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A PALAEONTOLOGICAL STUDY OF A LAYER OF CLAY BENEATH AN INDIGENOUS SETTLEMENT FROM THE ROMAN PERIOD ON THE OUDE RIJN NEAR HAZERSWOUDE

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Dr. H. BRUNSTING, curator of the National Museum of Antiquities in Leiden, enabled the present writer, in April 1951, to study a layer of clay beneath a mound dating from the Roman period, situated at Hazerswoude, about 700 ms south of the Oude Rijn (co-ordinates on the Topographical Map: 99.2 and 459.6; see map no. 1 and no. 2). Dr. BRUNSTING hopes to give further information on the archaeological investigations later on. We only want to mention the date of the oldest (Roman) findings as about 50 years A.D.

The palaeontological study was made in three places situated at some metres distance from each other. They will be indicated here as Haz. A, B and C. Of Haz. A and B the entire layer of clay was analysed, of Haz. C (situated between A and B), by way of trial, only a sample at 2.30 ms—O.D. (O.D. = N.A.P.). The strongly disturbed, entirely dug up clay with remainders of the settlement was not studied. The underlying 60 cms of the clay investigated could be sampled in profiles. About 30 cms of it originated from the layer raised by man. For the sampling of the clay below the ground waterlevel a Dachnowsky sampler was used. It was not possible to take out the humic clay deeper than 140 cms (3.10 ms—O.D.), since the sampler touched a hard layer of wood. Besides clay of the Rijn also two potsherds of the settlement from Roman times were examined for diatoms.

In the following explanation we will discuss first the analytical study, outlined in a table and a pollen diagram. After that follows a short survey of what was discussed.

The tough, heavy clay was highly humous at the bottom, which

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contained much wood and bark of *Alnus*. Higher up the humosity decreased, while the percentage of lime increased. Little alder branches were still found up to 2.40 ms—O.D. At this depth also some *Alnus* fruits, as well as two little branches of *Scorpidium scorpioides* with leaves were found.

The s.c. Phytolitharien (EHRENBERG, 1866), silicified cells of the epidermis of *Gramineae* (GROB, 1896 and BROCKMANN, 1940), indicate growth of grasses.

Mr. VAN DER WERFF examined the samples of Haz. A and B, as well as Haz. C 2.30 ms—O.D. for diatoms. No far-reaching conclusions with a high degree of certainty can be drawn from these analyses, since the number of recognizable specimens was very small, and in the three lower samples even nihil. However, some samples contained a fair number of fragments. We may assume with a fair amount of certainty that the deposition of the highly weathered clay under the settlement took place in an environment influenced by the sea and therefore became brackish now and then, but after that became fresh again for some time. From the small number of marine diatoms (which are often more resistant than most species living in fresh and brackish water) one gets the impression that the marine inundations only had an incidental character. From the oligohalob species found here (see table) it appears that the refreshening process after such inundations, which presumably carried the marine diatoms found, must have been complete or practically complete. This refreshening process must have been rapid, because in the same sample (which for a diatom analysis needs not to be large—in our case about 25 mm^3) species living in brackish water as well as those living exclusively in fresh water were found (the allochthonous species are left out of consideration). Whether such a conclusion is also pedologically justified, still remains a point of discussion, since the extent to which homogenization (HOEKSEMA, 1953) of deposits formed just below the surface of the water is not known.

On the ground of the diatom analysis it is not possible to say with any certainty whether also the water from the river played a part of any importance in this refreshening. Only in two samples (Haz. B and C at 2.30 ms—O.D.), and that in one single specimen, were species found which are abundant in rivers, namely *Melosira italica* and *Meridion circulare*. Both diatoms, however, are not specifically fluvial, least so *Melosira italica*. They were found, both by Mr. VAN DER WERFF and the present writer, several times in young-holocene peat and gyttja in the dunes. A better indication for river influences is the presence of *Coscinodiscus rothii* var. *subsalsa* (Haz. A 2.55 and 2.42 ms—O.D.). According to HUSTEDT (1930) this diatom lives apart from other places in the saltish water of a river mouth. Mr. VAN DER WERFF found the said variety for instance in a recent sample from the Biesbos. However, it is also found in young-holocene marsh deposits (i.a. just beneath the upper peat in the Osdorp polder between Amsterdam and Haarlem).

As to the food content of the water, it could be said that presumably the water has not always been eutrophic. For some diatoms do not find their optimum in a eutrophic environment, namely *Pinnularia nobilis* (optimal in oligotrophic water), as well as *Pinnularia microstauron* var. *brébissonii*. *Melosira arenaria*, *Meridion circulare* and *Melosira italica* (optimal in an oligotrophic or mesotrophic environment).

At 2.50 ms—O.D. (Haz. B) a fragment of *Pediastrum boryanum* was found. This algae species is sometimes found rather abundantly in shallow waters, swamps, etc.

According to information received from Dr. VAN VOORTHUYSEN, in the samples studied by him (Haz. B) no foraminifera were present. The phenomenon that the same samples contained marine diatoms, but no foraminifera, was repeatedly recorded and needs further explanation.

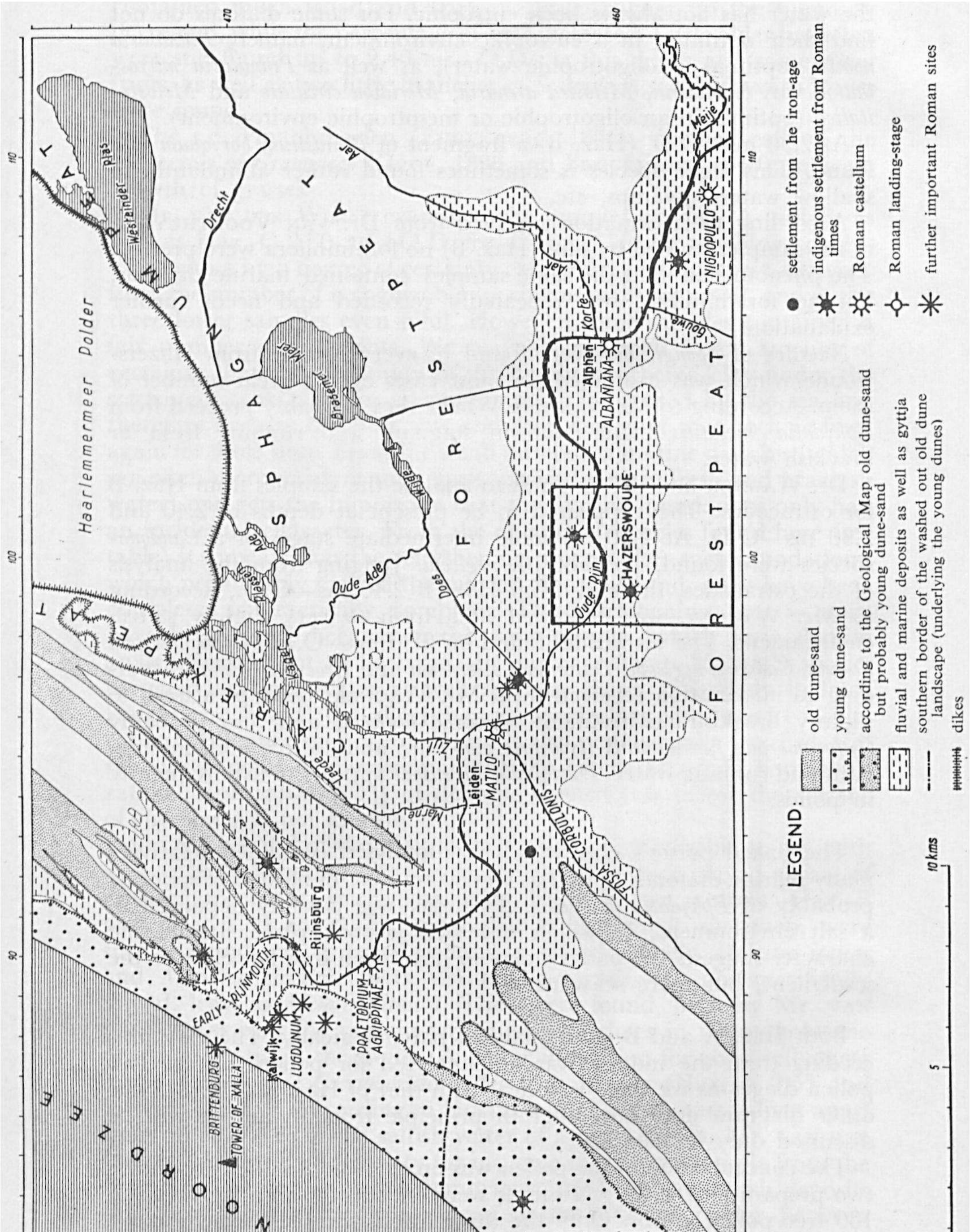
Needles of *Spongillidae* were found in every sample from Hazerswoude which was examined, in most cases even a great number of them. According to Mr. VAN DER WERFF they probably proceed from *Ephydatia fluviatilis* living both in stagnant and running fresh or brackish water.

Dr. WAGNER had the kindness to analyse the samples from Haz. B for ostracodes. They appeared to be present at depths of 2.40 and 2.30 ms—O.D. At 2.40 ms some intermediate stages of a *Candona*-species were found, probably *C. neglecta*. Judging from the analysis of the ostracodes, the clay from Haz. B 2.40 ms—O.D., according to Mr. WAGNER, was deposited in a fresh to very slightly saltish environment. The ostracodes found on 2.30 ms—O.D. (*Cytheromorpha fuscata*, *Candona neglecta*, *Darwinula stevensoni* and *Ilyocypris gibba*), according to information received from Mr. WAGNER, point to a fresh to slightly brackish environment. *Candona neglecta*, and also probably *Cytheromorpha fuscata* and *Ilyocypris gibba* are able to live both in stagnant and running water. *Darwinula stevensoni* appears to live frequently in ponds.

The baked potter's clay which was analysed contained relatively many marine diatoms, as well as a great number of needles of sponges, probably of *Ephydatia fluviatilis*. This clay was possibly deposited in a salt environment, in which refreshening took place. Its marine character suggests the potter's clay to have been dug not close to the settlement, but more seaward.

Both Haz. A and B were analysed palynologically. The clay proceeding from the mound was not analysed for pollen. Of the two pollen diagrams we shall only deal with that of Haz. B (Fig. 3). The other diagram does not differ in principle from it, and it will be discussed only incidentally.

The concentration of the pollen was on the whole sufficient; one or two preparations of 20 × 26 mms were enough for an analysis up to 150 tree pollen grains. Only the three lowest samples, which, as we have already stated, consisted for the greater part of wood, contained little or no pollen.


Haarlemmermeer Polder
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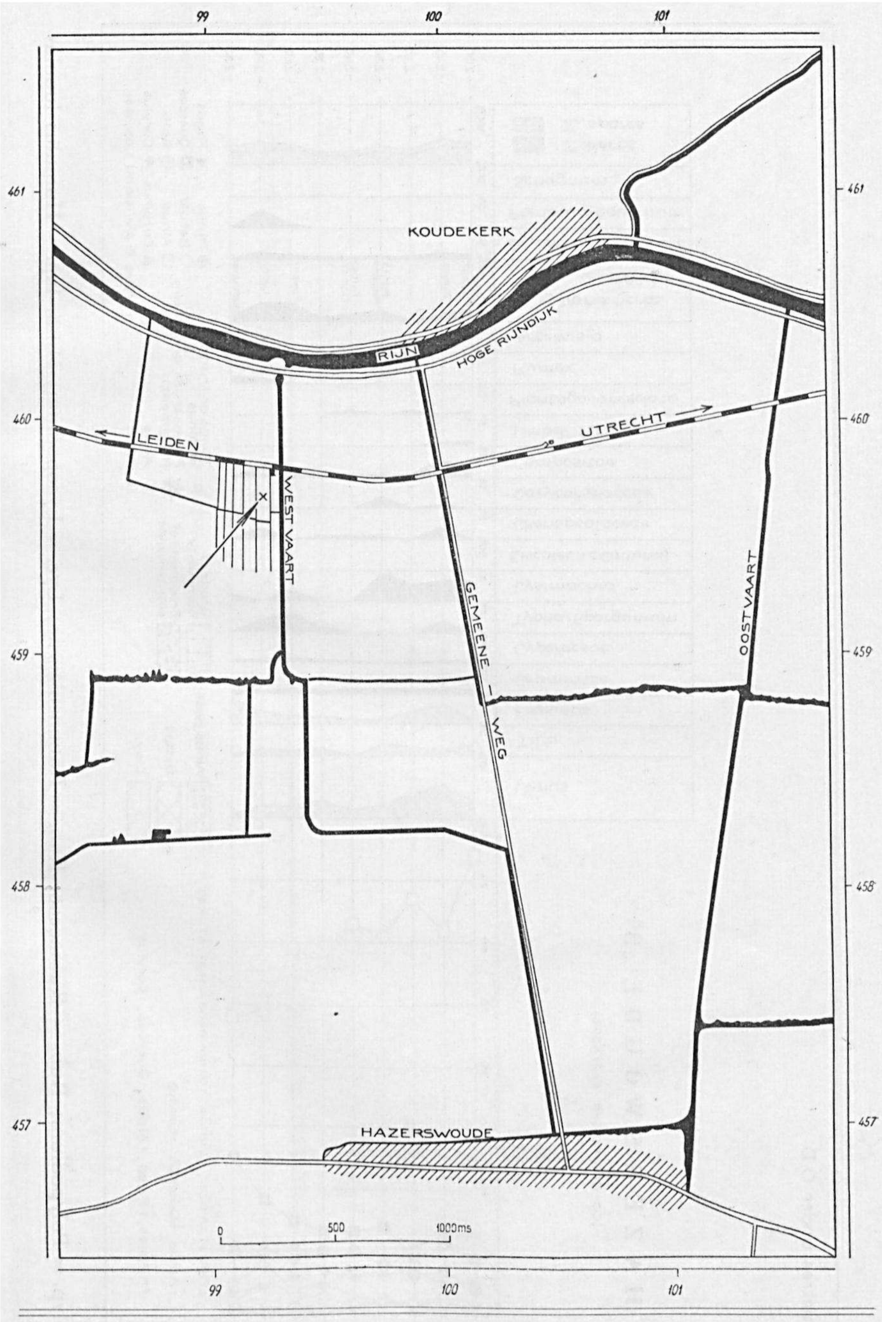
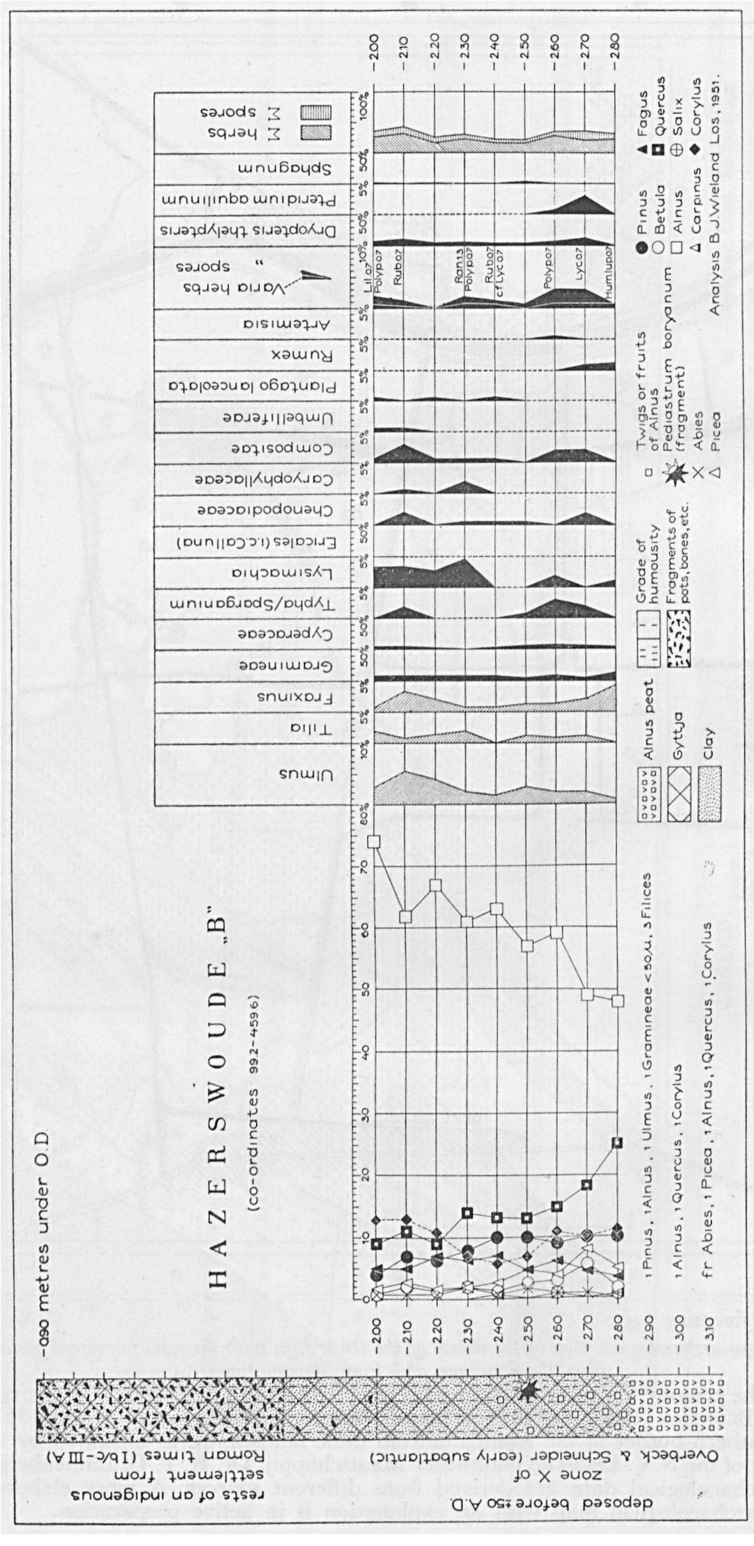
HAZERSWOUDE
NIGROPULLO
CORBULONIS FOSSA
Rijnsburg
Katwijk
LUGDUNUM
PRAETORIUM AGRIPPINAE
BRITTENBURG
TOWER OF KALLA
EARLY RIJNMOUTH
NOORDZEE
SPHAGNUM PEAT
FOREST PEAT
LEGEND:
old dune-sand
young dune-sand
according to the Geological Map old dune-sand but probably young dune-sand
fluvial and marine deposits as well as gyttja
southern border of the washed out old dune landscape (underlying the young dunes)
dikes
settlement from he iron-age
indigenous settlement from Roman times
Roman castellum
Roman landing-stage
further important Roman sites
0
5
10 kms



Map of foregoing page:

General geo-archaeological map of the mouth of the Oude Rijn with the most important findings from the iron age and from Roman times.

As for the geology the present writer used the Geological map (1:50.000), the peat map of BENNEMA (1949) and the soil map from the thesis of VAN DER MEER (1952). The southern border of the washed out old dune landscape was indicated by the director of the N.V. Leidsche Duinwater Maatschappij, Dr. Ir. P. C. Lindenbergh. The archaeological data are derived from different sources. A more elaborate archaeological map with an explanation is in active preparation.



Abbreviations used:
Lil. = Liliaceae; Polyp. = Polypodium; Rub. = Rubiaceae; Ran. = Ranunculaceae; Lyc. = Lycopodium; Hum. lup. = Humulus lupulus

neritic or benthal	epontic	planktonic	oligotrophous	mesotrophous	eutrophous	oligohaline	euryhaline	stenohaline	chloring degree	m — O.D.	Hazerswoude A										B													C
											— 2.35	— 2.42	— 2.50	— 2.55	— 2.62	— 2.70	— 2.85	— 2.90	— 3.00	— 3.10	— 1.70	— 1.80	— 1.90	— 1.95	— 2.00	— 2.10	— 2.20	— 2.30	— 2.40	— 2.50	— 2.70	— 2.90	— 3.10	— 2.30 [8])
										FLAGELLATAE, cysts; (A. van der Werff).															rr									
										DIATOMEAE; (A. van der Werff).																								
×		×			×			×	M	*Aulacodiscus argus* (Ehr.) A.S.				f													f		f					rr
×		×			×		×		M	*Opephora pacifica* (Grun.) Petit																		r						
×		×			×			×	M	*Podosira stelliger* (Bail.) Mann					f											r	rr	rr	f					rr
×		×			×			×	M	*Thalassiothrix* sp. (? *frauenfeldii* Grun.)																								rr
×		×			×			×	M	*Triceratium favus* Ehr.																r		r						
		×			×		×		MB	*Actinoptychus undulatus* (Bail.) Ralfs.																		r						
×		×			×		×		MB	*Diploneis bombus* Ehr.				f																				
		×			×		×		MB	*Hyalodiscus scoticus* (Kütz.) Grun.					rr	rr					rr				r			r	rr					
×		×			×		×		B	1) *Campylodiscus echeneis* Ehr.																								rr
		×			×		×		B	*Coscinodiscus rothii* (Ehr.) Grun. var. *subsalsa* (Juhl-Dannf.) Hust.		f		rr																				
×					×		×		BZ	*Navicula rostellata* Kütz.													rr											
	×	×		×	×		×		ZB	*Cocconeis placentula* Ehr.													rr					r						
	×	×		×	×		×		ZB	2) *Epithemia turgida* (Ehr.) Kütz.																		r	f					
	×	×		×	×		×		ZB	3) *Epithemia zebra* (Ehr.) Kütz.																rr								
×		×		×	×		×		ZB	4) *Gyrosigma attenuatum* (Kütz.) Rab.															f									
		×	×	×		×			ZB	*Melosira italica* (Ehr.) Kütz.																		o						
		×	×	×		×			ZB	5) *Meridion circulare* (Grev.) Ag.																								rr
×		×		×	×		×		ZB	*Surirella ovata* Kütz.		rr																						
×	×	×		×	×		×		ZB	*Synedra ulna* (Nitzsch) Ehr.													rr											rr
×		×	×	×		×			Z	6) *Melosira arenaria* Moore; (B. J. Wieland Los)														rr										
×		×	×	×		×			Z	*Pinnularia microstauron* (Ehr.) Cl. var. *brébissonii* (Kütz.) Hust.											rr													
×		×	×	□		×			Z	7) *Pinnularia* sp. (? *nobilis* Ehr.)																		r						
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		×		□	×				ZB	*Pediastrum boryanum* (Turp.) Menegh.; (B. J. Wieland Los)																				f				
										BRYOPHYTA; (Prof. Dr. R. van der Wijk)																								
				×	(k) ×				Z	*Scorpidium scorpioides* (Hedw.) Limpr.																			•					
										ANGIOSPERMAE.																								
									MBZ	"Phytolitharien"; (A. van der Werff).																			r					
										rootlets of *Carex* sp.		•																						
									(M–B)Z	fruits of *Carex* (div. sp.)												3												
									(ZB–Z)	*Alnus* sp., twigs.																			rr	r	+	cc	cc	
				□	×	×			(ZB–Z)	*Alnus* sp. (? *glutinosa* Gaertn.), fruits																			4					
										FORAMINIFERA; (Dr. J. H. van Voorthuysen)																								
	×			×	×		×		B–ZB	*SPONGILLIDAE*, needles, probably of *Ephydatia fluviatilis* L; (A. van der Werff).	r	r	r	r	r	r	+	+	r	r	+	r	r	+	+	+	+	+	r	r	r	r	r	c
										OSTRACODA; (Dr. C. W. Wagner).																								
×						×	×		ZB	*Cytheromorpha fuscata* (B.)																		a)						
×						×	□		ZB	*Candona neglecta* Sars																		b)						
									(ZB)	*Candona* cf. *neglecta* Sars																			c)					
×						×			ZB	*Darwinula stevensoni* B. et R.																		d)						
×						×			ZB	*Ilyocypris gibba* (Ramdohr)																		e)						
										MOLLUSCA; (Dr. C. O. van Regteren Altena)																								
										undeterminable, thin-walled fragments.																								f

										Analyses on fragments of "Fries-Batavian" pottery; (A. van der Werff)	fragm. no 1	fragm. no 2
×		×								*FLAGELLATAE*, cysts	r	
										DIATOMEAE		
×		×			×			×	M	*Aulacodiscus argus* (Ehr.) A.S.	r	r
×		×			×			×	M	*Melosira sulcata* (Ehr.) Kütz.		r
×		×			×			×	M	*Melosira westii* W. Sm.	r	
×		×			×			×	M	*Podosira stelliger* (Bail.) Mann	r	r
×		×			×			×	M	*Triceratium favus* Ehr.	r	r
	×		×	□					Z	9) ?*Melosira roeseana* Rabh.	r	
										Diploneis sp.	f	
	×			×	×		×		ZB	*SPONGILLIDAE*, needles, probably of *Ephydatia fluviatilis* L.	c	c

a) 1 ad. ♀, some juv. b) 6 ad. ♀, 1 ad. ♂?, 20 juv. c) some juv. d) 2 ad. e) 1 ad., 1 juv.

1) *Campylodiscus echeneis* Ehr. According to Cleve-Euler (1952) also found in almost fresh water, according to Mr. van der Werff optimal in saltish water. A typical representative of sandy coastal districts, (muddy) sand-banks, etc., in our case probably allochthonous.

2) *Epithemia turgida* (Ehr.) Kütz. According to Cleve-Euler (1952) very frequent in slightly brackish water.

3) *Epithemia zebra* (Ehr.) Kütz. According to Cleve-Euler (1952) very frequent in fresh water, seldom in brackish water. Mr. van der Werff informed me that, with respect to the degree of salinity, he has found little or no difference between *E. turgida* and *E. zebra*.

4) *Gyrosigma attenuatum* (Kütz.) Rab. According to Cleve-Euler (1952) typical of its "clear water flora". However, Mr. van der Werff found this diatom also at Abcoude, where the water is in general not clear. *G. attenuatum*, according to Cleve-Euler, is minerotrophic.

5) *Meridion circulare* (Grev.) Agardh. According to Cleve-Euler (1953) not present in big lakes and calciphilous; according to Mr. van der Werff and the present writer the latter is not obligatory.

6) *Melosira arenaria* Moore. According to Hustedt (1930) frequently found on the shores of European lakes, particularly on flat, sandy shores, sometimes also in rivers and ditches. Cleve-Euler (1952) considers this species typical of clear water. She found it more frequently as a fossil than as a recent species. In our country Mr. van der Werff has not yet found living species of *Melosira arenaria*. He did find it in a sandy deposition of a pond of the former country-seat *Velserhooft* (XVIIth and XVIIIth century) at Velsen (a study by the present writer in 1954).

7) *Pinnularia nobilis* Ehr. According to information received from Mr. van der Werff sometimes also in a mesotrophic environment, e.g. in the Oosterwijk ponds. According to Cleve-Euler (1953) in lakes and swamps. In this case no trophic-indication was given.

8) analysis B. J. Wieland Los.

9) *Melosira roeseana* Rabh. Aerophilous (Cleve-Euler, 1951; Weckering, (1953), cold stenothermic (Cleve-Euler, 1951) fresh water diatom, which is especially found in mosses and on inundated stones (Hustedt, 1930), and authors mentioned before), e.g. humous rocks and mosses along the banks of brooks, naturally in the mountains in particular, less in the low-lying plain (Hustedt, 1930).

Abbreviations used (chloring degree mg/l)
M = 18.000; MB = 18.000–10.000; B = 5.000–1.000; BZ = 1.000–500; ZB = 500–100; Z = 100

• = present; + = common; c = very common; cc = abundantly; rr = extremely rare; r = rare; f, ff = fragment(s); o = cyst; juv. = juvenal; ad. = adult; × = regularly found in a specific environment; □ = occasionally found in a specific environment ;(k) = facultative calciphilous.

The pollen had generally been well preserved. Only at the dephts of 2.50 and 2.30 ms—O.D. the material was slightly affected.

The percentages of *Fagus* are characteristic of the beginning of the subatlantic of the central and northern parts of the Netherlands. The low *Carpinus* values point to period X of OVERBECK and SCHNEIDER (cf. VAN ZEIST, 1955), with which in general the subatlantic is considered to begin. Further it is notable that higher up *Alnus*, which dominates in our diagram, increases at the cost of *Quercus*. The percentages of *Ulmus* correspond more or less with those which are found in general in subboreal and subatlantic spectrums in our country, those of *Tilia* are somewhat higher. No conclusion about the presence of this tree in the area around the mouth of the Oude Rijn—WATERBOLK (1954) even presumes that *Tilia* disappeared from our natural vegetation in the course of the subboreal—can be drawn from it, because we have to consider the appearance of secondary pollen. An indication of it are the relatively high percentages of pollen of *Picea* and *Abies*, trees which presumably are not indigenous. In our case the *Picea*- and *Abies* pollen will most likely not have been carried by air, but by water. A similar phenomenon was found by FLORSCHÜTZ and JONKER (1939) in postboreal (river)clay near Wijk bij Duurstede. In this case there were moreover high percentages of *Pinus*, whilst the *Fagus* curve was irregular. In our case neither is the case. FLORSCHÜTZ and JONKER think it probable that part of the pollen contained in the clay analysed by them was brought down from the woods of the upper Rijn. They drew the attention to the fact that *Picea*, *Abies* and *Fagus* strongly extended there during the atlantic and subboreal. Besides this hypothesis of FLORSCHÜTZ and JONKER there is still one of POLAK (1936*a* and *b*), namely that deposits rich in *Picea*- and *Abies* pollen are washed by a river or by the sea and that the pollen liberated by it is deposited on other places. This latter theory was suggested by FLORSCHÜTZ (1953), who found *Picea* pollen in a deposit from the aeneolithic period at Hekelingen (situated about 12 kms southwest of Rotterdam). Not only from a detailed survey made by BENNEMA (1953), but also from a diatom analysis by the present writer, it has appeared that besides marine influences, also fluvial influences (estuary) have played a part in this place, so that it is possible that just as in Wijk bij Duurstede the *Picea* pollen was brought down by the Oude Rijn. To me this seems the most plausible explanation for our diagram. More seaward, however, namely near the castellum of Valkenburg (*Praetorium Agrippinae*, see map no. 1), it was the sea, according to VAN ZEIST (1953) which brought secondary pollen (also of *Pinus*).

The percentages of non-arboreal-pollen and spores are low, which points to a woody environment. From the low *Chenopodiaceae* values it appears that also in the Hazerswoude area marine influences (which, as we have seen when speaking of the diatom analyses, must have occurred on the spot in small numbers) were not important. When judging the *Chenopodiaceae* curve, we must bear in mind that a number of *Chenopodiaceae* are not halophilous or need not be represented as such.

Lysimachia was common. The *Lysimachia* species grow in an mesotrophic or eutrophic environment, in humid soil or in a moor and are not anemophilous. The relatively rather high percentages suggest that *Lysimachia* lived on the spot or very near to it. Of *Typha* which will no doubt have been present in this wet environment pollen was found several times. *Humulus lupulus* fits well in an alder wood. As to *Polypodium*, one would think rather of a place with oaks. The spores of *Pteridium aquilinum* will probably have proceeded from plants growing in the dunes.

Plantago lanceolata was found three times in the two diagrams, which means 2 ‰ on a average. In early subatlantic spectrums of the upper peat near Zaandam I found it more frequently (up to 3 %). Compared with Kennemerland the area of the Oude Rijn was therefore thinly populated, or rather cattle-breeding was of little significance.

Summarizing the foregoing, we may say that the subatlantic humous clay-gyttja analysed by us (dating before the first decades of the first century) was deposited in a wooded area, namely in a shallow, overgrown pool, which contained on the whole eutrophic water, but which presumably was sometimes a little less nutritious. The water was often fresh, though sometimes mesohalinic to polyhalinic; the latter probably only after high tides. The complete change into fresh water suggests that there was a regular mixing with fresh water. The place studied may have been a quiet spot near the mouth of a river in the sense of VINK (1926), i.e. a broad stream, now not running at all, now running slowly, connected with the middle course of a river and receiving nutrition salts from it, and carrying silt only at high tide.

The water level must have gradually risen. Owing to the depositing process however, the depth of the water did not increase considerably. A raise of the water level around Hazerswoude is the most plausible explanation of the phenomenon established by us by means of the pollen analysis that the oak wood was replaced by an alder wood.

During the silting-up of the area around Hazerswoude it was insuitable for habitation. So far we know in the entire area of the Oude Rijn only one settlement from the (pre-Roman) iron age. In the Roman period, however, this area was relatively densily populated (see map). This does not only apply to the levee soils, where we may expect older settlements as well, but also to the clay area. Before man settled here, however, he first raised the level of the earth. Since the inhabitants must have had arable land and meadows, too, we can safely assume that regular human habitation was only possible after a fall of the water level.

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