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A LATE-GLACIAL LAKE DEPOSIT NEAR WASKEMEER (PROV. OF FRIESLAND)

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The numerous bowl-shaped, sometimes fairly deep depressions which may be wholly or partly filled with organic sediments constitute a characteristic feature in the ground moraine landscape of the northern Netherlands. As for the origin of these depressions, some of them were supposed to be kettle-holes (*cf.* De Waard 1947), while others were regarded as the product of wind erosion during the last part of the Late-glacial (Veenenbos 1952). As it was during the Riss (Penultimate) glaciation that a part of the Netherlands was covered by the ice cap, it was difficult to understand why interglacial (Eemian) peat or gyttja is never found in the depressions considered to be kettle-holes, but only organic deposits from the Late-glacial and later. In place of the kettle-hole theory another hypothesis for the origin of this last type of depression was brought forward by Maarleveld and Van den Toorn (1955). According to these authors, some of the depressions in the northern Netherlands are to be interpreted as the remains of pingos.

Today the formation of pingos takes place in the tundra area of Alaska, Greenland and Siberia, *i.e.* in regions with a permanently frozen subsoil. Pingos are round to oval mounds with a core of ice and water. Although they are mostly much smaller, they can reach a diameter of more than 1000 m and a height of 100 m. The formation of these hills must be ascribed to the forces which come into play during the re-freezing of the water-logged topsoil thawed in summer. When, during the summers, the ice in the core melts off, the pingo collapses, and eventually a hollow is left in the soil. The depression is often surrounded by a ridge, the soliflucted material of the pingo skin (for literature see Maarleveld and Van den Toorn 1955). Such a ridge has in fact been observed around some hollows in the ground moraine landscape of the northern Netherlands.

Terrain depressions formed during the Pleni-glacial would probably have been filled with sand within a comparatively short time. It would not have been until the transition from the Pleni-glacial to the Late-glacial that a more considerable deposition of organic material in pingo remnants began.

The depression filled with gyttja and peat from which was taken the profile to be discussed in this paper is situated 1.3 km northwest of the

[1]) Mr. P. Houtsma of Waskemeer kindly drew our attention to this deposit.

town of Waskemeer.[1]) 400 m south of the sampling spot lies the "Ganzemeer", one of the finest examples of a pingo remnant in this region (Fig. 1).

The Waskemeer diagram is composed according to the method introduced by IVERSEN (1942) for late-glacial diagrams. This diagram (Fig. 2) shows much resemblance to others published from the northern Netherlands (VAN DER HAMMEN 1949, 1951; DE PLANQUE 1949/50; WATERBOLK 1954; VAN ZEIST 1955). Consequently a general discussion of this diagram can be omitted and only some points will be touched upon.

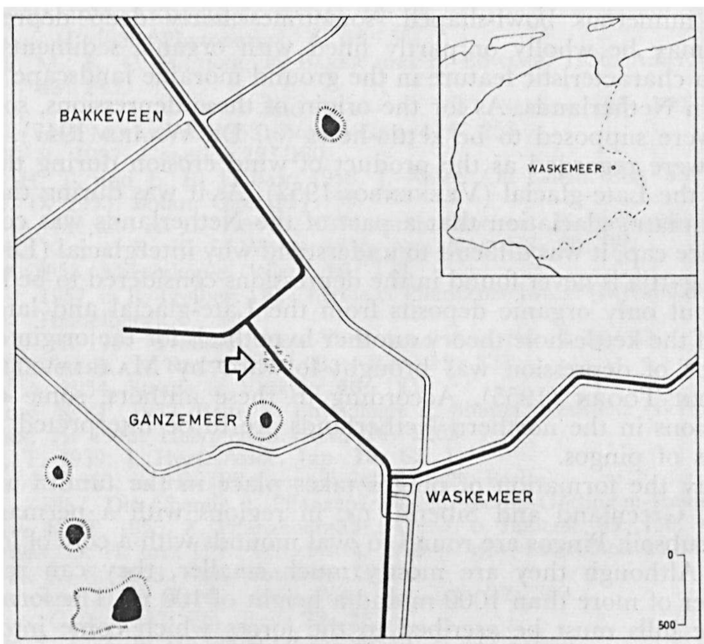


Fig. 1. Map of the Waskemeer region. The sampling spot is indicated by the arrow.

Zone II shows two *Pinus* maxima, suggesting a short deterioration of climate during the comparatively favourable Allerød time. As in several diagrams from Denmark *Betula* has a forked graph in Allerød time IVERSEN has already arrived at a tripartition of zone II, namely two relatively warm phases separated by a colder one (*cf.* KROG 1954). In the Waskemeer diagram this oscillation during the Allerød period would also be demonstrated for the northern Netherlands.

In the diagram of Fig. 2 the first *Pinus* maximum coincides with the presence of a small quantity of rebedded pollen of thermophilous trees. As with the exception of the lowermost samples pollen of certainly secondary origin is relatively scarce in this deposit it may be wondered whether the first *Pinus* maximum could be caused by rebedded *Pinus* pollen. The curves for *Pinus* and for the sum of the certainly secondary pollen (*Alnus*, *Quercus*, *Tilia*, *Ulmus*, *Picea*, *Juglans*) in the lower part of the Waskemeer diagram (zones I, II and the beginning of III) are represented in Fig. 3. In contrast to those of Fig. 2 the pollen frequencies are shown here as percentages of the total tree pollen sum. The secondary pollen would for the greater part be derived from the boulder clay. As from this region no pollen analyses of boulder clay samples are available the correction method worked out by IVERSEN (1936) cannot be applied here. Nevertheless it is possible to determine whether the first *Pinus* maximum could be effected by contamination with rebedded pollen or not.

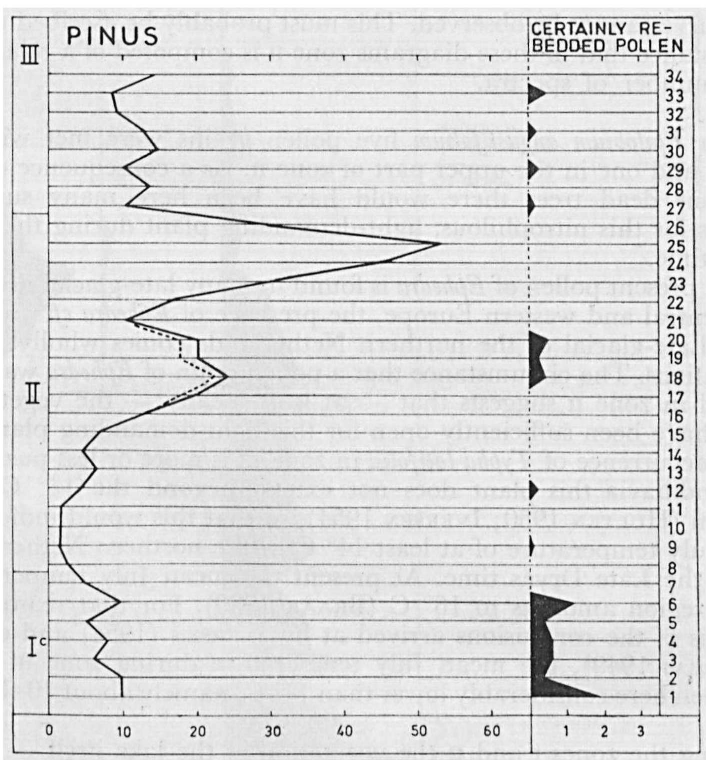


Fig. 2. For explanation see text.

As the amount of certainly secondary pollen is very low calculations carried out on the basis of this pollen will obviously be rather inaccurate. In the samples 1 to 7 (zone I) a total of 196 pollen grains of *Pinus* and 18 certainly rebedded ones were met with. In the samples 17 to 20 — the first *Pinus* maximum — 11 pollen grains of this last type were counted. Assuming that in the samples 1 to 7 all the *Pinus* pollen is of secondary origin the total number of rebedded *Pinus* pollen in the samples 17 to 20 can be calculated at $11/18 \times 196 = 120$, that is an average of 30 in each sample. The dotted line in Fig. 3 gives the *Pinus* percentages in the samples 17 to 20 corrected for the pollen of thermophilous trees and the rebedded *Pinus* pollen. Besides rebedded

Pinus pollen, *Betula* pollen of secondary origin would undoubtedly likewise be present. By subtracting the secondary *Betula* pollen from the tree-pollen sum already corrected for the rebedded pollen of *Pinus* and thermophilous trees, the values for *Pinus* will become somewhat higher than those represented by the dotted line. As nothing is known about the amount of rebedded *Betula* pollen this correction cannot be applied here.

Even in the case of too strong a correction for *Pinus* the curve for this tree clearly shows two maxima. In the Allerød part of other diagrams published from the northern Netherlands this course of the *Pinus* curve cannot be observed. This must probably be ascribed to the circumstance that in these diagrams zone II is composed of a relatively small number of spectra.

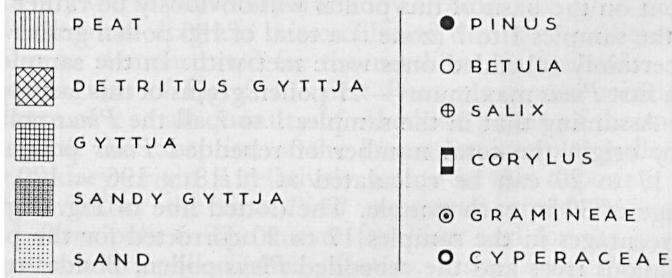
From *Epilobium angustifolium* five pollen grains were met with in zone III and one in the upper part of zone II. As a consequence of the numerous dead trees there would have been here many suitable habitats for this nitrophilous, light-demanding plant during the Late Dryas time.

As at present pollen of *Ephedra* is found in many late-glacial deposits from central and western Europe, the presence of *Ephedra cf. distachya* in the Late-glacial of the northern Netherlands comes wholly up to expectations. The circumstance that a pollen grain of *Ephedra* was also counted in zone II suggests that — at least locally — the vegetation would have been sufficiently open for this light-demanding plant.

The occurrence of *Typha latifolia* in zone III is more or less puzzling. In Scandinavia this plant does not extend beyond the 14° C July isotherm (HULTEN 1950; IVERSEN 1954), so that this would indicate a mean July temperature of at least 14° C in the northern Netherlands during the Late Dryas time. At present the mean July temperature in this region amounts to 16° C (BRAAK 1950). For that reason, on the basis of the conclusions arrived at by IVERSEN (1954) and others (*cf.* FIRBAS 1949), the mean July temperature during zone III must have been here considerably lower than 14° C, namely about 10–11° C.

During the zones I and II the vegetation of the lake itself — *Potamogeton, Myriophyllum alterniflorum, Isoetes lacustris, Lobelia, Equisetum* —

Fig. 3. Legend to the diagram



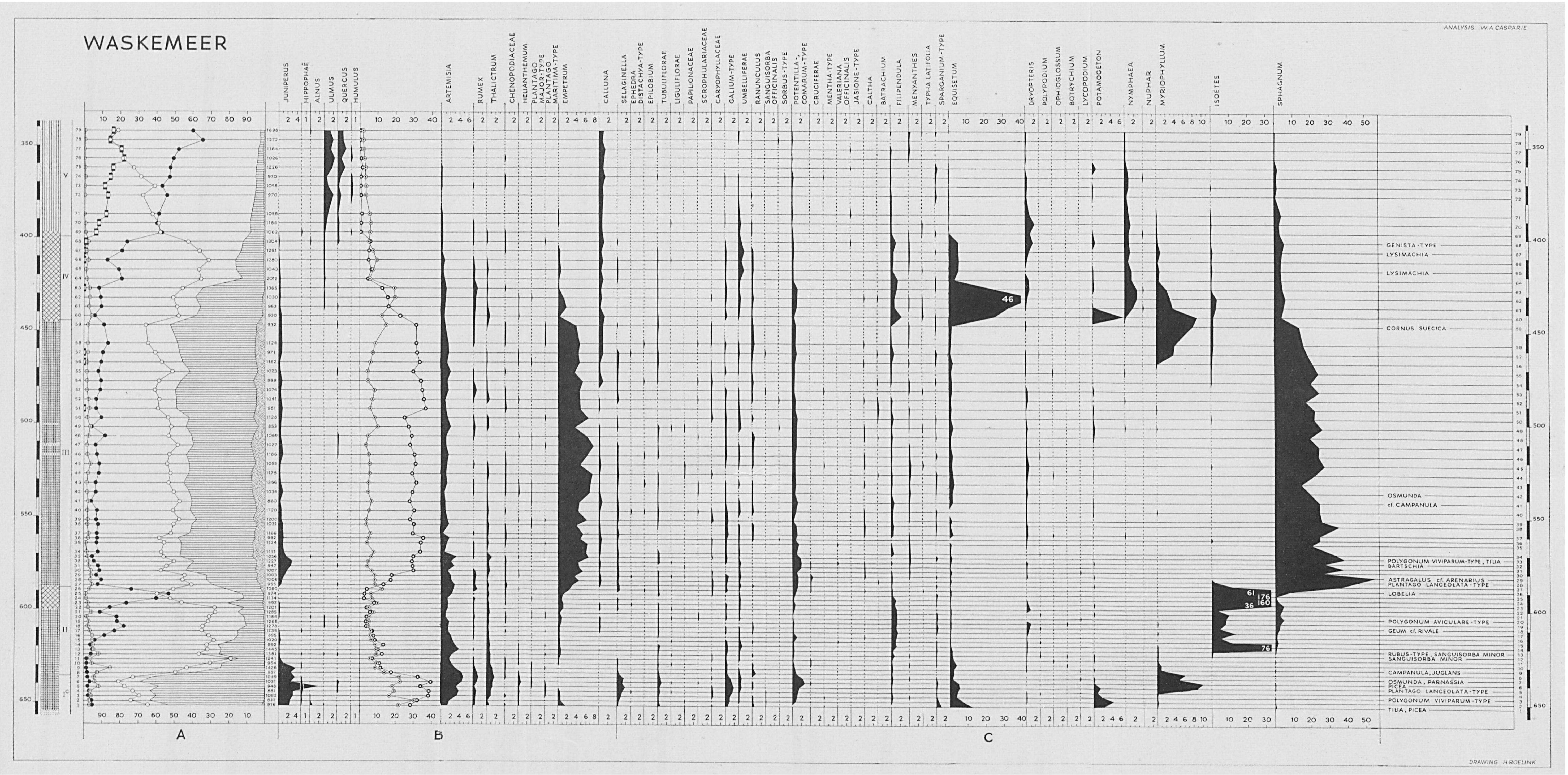

WASKEMEER
ANALYSIS W.A.CASPARIE
JUNIPERUS
HIPPOPHAË
ALNUS
ULMUS
QUERCUS
HUMULUS
ARTEMISIA
RUMEX
THALICTRUM
CHENOPODIACEAE
HELIANTHEMUM
PLANTAGO MAJOR-TYPE
PLANTAGO MARITIMA-TYPE
EMPETRUM
CALLUNA
SELAGINELLA
EPHEDRA DISTACHYA-TYPE
EPILOBIUM
TUBULIFLORAE
LIGULIFLORAE
PAPILIONACEAE
SCROPHULARIACEAE
CARYOPHYLLACEAE
GALIUM-TYPE
UMBELLIFERAE
RANUNCULUS
SANGUISORBA OFFICINALIS
SORBUS-TYPE
POTENTILLA-, COMARUM-TYPE
CRUCIFERAE
MENTHA-TYPE
VALERIANA OFFICINALIS
JASIONE-TYPE
CALTHA
BATRACHIUM
FILIPENDULA
MENYANTHES
TYPHA LATIFOLIA
SPARGANIUM-TYPE
EQUISETUM
DRYOPTERIS
POLYPODIUM
OPHIOGLOSSUM
BOTRYCHIUM
LYCOPODIUM
POTAMOGETON
NYMPHAEA
NUPHAR
MYRIOPHYLLUM
ISOËTES
SPHAGNUM
GENISTA-TYPE
LYSIMACHIA
LYSIMACHIA
CORNUS SUECICA
OSMUNDA
cf. CAMPANULA
POLYGONUM VIVIPARUM-TYPE, TILIA
BARTSCHIA
ASTRAGALUS cf. ARENARIUS
PLANTAGO LANCEOLATA-TYPE
LOBELIA
POLYGONUM AVICULARE-TYPE
GEUM cf. RIVALE
RUBUS-TYPE, SANGUISORBA MINOR
SANGUISORBA MINOR
CAMPANULA, JUGLANS
OSMUNDA, PARNASSIA
PICEA
PLANTAGO LANCEOLATA-TYPE
POLYGONUM VIVIPARUM-TYPE
TILIA, PICEA
A
B
C
DRAWING H.ROELINK

Fig. 3

is typical for oligotrophic water and has to be assigned to the *Littorellion uniflorae* (*cf.* WESTHOFF *c.s.* 1946). The Late Dryas part of the diagram shows relatively high *Sphagnum* values, whereas from the plants mentioned above in general only a small number of pollen or spores was counted. In view of the character of the deposit — a sandy gyttja — there can have been no question of a small raised bog during zone III. It is probable that a vegetation of peat mosses growing in the water was concerned here. With regard to the marked decrease of *Potamogeton* and others, this could perhaps be ascribed to the deterioration of climate after the Allerød period only in the case of *Isoetes*. Thus in the diagrams from the Hijkermeer and the Mekelermeer (VAN DER HAMMEN 1949, 1951) high values for *Isoetes* can be observed both in zone II and zone IV. *Equisetum*, *Myriophyllum* and *Potamogeton* show fairly high values in zone I, so that the low percentages for these plants in zone III cannot be attributed to an unfavourable climate.

The relatively high percentages for *Sphagnum* contrasted with the low values for *Myriophyllum* and others could suggest that during zone III the water table in the lake was much higher than in the preceeding periods. In the central part of the depression the water would have become too deep for species such as *Equisetum* and *Myriophyllum*. These plants would have found suitable habitats on the border of the lake. In this connection it has to be remarked that the boring was carried out in the deepest part of the depression.

During the Late Dryas time a considerable sedimentation took place. This must have been effected to a large degree by the blowing in of sand. Between 5.00 and 5.20 m even some narrow sand layers were present. It seems that at the end of zone III the depth of the water had decreased even in the centre of the lake in such a way that *Myriophyllum alterniflorum* could thrive on the spot. The strong increase of *Equisetum* — probably *Equisetum fluviatile* — at the beginning of zone IV would have to be ascribed to the same circumstance.

The expansion of *Nymphaea alba* at the beginning of zone IV would have been the effect of the amelioration of climate. As for the vegetation of the lake during the Preboreal it can be remarked that a *Littorellion* in which *Nymphaea alba* as well as *Nuphar luteum* occurred was concerned here.

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