

**PLANT MACROFOSSILS OF THE BOREHOLE AT ZUURLAND, BRIELLE,
SW NETHERLANDS (INTERIM REPORT OF THE SECTION -5 TO -63 M)**

by

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Plant macrofossils found in the Zuurland borehole were studied. Seeds, fruits, megaspores etc., belonging to at least 80 different species were encountered in samples between -5 and -63 m. The plant species belong to brackish-, freshwater-, and (dry) land-communities. Most of them could well have grown in a river valley. Several characteristic interglacial species, as for example *Brasenia schreberi* Gmel., *Vitis sylvestris* Gmel., *Phellodendron elegans* Reid, *Actinidia faveolata* Reid, *Pterocarya fraxinifolia* (Lamarck) Spach and *Proserpinaca reticulata* Reid were found. From the top of the borehole down to -23 m the fossils are of Holocene age, below -23 m the age is Pleistocene. From -42 m to -63 m the species indicate an Early Pleistocene age.

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CONTENTS	Samenvatting, p. 39
	Introduction, p. 40
	Results, p. 41
	Discussion and conclusions, p. 44
	Acknowledgement, p. 46
	References, p. 47.

SAMENVATTING

Plantenresten uit de boring Zuurland te Brielle, ZW Nederland (interim rapport van het gedeelte -5 tot -63 m).

Een voorlopig overzicht wordt gegeven van de plantensoorten die als zaad, vrucht of megaspore zijn gevonden in de boring Zuurland-2. Verdere analyse zal het aantal zaden en waarschijnlijk ook het

aantal soorten nog doen toenemen. Tenminste 80 soorten werden tot nu toe in de monsters tussen 5 en 63 m aangetroffen. Zij wijzen op de vroegere aanwezigheid van diverse brakwater-, zoetwater- en landmilieus. Veel soorten zullen in het dal van een grote rivier hebben gegroeid. Een aantal planten heeft hier gedurende interglaciale perioden geleefd, zoals *Brasenia schreberi* (kleine rode waterlelie), *Vitis sylvestris* (wilde druif), *Phellodendron elegans* (kurkboom), *Actinidia faveolata* (straalstempel), *Pterocarya fraxinifolia* (vleugelnoot) en *Proserpinaca reticulata*. Zij zijn hier nu uitgestorven. De in de bovenste 23 meter aangetroffen soorten wijzen op een Holocene ouderdom. Van -42 tot -63 m zijn planten aanwezig die kenmerkend zijn voor het Vroeg Pleistoceen.

INTRODUCTION

From the beginning of 1984 Mr L.W. Hordijk has been working on a borehole in the polder of Zuurland (Hordijk, 1985, 1986). The drilling locality is situated at a distance of some 1.5 km from the city of Brielle (Fig. 1). The mainly sandy Quaternary deposits were analyzed for their fossil contents in cooperation with various specialists (Gaemers, 1988; de Jong, 1988b; van Kolfshoten, 1988; Meijer, 1988). Historical, lithological, lithostratigraphical and sediment-petrological information on this borehole is given by Burger (1988), Burger *et al.* (1988), de Jong (1988a) and Hordijk (1988). The plant macrofossils discussed here were encountered in samples taken from intervals of 1 m. Thanks to the procedure of sediment upwelling Mr. Hordijk often succeeded in obtaining rather large samples. This technique was especially applied to highly fossiliferous intervals. As a result the



Fig. 1. Situation of the Zuurland-2 borehole at Brielle, province of Zuid-Holland, The Netherlands.

amounts of fossils in the various samples are not comparable. The samples were taken with a bailer and washed on a 0.4 mm mesh sieve. The residue was dried and analyzed using a binocular microscope. Only seeds, fruits, cones, megaspores, etc. were identified, not wood and buds; leaves were not found. The analysis is highly time-consuming and has not yet been completed. As a consequence the number of specimens recognized in the section of -20 m to -63 m may rise on continuation of the analyses. Also additional species are likely to be found.

Thanks to numerous pollen studies, the vegetational history of The Netherlands during the Pleistocene is rather well-known. However, our knowledge of plant macrofossils is still poor. The latter often give more information on species level than pollen. Moreover, macrofossils also give better evidence of the in situ presence of plant species.

A pioneering contribution to the knowledge of the Pleistocene seed flora of The Netherlands was made by van der Vlerk & Florschütz (1950). They outlined the then known plant macrofossils of presumed Tiglian, Needian (= Holsteinian), Drenthian (= Saalian), Eemian and Tubantian (= Weichselian) deposits. Afterwards more data became available about the Tiglian (van der Hammen, 1951; Zagwijn, 1963), the Holsteinian (Zagwijn, 1978) and the Eemian (van Geel *et al.*, 1986). The research of the Zuurland-2 borehole offered the opportunity to extend our knowledge on the Quaternary floras.

RESULTS

The quantity of material in the different samples varies considerably, partly due to the sampling technique mentioned above. The plant macrofossils comprise mainly rounded and flattened pieces of branches and twigs, roots, fibers, bark etc. Amongst these, the often badly preserved seeds were encountered. Their number varies from zero to several hundreds of specimens in the various samples. Data about all species present, with a description of their fossil remains, will be published in greater detail in a paper covering the completed borehole.

As yet the following species were found:

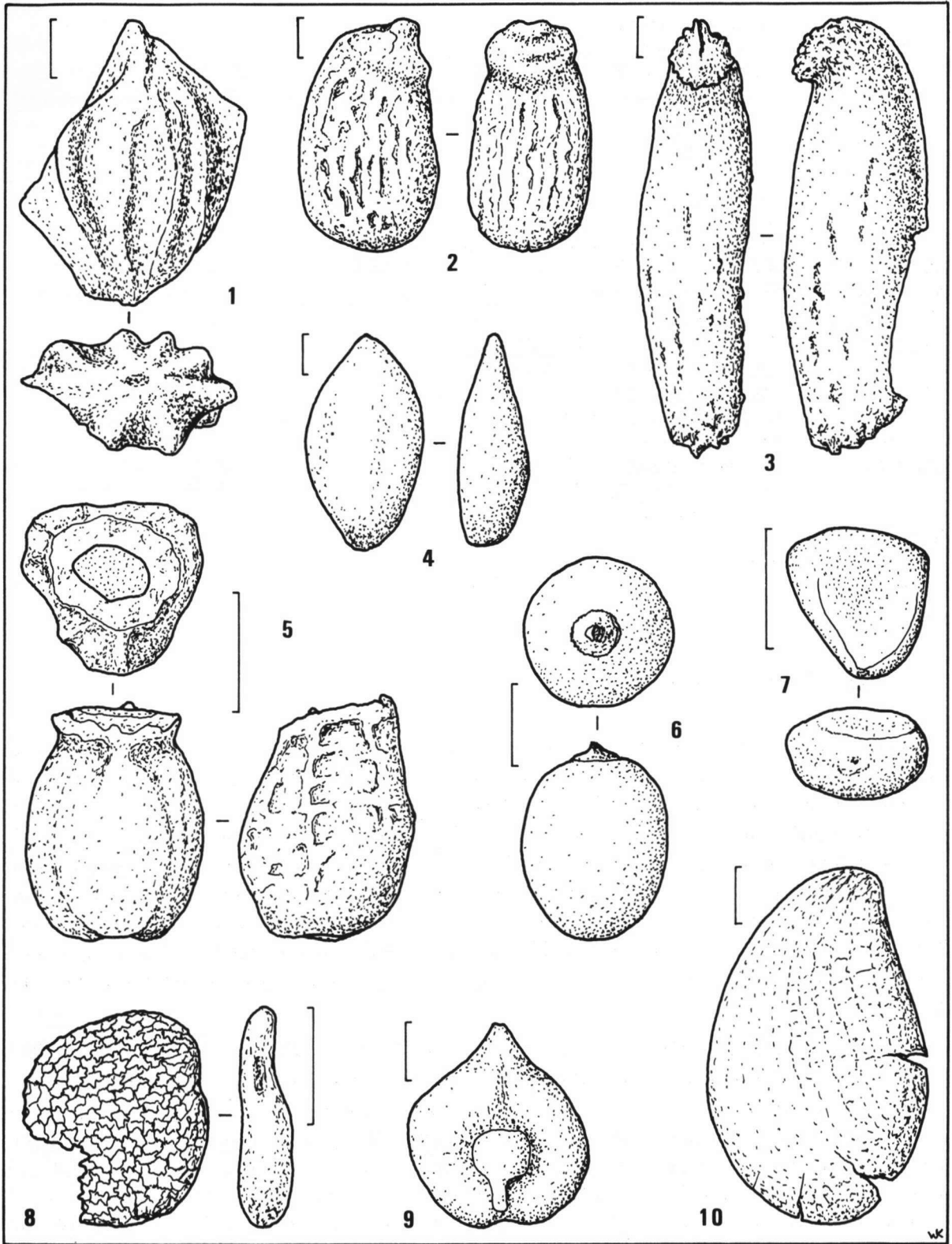
Aceraceae	<i>Acer</i> sp.
Actinidiaceae	<i>Actinidia faveolata</i> Reid
Azollaceae	<i>Azolla filiculoides</i> Lamk
Betulaceae	<i>Alnus glutinosa</i> (L.) Gaertner
	<i>Betula</i> sp.
	<i>Carpinus betulus</i> L.
	<i>Corylus avellana</i> L.
Cannabaceae	<i>Humulus lupulus</i> L.
Caprifoliaceae	<i>Sambucus ebulus</i> L.
	<i>Sambucus nigra</i> L.
Caryophyllaceae	<i>Stellaria media</i> L.
Ceratophyllaceae	<i>Ceratophyllum demersum</i> L.
	<i>Ceratophyllum submersum</i> L.
Characeae	<i>Chara</i> sp.
	<i>Tectochara</i> sp.
Chenopodiaceae	<i>Atriplex littoralis</i> L.-type
	<i>Atriplex patula</i> L./ <i>prostrata</i> Boucher ex DC.
	<i>Chenopodium album</i> L.
	<i>Chenopodium polyspermum</i> L.
	<i>Suaeda maritima</i> (L.) Dum.

Cornaceae	<i>Cornus sanguinea</i> L.
Cyperaceae	<i>Carex</i> sp. div. <i>Cladium mariscus</i> (L.) Pohl <i>Scirpus lacustris</i> L. <i>Scirpus maritimus</i> L.
Droseraceae	<i>Aldrovanda vesiculosa</i> L.
Euphorbiaceae	<i>Euphorbia</i> cf <i>palustris</i> L.
Fagaceae	<i>Quercus</i> sp.
Gramineae	<i>Glyceria</i> sp.
Gunneraceae	<i>Proserpinaca reticulata</i> Reid (Pl. 1, Fig. 5)
Guttiferae	<i>Hypericum</i> sp.
Haloragaceae	<i>Myriophyllum</i> sp.
Hippuridaceae	<i>Hippuris vulgaris</i> L.
Hydrocharitaceae	<i>Stratiotes aloides</i> L. (Pl. 1, Fig. 3) <i>Stratiotes</i> cf <i>kaltenordheimensis</i> (Zenker) Keilhack (Pl. 1, Fig. 2)
Juglandaceae	<i>Pterocarya fraxinifolia</i> (Lamarck) Spach (Pl. 1, Fig. 1)
Labiatae	<i>Ajuga reptans</i> L. <i>Galeopsis</i> sp. <i>Lycopus europaeus</i> L. <i>Stachys palustris</i> L.
Lythraceae	<i>Decodon globosus</i> (Reid) Nik. (Pl. 1, Fig. 7)
Menyanthaceae	<i>Menyanthes trifoliata</i> L.
Najadaceae	<i>Najas marina</i> L.
Nymphaeaceae	<i>Brasenia schreberi</i> Gmel. (Pl. 1, Fig. 6) <i>Nymphaea alba</i> L. <i>Nuphar lutea</i> (L.) Sm.
Onagraceae	<i>Trapa natans</i> L.
Papaveraceae	<i>Fumaria officinalis</i> L.
Pinaceae	<i>Pinus sylvestris</i> L. (Pl. 1, Fig. 4)
Polygonaceae	<i>Polygonum lapathifolium</i> L. <i>Rumex hydrolapathum</i> Hudson <i>Rumex</i> sp.
Potamogetonaceae	<i>Potamogeton</i> sp. div. <i>Ruppia maritima</i> L. <i>Zannichellia palustris</i> L.

Plate 1. Borehole Zuurland-2, Brielle. Seeds and fruits.

1. *Pterocarya fraxinifolia* (Lamarck) Spach (-55 to -56 m).
2. *Stratiotes* cf *kaltenordheimensis* (Zenker) Keilhack (-32 to -33 m).
3. *Stratiotes aloides* L. (-42 to -43 m).
4. *Pinus sylvestris* L. (-28 to -29 m).
5. *Proserpinaca reticulata* Reid (-54 to -55 m).
6. *Brasenia schreberi* Gmel. (-35 to -36 m).
7. *Decodon globosus* (Reid) Nik. (-52 to -53 m).
8. *Physalis alkekengi* L. (-54 to -55 m).
9. *Vitis sylvestris* Gmel. (-42 to -43 m).
10. *Phellodendron elegans* Reid (-15 to -52 m).

Bar length represents 1 mm.



Ranunculaceae	<i>Ranunculus aquatilis</i> L.-type <i>Ranunculus</i> cf <i>flammula</i> L. <i>Ranunculus repens</i> L. <i>Ranunculus sceleratus</i> L. <i>Thalictrum flavum</i> L. <i>Thalictrum minus</i> L.
Rosaceae	<i>Potentilla</i> sp. <i>Prunus spinosa</i> L. <i>Rubus caesius</i> L. <i>Rubus fruticosus</i> L. <i>Rubus</i> sp.
Rutaceae	<i>Phellodendron elegans</i> Reid (Pl. 1, Fig. 10)
Salicaceae	<i>Salix</i> sp.
Salviniaaceae	<i>Salvinia natans</i> (L.) All.
Selaginellaceae	<i>Selaginella</i> sp.
Solanaceae	<i>Physalis alkekengi</i> L. (Pl. 1, Fig. 8) <i>Solanum dulcamara</i> L.
Sparganiaceae	<i>Sparganium erectum</i> L. <i>Sparganium minimum</i> Wallr.
Thymelaceae	<i>Daphne mezereum</i> L.
Umbelliferae	<i>Aethusa cynapium</i> L. <i>Heracleum sphondylium</i> L. <i>Oenanthe aquatica</i> (L.) Poiret
Urticaceae	<i>Urtica dioica</i> L.
Violaceae	<i>Viola</i> sp.
Vitaceae	<i>Vitis sylvestris</i> Gmel. (Pl. 1, Fig. 9)

DISCUSSION AND CONCLUSIONS

The majority of the macrofossils is badly preserved. Many of the seeds were flattened by post-depositional compression. Abrasion of the material must be due to water transport. This is confirmed by the fluvatile aspect of the associations (see below), but also by the absence of many species with fragile seeds and a thin seed coat in combination with the rather large numbers of hard coated seeds. The latter contrast clearly points to a selection by water transport. The species found, and the nature of the sediments, demonstrate that the facies was fluvially influenced. However, especially in the upper part of the borehole some plants from marine environments occur: *Ruppia maritima*, *Atriplex littoralis* and *Suaeda maritima*. This section (Holocene) is therefore assumed to have been deposited in a brackish to marine environment. Likely the site was located in a marine area close to the outlet of a river.

Indications of marine influences were also found near -54 m and between -62 m and -63 m. This implies that the conclusion of Meijer (1988, this volume), based on a study of the molluscs, that most of the sediments in the Zuurland-2 borehole were deposited under marine influenced conditions, is, at first glance, not confirmed by the plant macrofossils. Many of the plant species encountered, flourish in environments commonly found in the valleys of large rivers. Plant remains were derived from stagnant to running water (mainly nutrient-rich) environments, from marshy banks and swamps, from low vegetations and from more woody areas on somewhat higher grounds. This indicates that presumably one or more river valleys, with a wide variety in vegetation, existed repeatedly in the neighbourhood (East) of Zuurland during the Pleistocene.

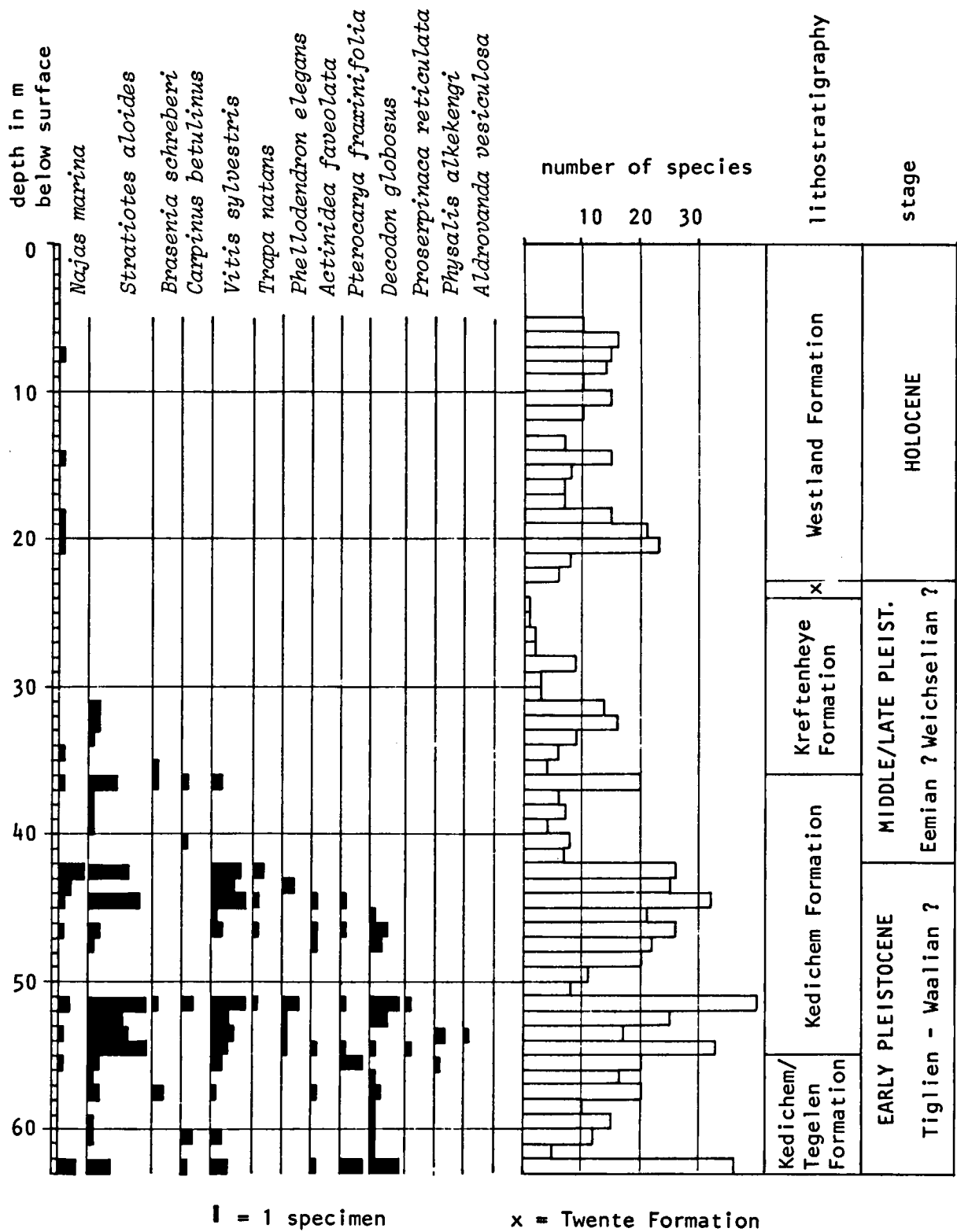


Table 1. Plant macrofossils of borehole Zuurland-2 at Brielle, The Netherlands. Distribution of some characteristic species, number of species, lithostratigraphy and provisional chronostratigraphy.

Today, several of the species found are remarkably missing in the flora of this part of Europe, others are even extinct. Obviously the Pleistocene vegetation differed in composition and in diversity from the Recent flora. This holds especially for the Early Pleistocene.

Several species, distinctive for interglacials, were found. Especially *Actinidia faveolata*, *Aldrovanda vesiculosa*, *Azolla filiculoides*, *Brasenia schreberi*, *Decodon globosus*, *Phellodendron elegans*, *Physalis alkekengi*, *Proserpinaca reticulata*, *Pterocarya fraxinifolia*, *Salvinia natans*, *Stratiotes aloides*, *Trapa natans*, and *Vitis sylvestris* point to a climate warmer than today. Plants, distinctive for cold periods (glacials) were not found. The low number of species between -23 m and about -30 m and the presence of *Pinus sylvestris* and *Betula* sp. between -28 m and -33 m probably indicates a cool climate. The sediments of this part could well have been deposited during a mild part of a glacial or during the cool marginal periods at the beginning or end of an interglacial.

Down to a depth of -23 m the species found are also common in the present-day flora. This matches well the results of analyses of Holocene deposits elsewhere in the Dutch coastal area. This, and also data on the geology of the area (van Staaldin, 1979), leads to the conclusion that this part of the borehole represents the Holocene. A subdivision on the basis of plant macrofossils is not possible. Between -23 m and -31 m the sediment yielded a low number of seeds. As mentioned above, the pine and the birch were found between -28 m and -33 m. This might indicate a cool period, Weichselian or Late Eemian. Below -31 m the first interglacial species was found: *Stratiotes aloides*. Near -36 m more interglacial species, *Brasenia schreberi*, *Carpinus betulus* and *Vitis sylvestris* were found. The flora indicates an Eemian age.

Downwards, apart from two poor intervals near -40 m and -50 m, more thermophilous species occur. Below -42 m the species indicate an Early Pleistocene age. Worth mentioning are *Proserpinaca reticulata* (Pl. 1, Fig. 5), *Actinidia faveolata*, and *Phellodendron elegans* (Pl. 1, Fig. 10). These are Tertiary relicts, which had a last occurrence in Europe during the Early Pleistocene. In The Netherlands they are only known from the Tiglian.

Evidently the borehole has cut into deposits of mainly interglacial origin. To interpret the alternation of levels with abundant and with few fossils and the presence or absence of interglacial species is not an easy task. Are these phenomena the result of fluvial sedimentary processes, including redeposition, or do the different floras reflect changing climate and age? The latter possibility seems more acceptable if the actual depth is taken into consideration together with the associations recovered. Consequently the Tertiary *Stratiotes* cf. *kaltennordheimensis* (Pl.1, Fig. 2) must have been reworked. This, however, confirms that redeposited material is present indeed.

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