented by a relatively large number of unbroken frustules, but, bearing in mind that the frustules of *Cymatosira belgica* are small, while those of *Melosira sulcata* are tough, a sudden influx of salt water seems unlikely on this evidence. Two other possibilities present themselves:

1. The environment was gradually silting up due to transgression processes;
2. An inflow of disturbed material originally deposited in a marine-brackish environment took place, the material now being redeposited under predominantly fresh-water conditions.

The occurrence of *Navicula peregrina*, a brackish species, in almost always a broken condition, supports the second possibility. In a brackish environment this species would certainly have lived locally and would have been deposited with predominantly complete frustules. On the other hand, *Cyclotella striata,* also a brackish species, is – almost exclusively – represented by whole individuals, but in this case it is significant that the frustules are rather small and round in shape. The brackish-fresh species also occur chiefly with broken frustules. This is especially marked in *Synedra pulchella.* The highest proportion of unbroken specimens continues to be amongst the fresh-brackish types, notably *Fragilaria construens* and *Melosira granulata*. *Caloneis bacillum, Cocconeis placentula, Fragilaria brevistriata* and *Navicula cincta,* all fresh-brackish types, also contained predominantly unbroken specimens, which means they were well established here. During the deposition of the "kiekklei" (layer 3, spectra 5 – 7 in fig. 4) only slight changes in the environment are discernable. Marine, marine-brackish and brackish species remain, displaying roughly the same ratio of whole to broken specimens. However, the number of broken specimens of the small, round *Thalassiosira decipiens* increases, as does that of *Achnanthes delicatula, Diploneis interrupta* and *Navicula peregrina. Navicula salinarum,* which at first occurred only in a broken condition, disappears entirely. *Cyclotella meneghiniana, Navicula peregrina* var. *minor, Pinnularia globiceps* var. *krookii* and *Synedra pulchella* are the most common of the brackish-fresh species. All these, too, display a relatively high proportion of broken specimens. The fresh-brackish species *Caloneis bacillum, Cocconeis placentula*, *Diploneis ovalis* and *Navicula cincta*, of which about 50% were unbroken initially, finally consist of only broken specimens and are, therefore, allochthonous now. This can be explained either by an – additional – weak and temporary influx of fresh water or by wave action causing temporary movement of the water. A few other fresh-brackish species such as *Navicula dicephala, Navicula hungarica* and *Navicula pusilla* appear temporary with whole frustules. Only *Fragilaria construens* and, to a lesser extent, *Melosira granulata* manage to survive in this environment, which appears still to be predominantly fresh. There is little change among the marine species in the burnt layer which marks a Carolingian occupation (layer 4, spectrum 8 in fig. 4). In the case of the marine-brackish types, some show a decline in both broken and unbroken specimens while others are represented only by broken ones. *Cyclotella striata* is the only unbroken brackish type. In contrast, there is an increase in whole frustules amongst the brackish-fresh species. This is particularly clear in the case of *Nitzschia frustulum*. In addition, *Navicula mutica* also occurs. The presence of autochthonous specimens of *Nitzschia frustulum* indicates the return of conditions with more or less fresh, calm water. This conclusion is further strengthened by the occurrence of the fresh-brackish species *Fragilaria construens, Fragilaria pinnata* and *Melosira granulata* with predominantly unbroken frustules, while the number of certain other fresh-brackish diatoms such as *Calonais bacillum, Diploneis ovalis* and *Navicula cincta,* which were formerly always broken, decreases. Moreover, *Pinnularia borealis* and *Pinnularia viridis* make their appearance with few, but always inbroken specimens. The decrease in salinity of the environment to very low values must be associated with the presence of fresh-water pools (rain water?) on the Carolingian surface during a stationary phase in the deposition of the Dunkirk III material.

4.3. Conclusions from the diatom analysis

Although a large number of species of marine, marine-brackish brackish-marine, brackish and brackish-fresh diatoms appears throughout the deposition of layer 2, the fresh-brackish and fresh species – in particular *Fragilaria construens* and *Melosira granulata* – manage to maintain themselves. This fact points to the deposition of marine and brackish sediments from elsewhere, perhaps paired with some silting up of the environment although it remained, perhaps only locally, fresh enough for the survival of the fresh-brackish and fresh types. Later, during a somewhat longer break in the sedimentation of Dunkirk III material, these species were once more able to increase their numbers.

5 HISTORY OF THE LANDSCAPE, ITS VEGETATION AND ITS OCCUPATION

In the history of the landscape four phases can be distinguished, correlated with the layers 1 to 4.

Phase 1: There is an open landscape, consisting of sandy ridges and marshy basins. The water table is high. The sandy ridges are inhabited, but in a few places some trees like oak, ash, lime, elm and hazel are still growing. In the marshy basins swamp forests of alder and willow occur. Near the shore of the fresh-water Lake Wervershoof there is an agricultural occupation which grows wheat and barley. The water level of the lake shows small, periodical changes. Along the shore there is a zone of wet meadows and reed swamps. In this zone the development of alder carr is prevented by cutting and, predominantly, by cattle grazing.

Phase 2: The occupation near the lake shore changes its agricultural emphasis. Instead of wheat and barley, rye now becomes the important crop. The absence of *Centaurea cyanus* pollengrains in the pollendiagram may show that only summer rye is cultivated. (Mikkelsen, 1952; Wagenitz, 1953). The cattle grazing on the shore stops and consequently the alder carr develops quickly. Pollard-willows make their appearance in the landscape, with oak ferns in their tops. The lake stays fresh, but some marine material flows into it, possibly the beginning of the Dunkirk III transgression.

Phase 3: The Dunkirk III transgression inundates the region. This inundation must have been rather slow, as there are no sudden breaks in most of the graphs in the pollendiagram and the environment only becomes somewhat brackish. At any rate, occupation becomes impossible.

Phase 4: There is a temporary break in the transgression. Conditions become fresh again for a short time. Carolingian farmers, growing rye, occupy the former lake shore.

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