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PALYNOLOGY OF THE "UDDELER MEER"

A CONTRIBUTION TO OUR KNOWLEDGE OF THE VEGETATION AND OF THE AGRICULTURE IN THE NORTHERN PART OF THE VELUWE IN PREHISTORIC AND EARLY HISTORIC TIMES

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INTRODUCTION

In 1948 VAN ZINDEREN BAKKER published a paper entitled "Palynological and Stratigraphic Research on Bogs on the Veluwe", in which an account is given of most of the bogs found in that part of the country, and in which the "Uddeler Meer" too is dealt with. With regard to this sheet of water the author says that he obtained the impression that the deposits showed a pollution due to human activities. He also studied the "Bleeke Meer", 1 km to the north of the "Uddeler Meer", where he obtained a series covering the Preboreal and Boreal periods.

As VAN ZINDEREN BAKKER had taken his samples only along the banks of these sheets of water, the present author thought that it would be worth while to extend the investigation to deposits found in the centre of the latter. Thanks to the kind cooperation of Messrs Ir. E. Reinders and Ir. A. J. Lanz, who have the supervision of the Royal Crown Lands as foresters of this area, she could make use of a raft belonging to the swimming pool situated in the "Uddeler Meer", and move it to various parts of the latter. Sampling was done from this raft by means of a Dachnowsky auger. In this way she could sample 4 m of the organic mud under a cover of circ. 2.45 m water.

The "Bleeke Meer" originally was filled with peat; in fact, it derived its name ("bleek" means pale) from the *Young Sphagnetum* which formed the uppermost layer. The peat has been removed, only a small island being left, and on the latter the entire deposit down to the subsoil was sampled. The "Bleeke Meer" started with the same sediment and at the same time as the "Uddeler Meer", but being less deep, the mud became in due time covered with peat. Records of the "Bleeke Meer" will be published at a later date.

SITUATION AND ORIGIN OF THE "UDDELER MEER" AND OF THE "BLEEKE MEER"

The two sheets of water are situated in an outwash plain between two sand ridges (Fig. 1); to the north and to the south inland dunes occur. As the map (Fig. 1) shows, the region is very poor in surface water; (the sheets of water in the northern part are remains of the former Zuiderzee, which originated from a transgression of the North Sea in early historic times). A hundred years ago the area was entirely covered with heather; nowadays there are still large stretches of heath, but a great part of the latter has been reclaimed or has been planted with pine.

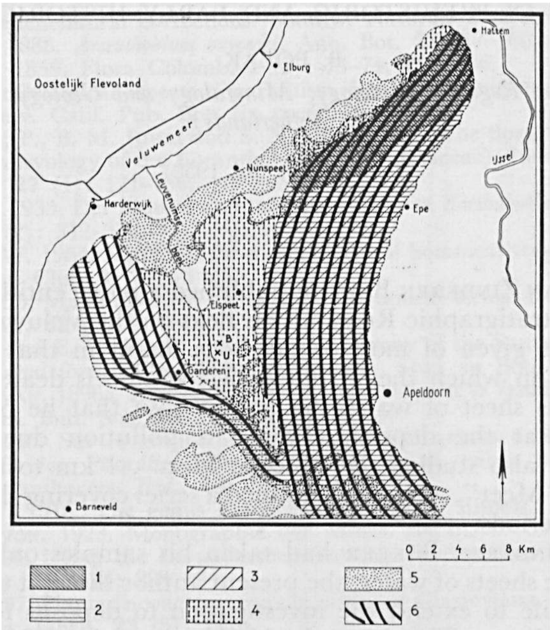


Fig. 1. Geomorphological map of the northern Veluwe. (after MAARLEVELD)
1, 2, 3, 6: Ice pushed ridges
4 : Outwash plain
5 : Inland dunes
U : Uddelermeer
B : Bleeke Meer

Until a short time ago geologists assumed that both sheets of water are Sölle or pseudo-Sölle (kettle-holes), i.e. that they originated either from dead ice of the Riss period or from holes blown out by the wind during the Younger Dryas period. LORIE (1910) considered the "Uddelermeer" as a deep scour hole in a bend of a Fluvioglacial river. Recently, however, MAARLEVELD (1955) came forward with another interpretation. According to him, these circular depressions in the landscape are remnants of pingos dating from the Würm Glacial period. Such a pingo owes its origin to the hydrostatic pressure of the ground water, and the crystallization force of ice. This causes faults with the result that the ice mass comes to the surface where it partly melts during the summer, the water running down the slopes in the form of rivulets. The pingo therefore is enclosed by a crater-like ridge. Depressions of this kind occur nowadays in regions with a permanently frozen subsoil, and such a permanently frozen subsoil was present in the Netherlands during the Würm Pleniglacial period.

The ridges round the "Uddeler Meer" and the "Bleeke Meer" are rich in gravel. The eastern part of the bank of the "Uddeler Meer" has been heightened artificially; this is the horseshoe-shaped "Hunneschans" (Fig. 2), which dates from the first centuries of our era. In both sheets of water the sedimentation of organic mud started in the Older Dryas time, which is in accordance with the conception that they came into existance in the Würm Pleniglacial period.

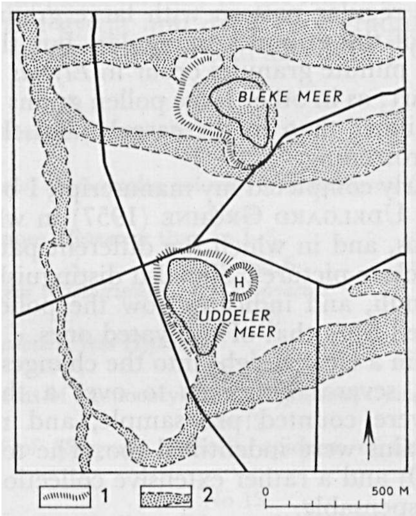


Fig. 2. Map showing the shapes and also the ridges around "Uddelermeer" and "Bleeke Meer". (after MAARLEVELD)

1: Ridges
2: Valleys and depressions filled with residual material
H: Hunneschans

METHODS

As mentioned before, sampling was done with a Dachnowsky auger from a raft and under a water layer of circa 2.45 m. The deeper layers of the deposit are rather stiff and dry, but upwards the mud becomes thinner and thinner and finally it becomes so thin that the youngest deposits could not be sampled. All the samples contain drift sand, especially at the bottom and at the top. VAN ZINDEREN BAKKER (1948) mentions the presence of erratic sandgrains in the greater part of the samples he obtained from different localities on the Veluwe. He comes to the conclusion that sanddrifts occurred there throughout the whole Post-Glacial period.

The material was treated with HF, acetolysed and stained with fuchsin. Counting was done with Zeiss Neofluar objectives, which give very clear pictures. For difficult pollen identifications a phase-contrast immersion-objective was used, with the help of which the genera of the cereals could be determined.

Since the work of FIRBAS (1937) it has become possible to distinguish the pollen of cereals from that of wild grasses. *Secale cereale* in most cases could be set apart by its shape, but *Triticum*, *Hordeum* and *Avena* originally were undistinguishable. With the phase-contrast method it turned out that there is a marked difference in sculpture. *Hordeum* often has an undulated contour, the small granules on the surface being rather wide apart. In *Triticum* the granules are arranged in an irregular pattern, and several of them are fused. In the annulus large dark spots occur which owe their origin to such fused granules. *Avena* again has a regular pattern with large granules. In *Secale* too the arrangement of the granules is regular, but the latter are very minute. The same minute granules occur in *Elymus arenarius*, but here they are wider apart; as in other large pollen grains from wild grasses, the cell wall is thinner than in the cereals, and the annulus also is thinner and less protruding.

When I had nearly completed my manuscript, I became acquainted with an article by UDELGARD GROHNE (1957) in which she describes similar observations, and in which the different patterns of sculpture are illustrated by clear pictures. She also distinguishes the shape and pattern of the annuli, and indicates how the pollen of wild grasses can be distinguished from that of cultivated ones.

In order to obtain a clear insight into the changes which took place in the vegetation, several hundreds to over a thousand grains of arboreal pollen were counted pro sample, and most of the non-arboreal pollen grains were indentified too. The textbook of FAEGRI and IVERSEN (1950) and a rather extensive collection of recent pollen grains proved indispensable.

The zonation of JESSEN as described in the textbook mentioned above, is applied here.

STRATIGRAPHY

At four places samples were taken. The main section is represented in Diagram I, and the three additional ones may serve to complete the image created by first one. Diagram I covers the main part of the series, from Dryas I to the Subboreal period. Sections (diagrams) II and III were sampled to obtain more details with regard to the bottom layers. The sedimentation started in the Older Dryas time, but a Bølling oscillation could not be detected. Diagram VI and VII are from the more recent layers. The deposits gradually become very thin; they could nevertheless be sampled up to the Subatlanticum.

In future more details will be given with regard to samples obtained from below the deepest point of the "Uddeler Meer", which was found after the other sections had already been investigated. In the "Bleeke Meer" a very fine Late-Glacial mud was found; in this mud the Allerød layer shows a sharp contrast in colour with the sediments of the two Dryas times.

All the sediments of the "Uddeler Meer" were deposited in water; they contain besides pollen and spores, plankton *Algae*, fragments of aquatic *Crustaceae* and other animal residues.

In section I, below a depth of 6.20 m the subsoil could not be penetrated by the auger. It consists of a very coarse gravelly sand. Up to approximately 4.90 m the sediment is a gyttja; from there on it changes gradually into a dark brown dy. Especially the Late-Glacial samples have a greenish-grey colour, and contain lime. The colour caused by the presence of *Chlorophyceae*, shines as a green haze through the grey or brown. In the Allerød layers the primary colour is olive, which in Zone III again grows paler, although the green undertone persists. Lime disappears already in the Allerød.

The transition of gyttja into dy is very gradual, so that in Zones VI–VII the colour of the sediment and also of its KOH extract becomes dark brown.

Description of Section (Diagram) I

Nrs 1–3

Olive-green; *Cladocera, Protococcales*, colonies of *Cyanophyceae* (*Gloeotrichia?*), *Hypnaceae.*

No 4

Colour brownish; more *Hypnaceae* than in 1–3.

Nrs 5 and 6

Greenish; *Cyanophyceae* (*Gloeotrichia*?), less *Hypnaceae*

Nrs 7–10

Cyanophyceae, less *Cladocera*, less *Hypnaceae*

No 11

Radicels and epiderms of Monocotyledons, *Hypnaceae, Cyanophyceae*

No 12

Hypnaceae, one leaf of *Sphagnum*, radicels, epiderm of *Gramineae*, no *Cyanophyceae*, *Pinnularia* (250 μ)

No 13

Radicels, *Hypnaceae*, microphyllous *Sphagna*, div. species of diatoms (*Navicula*)

No 14

Radicels and epiderms of *Cyperaceae*, shells of *Cladocera*, mandibles of *Arthropoda*, *Hypnaceae*, microphyllous *Sphagna*, leaf fragments of Dicotyledons (*Betula*?), woodvessels of *Betula*, some diatoms (*Navicula*)

No 15

Same as 14, but with *Rhizopoda* (*Centropyxis* type)

Nrs 16 and 17

Radicels and epiderms of *Cyperaceae; Hypnaceae* and microphyllous *Sphagna; Cladocera* shells; mandibles of *Arthropoda;* diatoms rather abundant

No 18

Radicels and epiderms of *Gramineae* and *Cyperaceae; Hypnaceae* and microphyllous *Sphagna;* leaf fragments of Dicotyledons; *Cladocera* and mandibles of *Arthropoda;* diatoms (*Pinnularia* and smaller species)

Nrs 19 and 20

Rather coarse, with much detritus; radicels, *Hypnaceae* and microphyllous *Sphagna*, woodvessels *Betula*, diatoms

No 21

Same, but with more diatoms (*Pinnularia*)

Nrs 22 and 23

Same, but with less diatoms

No 24

Same, but with few diatoms; spiculae of *Spongilla;* radicels and epiderms abundant (*Phragmites*); hairs of *Nymphaeaceae;* needle leaf of *Pinus;* animal remains

No 25

Fibrous; vessels, epiderms, humus flocks, few *Cladocera*, charcoal, some *Hypnaceae*, *Cenococcum geophilum*

No 26

Same; *Cyanophyceae* rather abundant, spiculae of *Spongilla*, diatoms

Nrs 27, 28 and 29

Less fibrous, flocks of humus; *Cyanophyceae*, more *Hypnaceae*, more *Cladocera*, mandibles of *Arthropoda*, spiculae of *Spongilla*, charcoal, *Cenococcum*

Nrs 30 and 31

Same, but more diatoms and less *Chlorophyceae* and *Cyanophyceae; Thelypteris* sporangium filled with spores, moss sporangium, *Microchaete*? (*Cyanophyceae*)

No 32

Detritus and humus, radicels, *Cladocera*, sporangia and setae of *Hypnaceae*, charcoal, *Microchaete*?, hairs of *Nymphaeaceae* ++, spiculae of *Spongilla*

No 33

Same, more *Spongilla*

No 34

Same; oospores of *Chara* —, *Cladocera* and other *Arthropoda* +, setae and sporangia of *Hypnaceae*, petioles of *Ceratophyllum* with hairs, hairs of *Nymphaeaceae*, *Microchaete*?, *Spongilla* and diatoms

No 35

Less *Chara*, *Cladocera* + +, *Ceratophyllum* + +, Radicels —, setae and sporangia of *Hypnaceae*, hairs of *Nymphaeaceae*, *Spongilla* and diatoms

No 36

Radicels and epiderms —, *Chara* spores ±, setae and sporangia of *Hypnaceae* +, *Cladocera* ±, *Copepoda*, *Cyanophyceae*, charcoal, diatoms (*Pinnularia*), *Spongilla* ±, *Ceratophyllum* hairs—, *Cenococcum.*

No 37

Same, but with less diatoms and *Spongilla.*

No 38

Chara spores ±, setae and sporangia of *Hypnaceae* —, *Cladocera* + *Cyanophyceae* (*Microchaete*?), charcoal, diatoms —, *Spongilla* —, *Ceratophyllum* petioles and hairs +, *Cenococcum*, clusters of *Phycomycetes*

Nrs 39–41

Same with microphyllous *Sphagna*, radicels ±, less *Ceratophyllum*, *Nymphaea* hairs

Nrs 42–44

Same, but without *Microchaete*?

Nrs 45–50

Larger residues very scarce, humus flocks, no *Ceratophyllum; Ostracoda*, *Copepoda*, *Cladocera*, further as 42–44

Section II (**Diagram II**)

As in Section I the subsoil consists of coarse gravelly sand, rich in lime. It is situated at a depth of 6.00 m. The first sample taken at a depth of 5.97 m is still very sandy and contains hardly any pollen. Incrusted *Chara* oospores occur together with a network of fungal hyphae and large fungal sporangia.

No 2

Same as No 1, with fruit of *Carex* and seta of a *Hypnacea*

No 3

Finer sand, high content of lime; incrusted *Chara* oospores +, *Cladocera*, *Arthropoda*, fruit of *Carex*, *Hypnaceae* ±

No 4

Same, less mossess

No 5

Same, less mosses, less *Chara*

Section III (**Diagram III**)

Subsoil at 6.20m, the same as in Section I and II. Samples 2 and 3 with hardly any pollen but containing a network of fungal hyphae and sporangia

No 4

Transition to organic sediment: incrusted *Chara* oospores +, *Cenococcum geophilum, Cladocera* and other animal residues +, rhizomes and radicels, *Cyanophyceae,*

Nrs 5 and 6

Fine sediment, ca 80 % of lime; the same as No 4, *Hypnaceae* +

Section IV (**Diagram VI, VII**)

The first samples are very wet, semi-fluid. The colour is pale green caused by clusters of *Algae*, such as *Scenedesmus, Tetraedron, Pediastrum* and *Botryococcus*. Microphyllous *Sphagna* occur, sporangia, setae and leaves of *Hypnaceae, Cladocera* and *Tubifex*

Nrs 3 and 4

Hypnaceae, microphyllous *Sphagna,* epiderms and radicels, megaspores of *Isoetes lacustris, Chara* oospores, fruits of *Potamogeton natans* and other *Potamogeta, Nymphaea* seed, sporangia of *Fungi, Cladocera, Tubifex* and mites.

No 5

Same, more radicels and epiderms

Nrs 6 and 7

Same, radicels and epiderms +, fruits of *Potamogeton natans, P. obtusifolius* and *P. acutifolius*

No 8

Balls of detritus, radicels, epiderms, megaspores of *Isoetes lacustris,* setae, leaves, sporangia of *Hypnaceae, Chara* oospores, *Nymphaea* hairs, sporangia of *Fungi, Cladocera, Tubifex, Rhizopoda* + (*Nebela* spec.?)

No 9

Same, but without *Rhizopoda*

No 10

Same, *Rhizopoda* ++ (*Nebela* ?)

The diagrams

Late-Glacial (Diagrams i, ii, iii; Tables i, ii, iii, iv). As mentioned before, the sub-soil of gravelly sand is rich in lime, and it contains abundant oospores of *Chara.* With the exception of fungi, other organic remains are scarce. The texture of the sand is represented in Table i.

TABLE I

Granular Composition of Subsoil at 6–6.70 m.

Larger than:	420	300 – 420	210 – 300	149 – 210	105 – 149	74 – 105	53 – 74	53 – 53	2 – 16	2 μ
Number 1	16.6	18.	19.4	15	7.2	0.8	8.7	11.7	0.7	1.9 %
Number 2	12.6	11.8	15.7	16.7	12.1	3.5	11.8	11.5	1.4	2.9
Number 3	10.7	28.9	37.4	11.7	6.4	0.4	1.5		3.0	

The "Uddeler Meer" must have started as a hard water pool in which the vegetation was poorly developed and in which *Chara* dominated. Judging from the pollen no phanerogamic marsh or water plants were present, but *Cyperaceae* are well represented, and come next to the *Gramineae.* Striking is the relatively high percentage of liguliflorous *Compositae*; this pollen strongly resembles that of *Taraxacum* (Wodehouse, 1935). Godwin (1956) mentions finds of fruits of the latter from the Full and Late-Glacial and from the early Post-Glacial

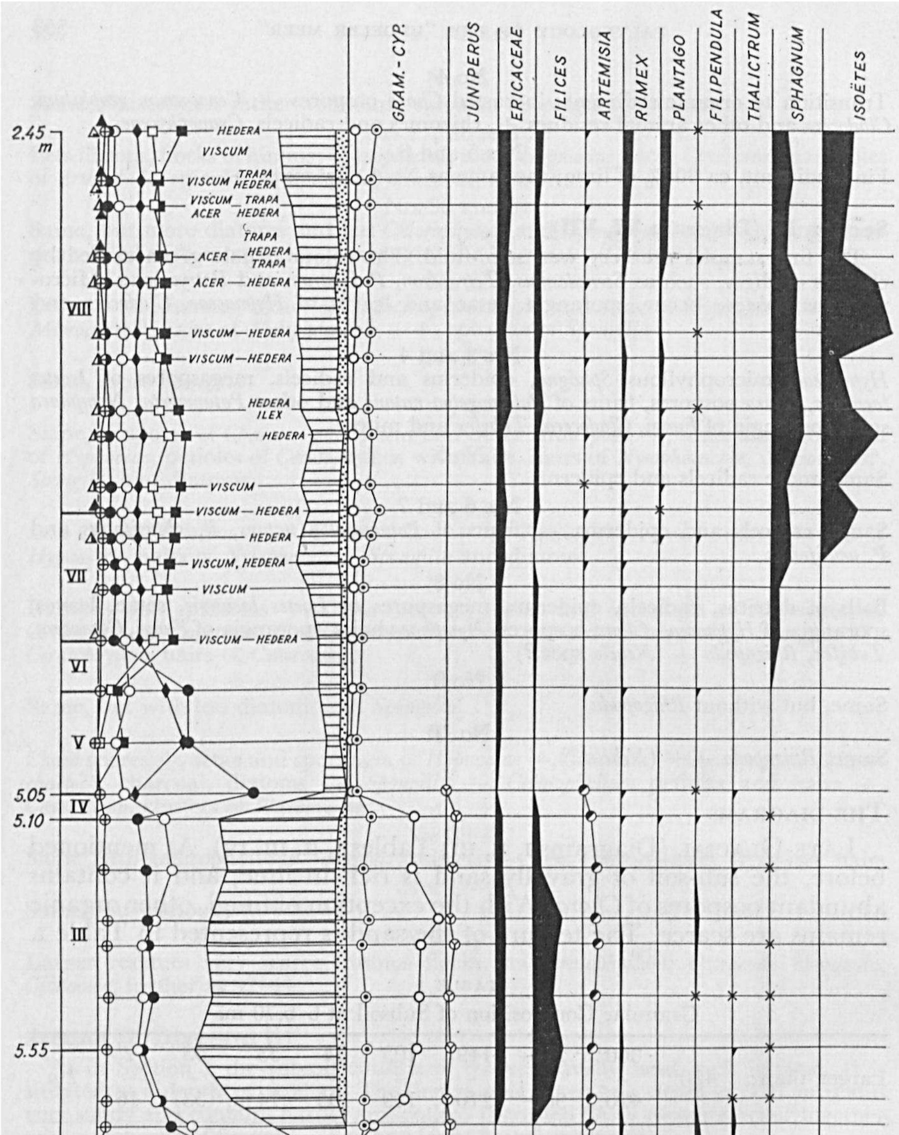
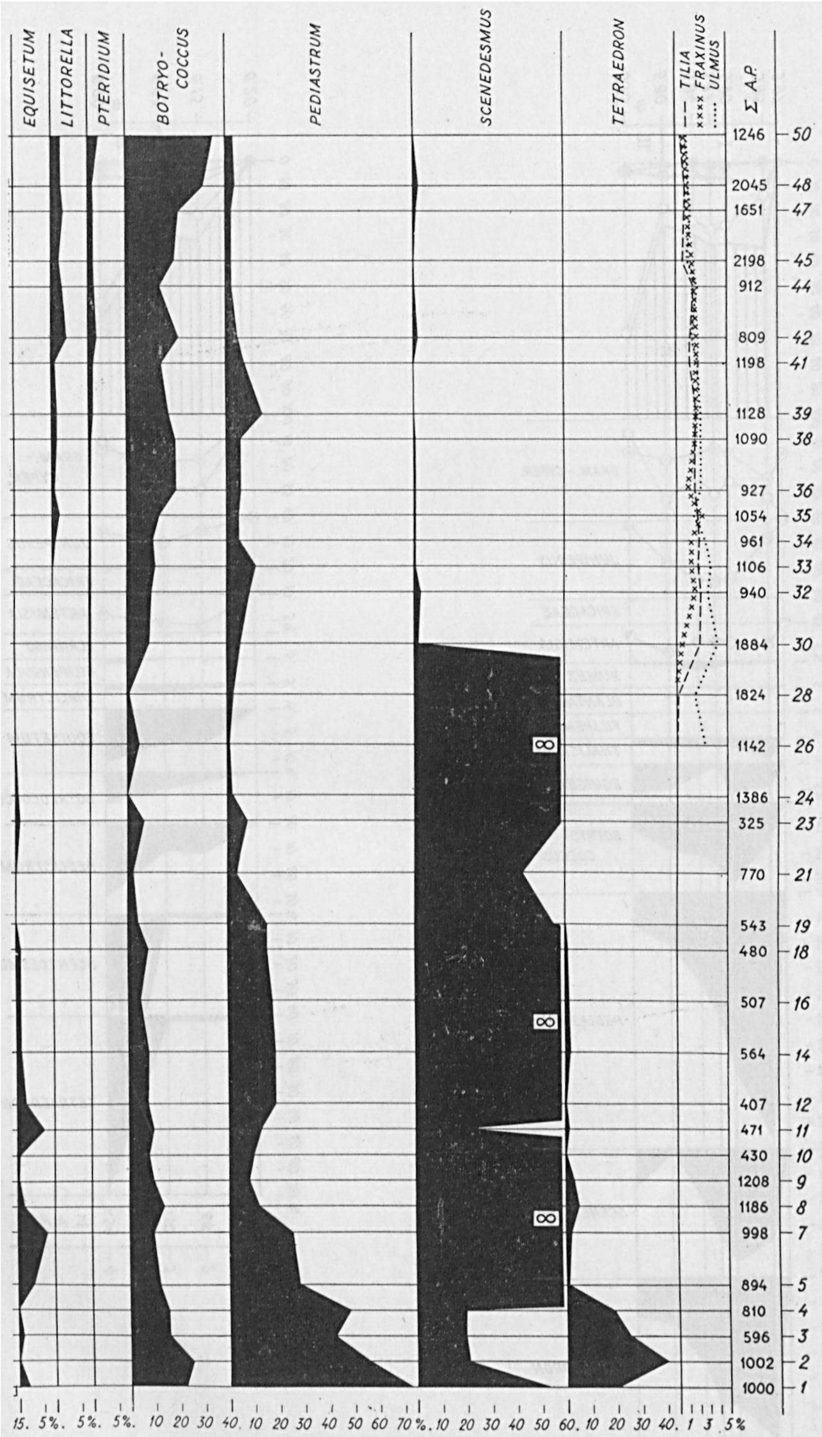


Diagram I

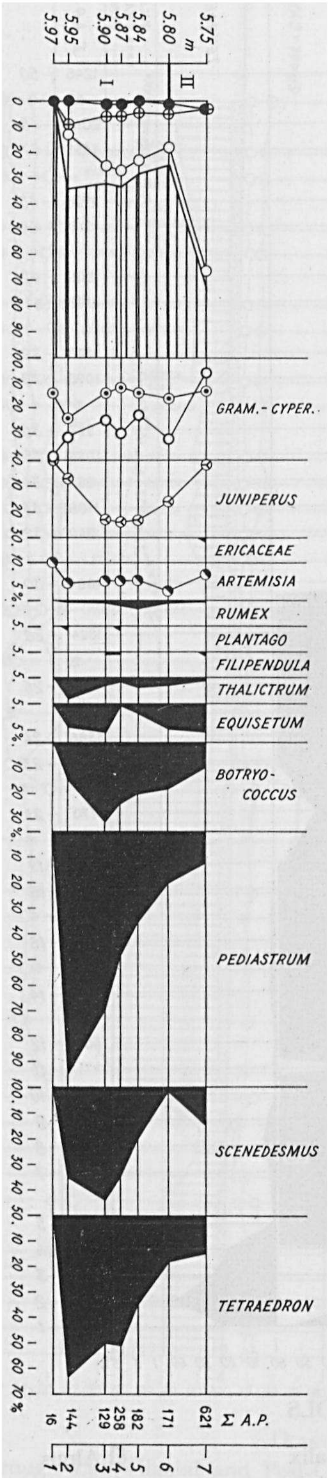
Section through Late-Glacial and Post-Glacial deposits. Total diagram in which only pollen of aquatic plants is left out of the pollen sum.

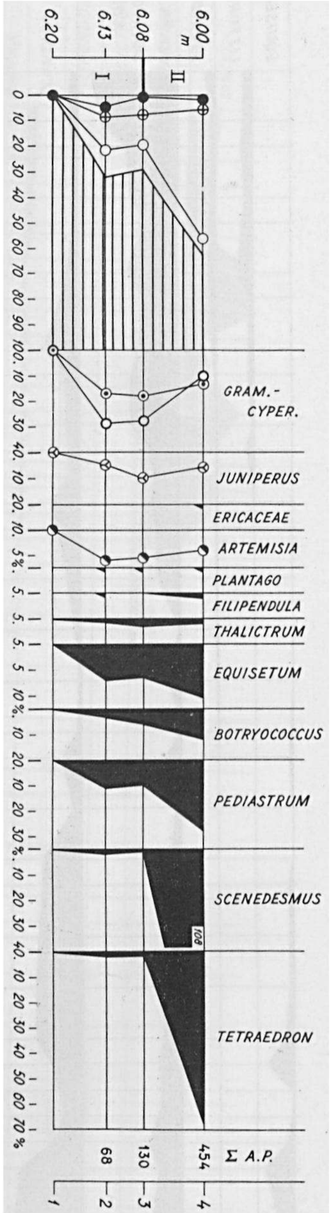
×) single grain, found after counting.



KEY TO THE SYMBOLS

● Pinus
♦ Corylus
Δ Carpinus
○ Betula
■ Q.M.
⊙ Gramineae
⊕ Salix
Δ Picea
O Cyperaceae
□ Alnus
▲ Fagus
▩ Ericaceae





DIAGRAMS II and III

Late-Glacial; Dryas I and beginning of Allerød. Note the relatively high values for *Artemisia*, *Juniperus* and *Chlorophyceae*.

	Populus	Hippophaë	Cornus Sanguinea	Cornus suecica	Helianthemum nummularium	Helianthemum oelandicum	Saxifraga oppositifolia	Sanguisorba officinalis	Sanguisorba minor	Menyanthes	Myriophyllum spic.	alterniflorum	Epilobium	Valeriana	Lonicera	Convolvulus	Polygonum amphibium	Polygonum bistorta	Polygonum persicaria	Galium	Batrachium	Ranunculaceae: Ranunculus	Ranunculaceae: Caltha	Rosaceae: Potentilla	Rosaceae: Geum
50			1											1					x	10		1		3	3
48																2				2		14		5	3
47															1					1		2		3	3
45																			1			16		3	6
44										1									x			1			1
42												x										1		1	2
41																			x	1		2		1	
39																			x		1				4
38										x										x		1		2	1
36																			x					1	1
35										x												1		2	
34	1									x										1		4			3
33																						5		1	3
32																							3	x	2
30																				1	1	1			3
28											4									1		3			1
26																									
24																				1		3			
23					1						1							1		3		5			5
21				1				2		1	1		1	1						2		9		6	1
19						3								2	1							5		1	1
18	2			1	1	2				1	1									3	2	5		3	2
16	5				1	1		1												6	2	3		2	1
14	1				2					1										11	3	1	2		4
12										2	2			1						2		4		2	3
11									x	4															1
10																						1		1	
9		1						x		x										1		1		2	
8						1		x		2			3	2						4		4		2	
7					1	1	2		1	4										8		7		3	2
5										7										2	4	9		2	1
4		1			4				1				1							6	2				2
3	1	1			6			2	1											4				2	3
2		2				3		2		1	1						1			9		1	1	2	3
1	2			1	1	6		1												6	2	2		3	

	Potamogeton: Eupotamogeton	Potamogeton: Coleogeton	Chenopodiaceae	Urtica	Humulus	Umbelliferae	Compositae: Tubuliflorae	Compositae: Liguliflorae	Papillionaceae	Lotus	Solanum dulcamara	Botrychium	Selaginella	Lycopodium: clavatum	Lycopodium: innundatum	Lycopodium: annotinum	Polypodium vulgare	Osmunda	Labiatae: Mentha-type	Labiatae: Galeopsis-type	Scrophulariaceae: Digitalis-type	Scrophulariaceae: Melampyrum	Caryophyllaceae: Lychnis-type	Caryophyllaceae: Stellaria-type	Campanulaceae: Jasione
50	8	3	1			2	5	1			1												1		
48	5	5	5	3		1	5	4		2	1						2		1	1	2		2		
47	5	2	4	2		3	5	4		1	3						1			3			1		
45	4	2	3	2		2	1	1		2							1			3			1		
44	3		2	1		x		2	x								2								
42	1	3	1	1						1							1		1	3				x	2
41	3		2		x			1	1		1						1		2	3			x		1
39	2		5	1		1	2	1	x	1							2	x	x		1		1		
38	1		3	1		x	1			1							1						x		
36			2	3			1		x							1	2		x			2	1	x	
35	2		x	1		1	x	x	2					1	1		x	2							
34	3		6	1		x	1								x		1			2			x		1
33	1		1	3		2		1									2						x		
32	4		1														2	x		1	1				
30	4		3	1		x	1																x		
28	8							2	1											4					1
26	10		1	1			2						x												x
24	5		1	1								x													
23	1	2	1			4							1							2	1		1		
21		3	1	2		1	1			2			10								1		3		
19	1	1		4		1	1			1	3	1	6			1									
18	3	2	1	2			3			1		2	6										2		
16	2	1	2	3		3	4					1	3										2		
14	2	2	2			1	6	1				1	8												
12	1	3	1	3		2	1						2										1		
11	3	2	1	1		2	1																x		
10							1			1															
9		2	1	1		4		1		1															
8	3	4	x	1		2	2								1					1			1		
7	2	6	3			3	1					2		1			2						1		
5	9	10	2	3			1																2		
4	2	6	1			2	1	1		1		3	4						1				1		
3		1	1				1			1		2											2		
2	1	4		1		2	2	3				2	1								4				
1	9	4	1			3	2			1	2	1	2	1											

	Campanulaceae: Campanula	Cruciferae	Succisa	Alisma	Butomus	Hottonia	Nuphar	Nymphaea	Typha: Sparganium, ang.	Typha: latifolium	Rhamnus cath.	Frangula alnus	Hydrocotyle	Sambucus	Euphorbia	Lysimachia	Cladium	Lythrum	Geranium	Drosera rot.	Pinus stomata	Nymphaea hairs	Ceratophyllum hairs	Verbascum hair
50	1		5						5		1		3	1		4								
48	3		7				1		2			1	3			7		1	1					
47	2		1				2		5															
45	1		4						5			1		1		5	1	2						
44			1				x	x	x	x	1			1		x	x					—		
42			3				x	x	2	x			1	1								—	—	
41			1				1					1	1			5			1			±	—	
39			2				4	x	2	x		7	6	2		2	1			x		+	—	
38			1			1		1	2		1	2	1	1		x		x				—	±	
36			1				x	x				1	8	3			1	1	x			+	—	
35	x	x	x				x	x	1				1			1	x	1	x			—	+	1
34			2				1	x	2	1	2		1	2		3	1	1				±	+	
33			3				2	4	2	1			7	1	x	7	x	x				+		
32	x		1				2	8	2	x			4	2		1	3	x				+		
30			x				1	8	2	x	1	1	3			4	8	2				+		
28			1			2	x	1	36												6			
26		1	x					3	10													1		
24									6						1	1					1	1		
23		1									1										2			
21									1															
19			1	1	1				2															
18							1																	
16		1																						
14		1			1																			
12		1																					x	
11			2						x												2		x	
10																					x	1		
9				x					2	x											10	1		
8		x	2			3					x										6	1		
7		1	1			2	2		3													1		
5			1																		2			
4						1																		
3									2	1														
2									3															
1																								

TABLE II Supplement to DIAGRAM I, IV and V, the figures representing scarce pollengrains in numerical numbers and not in percentages. x) single grain left out of the pollensum, found when looking through further slides after counting.

in England and supposes that this plant was frequent at that time because of the open soil conditions. Its next more or less accurately dated appearance in England is in Roman time. In the "Uddeler Meer" too, pollen of the same *Taraxacum* type came back in the youngest layers of the Subatlanticum (1.6 % of the arboreal pollen). In BROUWER's (1949) diagrams from Drente very high percentages for the *Compositae* are recorded, whilst HAVINGA in an unpublished diagram of a soil series obtained on the bank of the "Uddeler Meer" found also extremely high values for this type of pollen. However this may be, the samples obtained from deposits just above the mineral subsoil show signs of pollen corrosion, and it might be that selective corrosion plays a role in the composition of their spectra.

The samples from the higher strata are in better condition; they contain undamaged pollen and large amounts of *Chlorophyceae*. The matrix is a calcareous gyttja, grey in colour with a green shimmer, which darkens when exposed to the air.

The lower part of Diagram I, II and III (resp. samples 1–5; 3–5 and 4–6) belong to the Older Dryas time, Zone I according to JESSEN and IVERSEN (1950). The ratio of non-arboreal pollen amounts respectively to 36–45 % 73–78 %; and 67–71 %, *Juniperus* included. A Bølling oscillation could not be distinguished in either of the three diagrams; possibly the sedimentation started in phase Ic, i.a. after the Bølling oscillation.

DRYAS I (Diagram I, II, III, Zone I). A characteristic feature of Dryas I in our diagrams is that the *Juniperus* curve attains a maximum (over 20 %) in this period, in contrast to the *Juniperus* curves published by IVERSEN (1954) for Denmark, and by ZAGWIJN (1952) for the Alps, which have their maxima at the close of Zone III. These maxima, moreover, are much higher. In the records of VAN DER HAMMEN (1951), however, *Juniperus* is well developed in Dryas I and, except in Usselo c where hardly any difference between the two Dryas layers is to be seen, it reaches a maximum in the Older Dryas period. It seems probable that the Netherlands diagrams in this respect differ from the Scandinavian and the alpine ones.

Pinus stays low in Zone I, *Betula* being the main component of the tree pollen. It could not be established whether the latter originated from dwarf birches or not, but according to the characteristics of the pollengrains, TERASMAË (1951), a certain percentage may have been produced by *Betula nana*.

Salix amounts to 6 %, in one case to 8 %; the *Artemisia* curve is well-developed; it rises to over 5 %. *Rumex*, *Plantago*, *Filipendula*, *Equisetum* and ferns are represented in the diagrams, the main producers of the non-arboreal pollen, however, are grasses and sedges, the *Cyperaceae* attaining the highest values. No curves were drawn for *Helianthemum*, *Sanguisorba*, *Menyanthes*, *Populus* and *Hippophaë*. The numbers of grains found in each spectrum (a few pro mille only) are recorded in Tables II, III and IV. *Equisetum* is left out of the pollen sum.

The ALLERØD period is well-developed; it can be distinguished by the naked eye because of its dark colour, which contrasts with the paler samples of Dryas I and II. Right at the beginning lime disappears. There is a sharp rise in the arboreal pollen; first of *Betula*, then of *Pinus*; the non-arboreal pollen falls to 10.7 %. *Cyperaceae* retreat, and are surpassed by *Gramineae*; *Empetrum* starts with a few per cent; *Juniperus* decreases and so does *Artemisia*.

The *Betula-Pinus* forests must have been rather dense; in our area it is characteristic that *Pinus* surpasses *Betula* in the second half of the period; at this time it must have grown near the bank as *Pinus* stomata are found regularly in the samples (Table II).

DRYAS II (Diagram I, Zone III)

As mentioned before, the sediments of the Younger Dryas period are pale in colour and free of lime. The rise in the non-arboreal pollen, in which *Cyperaceae* predominate, is sharp. (maximum N.A.P. 61 %). *Empetrum* shows a continuous curve with a maximum of 3.9 %; a few grains of *Calluna* and *Vaccinium* occur too. *Pinus* reaches higher maxima than in Zone I; *Juniperus* stays low, but *Artemisia* rises again. *Rumex* and *Thalictrum* show continuous curves with low values; *Plantago* and *Filipendula* become rare. *Helianthemum*, *Sanguisorba*, *Menyanthes* occur in a few pro mille, *Hippophaë* is absent and *Populus* disappears in the upper samples.

Filices show a marked rise in this period. Their frequency shows a continuous curve with a maximum of 12 %. The kidney-shaped, pitted but naked spores could be identified as belonging to *Dryopteris linnaeana*. Being a terrestrial fern, it is included in the pollen sum.

SOME RARE SPECIES IN ZONES I, II AND III (Tables II, III and IV).

Centaurea cyanus was not found in our samples, but of *Centaurea scabiosa* a single grain occurred in Zone I. IVERSEN (1954) mentions it for Zones I and III.

Cornus suecica, Zones I and III. This species was first mentioned by VAN DER HAMMEN (1951), and it is also recorded by STRAKA (1952, 1954) from the Eiffel where it was found in Zone III. In the Netherlands this species still occurs as a relic.

Circaea (probably *alpina*). One grain in Zone I. *C. alpina* nowadays has a wide northern range (HULTEN, 1950). LANG (1952) mentions a find from the Late-Glacial of southern Germany.

Saxifraga oppositifolia, Zone I and the beginning of Zone II. IVERSEN (1954) found this species in different places in Zones I and III. It is mentioned by GODWIN (1956) from the Full-Glacial near Cambridge and from Late-Glacial deposits in Ireland, and by GÖTTLICH (1955) from Zone Ia of the Federsee.

Parnassia, Zone I; mentioned by VAN DER HAMMEN (1951) for all zones of the Late-Glacial.

Oxyria, Zone I; reported by VAN DER HAMMEN (1951) from Zones I, II and III.

Polygonum bistorta (*viviparum*, HEDBERG, 1946) Zone I; mentioned by VAN DER HAMMEN (1951) and by IVERSEN (1954) for Zone III.

Polemonium, beginning of Zone II; for the Netherlands the first find was recorded by VAN ZEIST (1955) for Haule, Zone I. In England it has according to GODWIN (1956) a wide-spread Late-Glacial range; IVERSEN (1954) mentions this species for Jutland in Zone III.

Ephedra distachya, Zone II. This species was mentioned for the first time by IVERSEN (1951) as one of the steppe elements of the Late-Glacial. Since then it was found to be widespread all over Late-Glacial Europe.

GRASSES

In all our Late-Glacial spectra we found a few grains of grass pollen with a diameter of approximately 40 μ or more, which cannot be of cereals as in many cases the wall is too thin and as the pore is not sufficiently prominent. FAEGRI (1940) mentions the same kind of grass pollen from Jaeren, but there it seems probable that it belonged to *Elymus arenarius*. This, however, cannot apply to STRAKA's finds in the Eiffel (1952) nor to LANG's finds in south western Germany. The "Uddeler Meer" too was situated far from the sea shore, and therefore it seems highly improbable that *Elymus arenarius* may have occurred there in the Late-Glacial. The pollen might have been from *Glyceria* or, as the characteristics of grass pollen are not yet well investigated, from some arctic species to which till now no attention has been paid. STRAKA (1952, 1958) supposes that the large grains were produced by polyploid wild grasses. If this be so, then it remains unexplained why the grasses only showed a tendency towards polyploidy during that period. It is not known that other plants produced larger pollen-grains in the Late-Glacial.

ALGAE

Large quantities of *Chlorophyceae*, viz. *Pediastrum*, *Scenedesmus*, *Tetraedron* and *Botryococcus* colour the deposit. The numbers have been counted and are recorded in the diagrams. The counting, however, is not very accurate; *Tetraedron* and *Scenedesmus* are very small and can hardly be stained, so that a considerable percentage may have been overlooked. *Botryococcus* colours very deeply, but the large clusters often are broken up, and in this way here too counting is made difficult; to a lesser degree this applies also to *Pediastrum*.

The following species occur in the Late-Glacial: *Pediastrum boryanum* f. *longicorne Reinsch* and f. *undulatum Wille*, *P. duplex Meyen* f. *rugulosum Raciborski*. and *P. integrum Nägeli f. granulata Raciborski*. *Scenedesmus bijugatus* is abundant and *Sc. quadricauda Turpin* rare, *Tetreaedron muticum* (A. Br.) is not so abundant as *T. minimum* (A. Br.) *Hansgirg f. scrobiculatum Lagerheim*.[1]) In the diagram the different species are treated as one. *Cyanophyceae* colonies of *Gloeotrichia*(?) are abundant in Zone I and occur also in II and III, but have not been recorded.

As may be seen from Diagram I, II and III, *Tetraedron* attains a high frequency in Zone I and falls sharply to low values recorded for the Zones II and III, whereas the other *Chlorophyceae* maintain high values.

[1]) Identification of *Algae* with: PASCHER, Süszwasserflora Deutschlands.

POST-GLACIAL (Diagrams I, IV, V, VI and VII; Tables II and V)

It is customary to make a total diagram of the Late-Glacial, in which both trees and herbs are taken into the pollen sum, and the percentages of tree and non-tree pollen are drawn opposite each other to give an idea of their ratio. In the diagrams I and VI we have continued the total diagram into the Post-Glacial, in order to illustrate the effect of deforestation.

Diagrams IV, V and VII are dissolved classical diagrams made of the same section. Diagram V is a "reduced" one; before adding them to the tree-pollen sum, the values found for *Alnus*, *Betula*, *Pinus* and *Corylus* have been divided by four, as it is supposed that they produce approximately four times as much pollen as the other tree genera do. In this way an attempt is made to give a picture of the part played by the different tree genera in the composition of the forest (FAEGRI and IVERSEN 1950). In all diagrams *Corylus* is included in the pollen sum.

PREBOREAL (Zone IV, Diagram I).

Zone IV is hardly developed: N.A.P. falls to 9.7 %; of the thermophilous trees *Quercus* is represented by 0.4, resp. 0.5 % [1]), *Ulmus* and *Alnus* are very low; *Corylus* comes to 15, resp. 17.1 % and *Pinus* rises sharply to 62, resp. 69 %. *Gramineae* surpass the *Cyperaceae*; *Pediastrum* falls to low values, *Botryococcus* is low, but *Scenedesmus* retains very high values. *Cyanophyceae,* especially *Gloeotrichia*(?), are rather abundant; star-shaped colonies consisting of *Gloeothece*-like cells also occur. A few pollen grains of Late-Glacial species are met; *Sanguisorba minor, Selaginella* and *Botrychium lunaria* are still present.

BOREAL (Zone V and VI, Diagram I, IV, V)

In this section first *Pinus* and soon afterwards *Corylus* reaches distinct maxima. In the sediment *Pinus* stomata occur in fair amounts; this is therefore the second period in which *Pinus* grew near the bank. Allerød and Boreal are the only periods in which *Pinus* was an important component of the forest.

Ulmus starts with 3.2, resp. 3.4 %, *Quercus* with 6.5, resp. 7 %. *Tilia* rises in Zone VI from a few pro mille to 2.4, resp. 2.8 %. *Calluna* comes to 1.7, resp. 1.8 %; the N.A.P. ranges from 8 to 11.7 %.

Towards the end of the Boreal oligotrophic waterplants begin to immigrate. A few pollen grains of *Littorella,* and some spores of *Isoetes* and *Sphagnum* were encountered. *Scenedesmus* stays high, but in the mass of *Scenedesmus bijugatus, Sc. quadricauda* comes up, and *Scenedesmus costatus Schmiddle* occurs for the first time.

Gloeotrichia-like colonies are still abundant.

ATLANTICUM (Zone VII, Diagram I, IV, V)

The Atlanticum starts at the intersection of the *Pinus* and *Alnus* curves. The most striking feature of this period is the relatively low height of the *Alnus* curve, and the fact that it is surpassed by that of

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[1]) The second figure refers to the classical diagram.

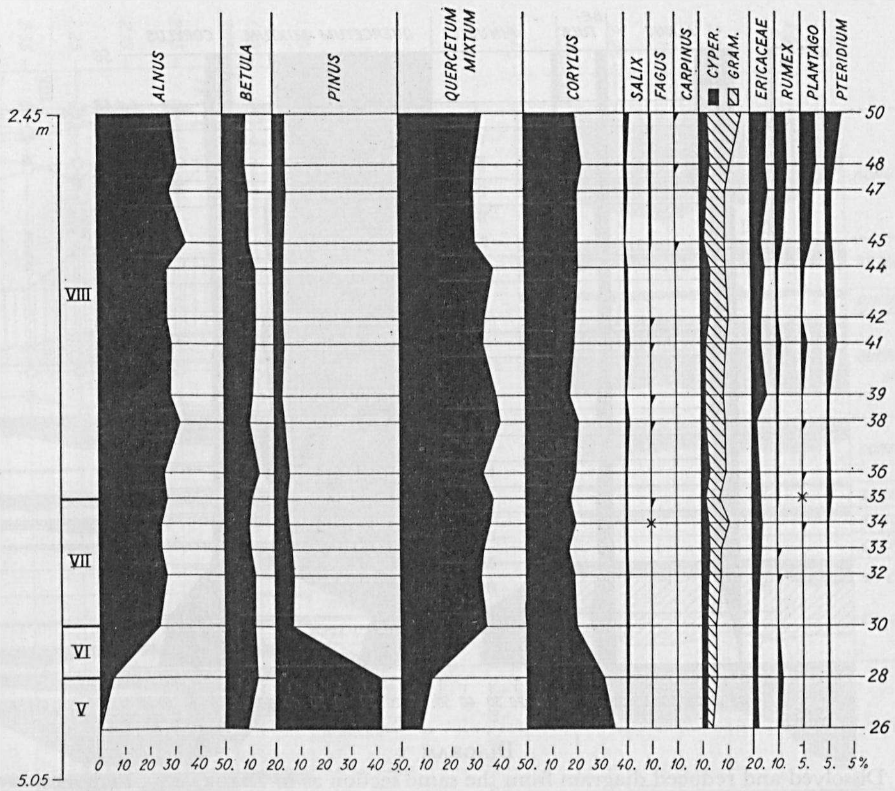

DIAGRAM IV
Classical dissolved diagrams of the Post-Glacial from the same section as in DIAGRAM I

the *Quercus* curve. In most other diagrams of the Netherlands *Alnus* is the tree which shows by far the highest value. The whole region around the "Uddeler Meer", however, was covered with dry sands; marshes and wet places which would favour aldergrowth were at a rather great distance (Fig. 1). The peats on which most Netherlands diagrams are based, were derived either from bogs grown with *Alnus* or from bogs situated near localities with a favourable environment for this species. Even in the province Drente *Alnus* regularly surpasses *Quercus*, but this area possesses much more wet places and brooks than the northern Veluwe. Our diagrams show a great resemblance to those of Jutland (IVERSEN 1941, JONASSEN 1950) and to a diagram of north-western Belgium (VANHOORNE 1951). Mrs. VERMEER-LOUMAN (1934) obtained an analogous diagram for the Wieringermeer, and HAVINGA for northern Groningen (unpublished).

Pinus stays low; its highest values are 6.6, resp. 7.8 %; its lowest at the end of the period 4.4, resp. 5.4 %; *Corylus* oscillates round 17, resp. 20 %, and shows no maximum.

Fraxinus increases and reaches a maximum of 2.7, resp. 3 %. The maximum of *Ulmus* attains 4.2, resp. 4.8 %; the curve falls to 1.6,

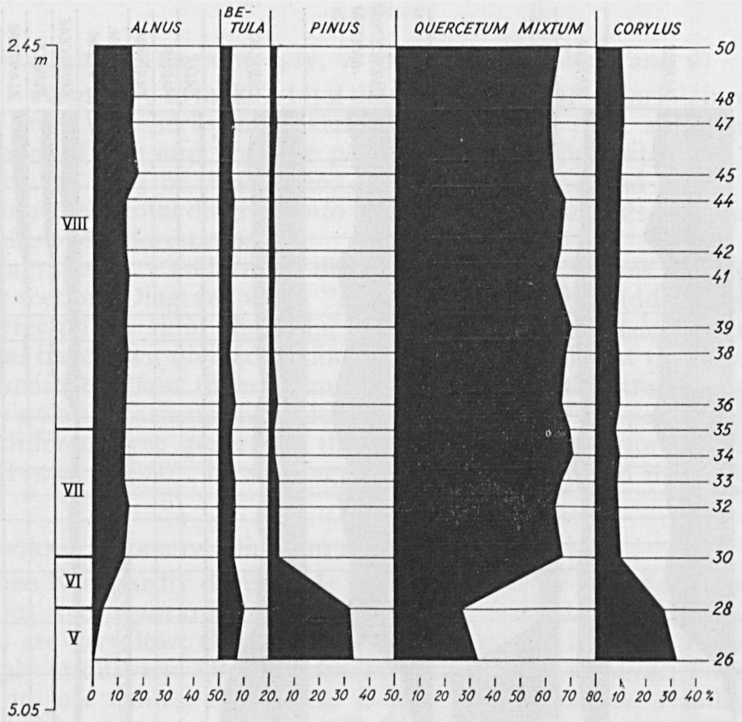

DIAGRAM V

Dissolved and reduced diagram from the same section as in DIAGRAM IV, to demonstrate the approximate composition of the forest in Post-Glacial times.

resp. 2 % at the close of the period. A few pollen grains of *Fagus* are found at the same time. *Picea* occurs with one or two pollen grains pro slide.

A gradual rise in N.A.P. is caused mainly by the grasses which increase from 5, resp. 6 % to 9, resp. 11 %. *Calluna* rises from 1.6, resp. 1.8 % to 3.1, resp. 3.7 %, probably on account of the leaching of the soil. *Viscum* and *Hedera* occur in a few pro mille only; *Pteridium* comes up with low values, 0.8 resp. 1 % at the close of the period. *Plantago lanceolata* was found twice; *Rumex* occurs regularly with a few pro mille, in the three last samples one pollen grain of *Hordeum* measuring 42 μ was found.

There is a distinct change in the quality of the water, which becomes oligotrophic; the sediment changes into a deep brown dy, very rich in pollen. *Nymphaea* and *Nuphar* pollen occur together with the characteristic hairs of these plants. *Potamogeton*, *Lythrum* and *Hydrocotyle* are found; towards the end of the period *Ceratophyllum* hairs become abundant. In the second half of the Atlantic period, *Isoetes* expands rapidly to a maximum of 12, resp. 14 %, *Littorella* comes up with 1.5, resp. 1.8 %. *Sphagnum* also rises, but not so much as in peat; in our deposits *Isoetes lacustre* plays the role which *Sphagnum* plays in peat.

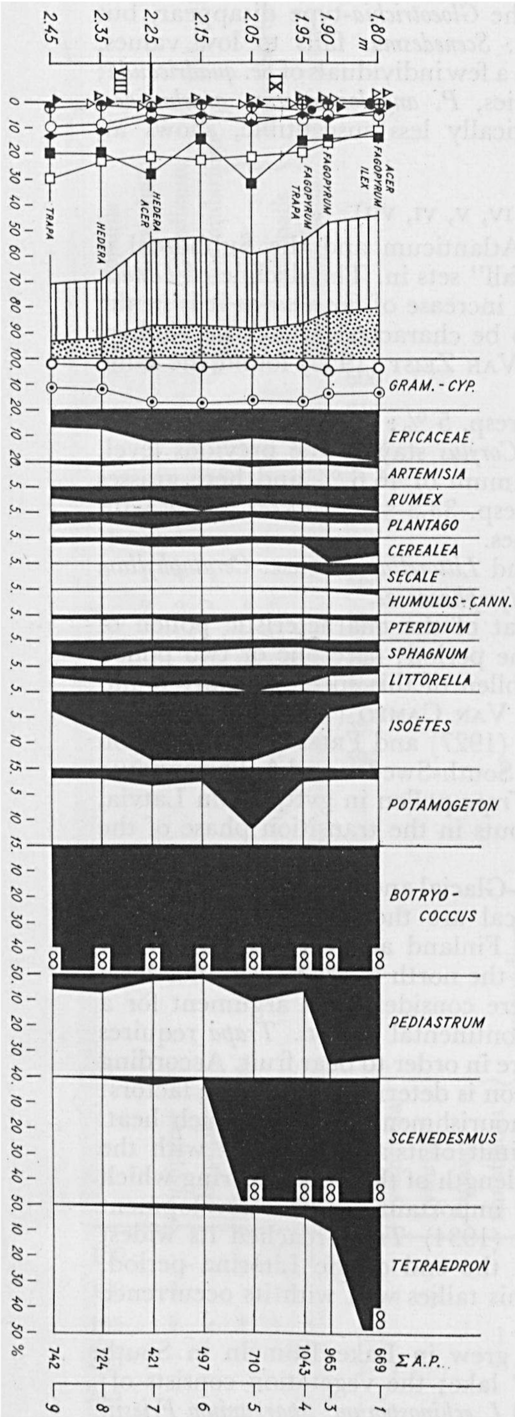

DIAGRAM VI
Total diagram of the uppermost layers. Note the expansion of weeds, cereals and *Chlorophyceae*.

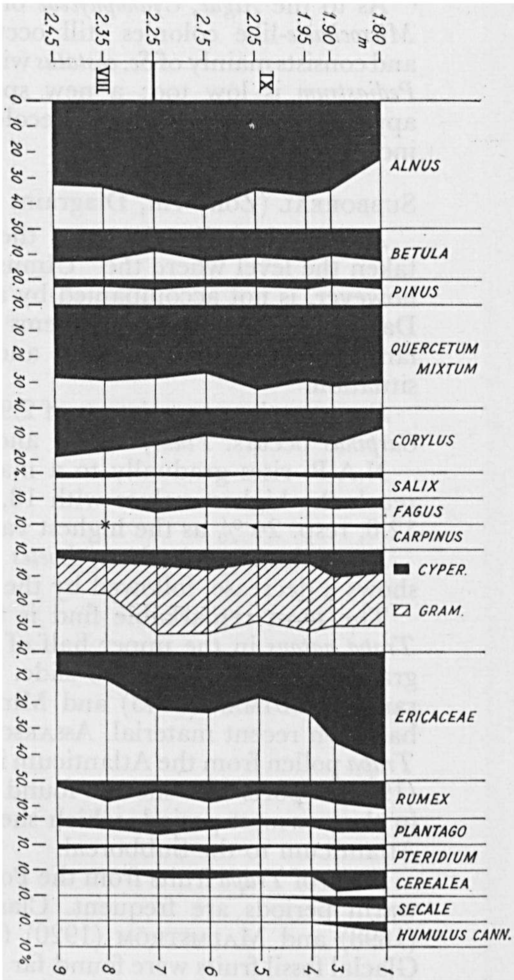

DIAGRAM VII
Classical dissolved diagram of the same section as in DIAGRAM VI

As to the *Algae*, *Cyanophyceae* of the *Gloeotrichia*-type disappear, but *Microchaete*-like colonies still occur. *Scenedesmus* falls to low values, and consists mainly of *Sc. costatus* with a few individuals of *Sc. quadricauda*; *Pediastrum* is low too; a new species, *P. angulosum* var. *arachnoides*, appears. *Botryococcus*, being ecologically less susceptible, shows an increase.

SUBBOREAL (Zone VIII, Diagrams I, IV, V, VI, VII)

As boundary line between the Atlanticum and the Subboreal is taken the level where the "Ulmus fall" sets in. The decline of *Ulmus*, however, is not accompanied by an increase of *Fraxinus* as it is in the Danish diagrams; but this seems to be characteristic for the Netherlands, for WATERBOLK (1954) and VAN ZEIST (1955) found the same situation.

Fagus attains a maximum of 2.9, resp. 5 %; a single pollen grain of *Carpinus* occurs. *Pinus*, *Betula*, and *Corylus* stay at the previous level.

N.A.P. rises gradually to a maximum of 46.6 % and here grasses reach the highest values with 18, resp. 33.3 %, *Ericaceae* follow with 12.6, resp. 24 % as the highest values.

As to the aquatic flora, *Isoetes* and *Littorella* increase. *Ceratophyllum* shows a decrease, followed by the *Nymphaeaceae*.

The most remarkable find is that of the characteristic pollen of *Trapa natans* in the upper half of the period; here one or two pollen grains occur regularly pro slide. Pollen of this species is only found rarely. ERDTMAN (1943) and Mme VAN CAMPO (1951) give pictures based on recent material. ASSARSON (1927) and FRIES (1951) mention *Trapa* pollen from the Atlanticum in South-Sweden and A. PRESNIKOWA (1956) reports that she has found *Trapa* pollen in gyttja from Latvia, in the warmest period, which she puts in the transition phase of the Atlanticum to the Subboreal.

Finds of *Trapa* fruits from the Post-Glacial and from the Inter-Glacial warm periods are frequent. Classical are the studies of ANDERSON (1898) and MALMSTRÖM (1920) for Finland and Sweden. The Post-Glacial fossil fruits were found far to the north of the present northern limit of the species. Those finds were considered an argument for a Post-Glacial warm period or for a continental period. *Trapa* requires summers with fairly high temperature in order to bear fruit. According to GAMS (1927) its present distribution is determined by three factors: it shuns lime, but requires much nourishment and also much heat. In North-Germany the northern limit of its area coïncides with the July isotherm of 18°. Especially the length of the period during which the water is sufficiently warm, is important for the development of fruits. According to SAMUELSSON (1934) *Trapa* reached its widest distribution in northern Europe at the end of the Litorina period, that is to say in the Bronze age. This tallies well with its occurrence in the mud of the "Uddeler Meer".

As recently as 1913, *Trapa* still grew in Lake Immeln in South Sweden. This is a typical "*Lobelia*" lake; the vegetation consists of: *Equisetum limosum*, *Isoetes lacustre* and *I. echinosporum*, *Sparganium Friesii*,

Populus	Hippophaë	Helianthemum oelandicum	Helianthemum nummularium	Sanguisorba minor	Sanguisorba officinalis	Epilobium	Valeriana	Cruciferae	Galium	Ranunculaceae Batrachium	Ranunculaceae Ranunculus	Rosaceae Geum	Rosaceae Potentilla	Potamogeton Eupotamogeton	Potamogeton Coleogeton	Chenopodiaceae	Urticaceae	Umbelliferae	Compositae Tubuliflorae	Compositae Liguliflorae	Lotus	Parnassia	Saxifraga oppositifolia	Oxyria	Ephedra	Nuphar	Plantago maritima	Plantago media	Plantago major	Succisa	Centaurea scabiosa	Menyanthes	Typha sparganium ang.	Typha latifolia	Jasione	Caryophyll. Lychnistype	Caryophyll. Stellaria	Scrophulariaceae	Labiatae Galeopsis type	Labiatae Mentha type	Botrychium	Selaginella	Sphagnum	Empetrium	Dryopteris Linneana	Nymphaea hairs	
	x	1		x	x	x			5				1	1	1	1	2	x			1				x	1			1	1		x	1					2				x		1		x	600
2	x		1						3			1		7	1			1	1										2			1					1			1				1	2		608
		3							1						1								1						1	1															2		613
		8															2		5	3																2						3					620

Table III Supplement to Diagram II

Populus	Hippophaë	Helianthemum oelandicum	Helianthemum nummularium	Sanguisorba minor	Sanguisorba officinalis	Epilobium	Valeriana	Cruciferae	Galium	Ranunculaceae Batrachium	Ranunculaceae Ranunculus	Rosaceae Geum	Rosaceae Potentilla	Potamogeton Eupotamogeton	Potamogeton Coleogeton	Chenopodiaceae	Urticaceae	Umbelliferae	Compositae Tubuliflorae	Compositae Liguliflorae	Lotus	Parnassia	Saxifraga oppositifolia	Oxyria	Ephedra	Nuphar	Plantago maritima	Plantago media	Plantago major	Succisa	Centaurea scabiosa	Menyanthes	Typha sparganium ang.	Typha latifolia	Jasione	Caryophyll. Lychnistype	Caryophyll. Stellaria	Scrophulariaceae	Labiatae Galeopsis type	Labiatae Mentha type	Botrychium	Selaginella	Sphagnum	Empetrium	Dryopteris Linneana	Nymphaea hairs	
1		1							2			1		1				3	1					1				3	4			2	1		2				1						3		575
	1	4	1					1	7			2	1	1				2	2					1					1	1		1	3	1		1	1	2									580
	2	2		3					4		2	1		3	1			2	4					1				2	3		1									1	1	2					584
		5			1		1		1			4	1	6	12	2		5											4				2								1						587
		1						1	2			2		7	1		1															2	1									1		1			590
	1	3	4	1	1				7	1		1	2	5	6		2	4	1			1					2		1			1	1						1	2		3		1			595
		2							1		1	13								30																8							2				597

Table IV Supplement to Diagram III

	Juniperus	Hippophaë	Centaura jacea	Fagopyrum	Menyanthes	Drosera rotundifolia	Myriophyllum spic.	alterniflorum	Polygonum amphibium	Polygonum aviculare	Polygonum convolvulus	Polygonum persicaria	Ranunculus Batrachium	Ranunculus Ranunculus	Rosaceae Geum	Rosaceae Potentilla	Lonicera	Thalictrum	Chenopodiaceae	Urtica	Umbelliferae	Compositae Tubuliflorae	Compositae Liguliflorae	Papillionaceae	Lotus	Solanum dulcamara	Myrica	Labiatae Mentha-type	Labiatae Galeopsis-type	Scrophulariaceae Digitalis-type
180				1	1						x	2	4	9	4	5			7	4	5	10	11	1	1		5	2		
190	1			1	1	x			x		1	1	3	6	5	5	1		5		2	10	9		3	1	6	1	4	1
195	2	x	1	1	1	1		x		1		1	2	4	3	2			9	1	1	5	4	1	1		2	1	10	1
205									1					2		2		1	7	2	1		2				1	1	3	
215									2					1	1				x	1	2	2	1	1		3		4		1
225		1							1					2	1	x			2	1			3	1	1	1	x		1	1
235							1		x			x			2	5			1	4		4	1		2		2	1	1	2
245									1				2	4	2	6			3	1	1	3	1						1	

	Scrophulariaceae Melampyrum	Caryophyllaceae Lychnis-type	Caryophyllaceae Stellaria-type	Spergula arvensis	Jasione	Campanula	Cruciferae	Succisa	Hottonia	Typha Sparganium	Typha latifolia	Nymphaea	Nuphar	Rhamnus cath.	Frangula alnus	Hydrocotyle	Sambucus	Lysimachia	Lythrum	Papaver	Lycopodium annotinum	Lycopodium inundatum	Polypodium vulgare	Galium	Filipendula	Vaccinium	Andromeda	Convolvulus	Cornus sanguinea	Nymphaea hairs	Ceratophyllum hairs
180		2		2	2		2	1		18		3	1			3							1	1	6		1	2	1	2	8
190		1	1	5	7		6	x		3	2		1			3	12	1	1					7	1	x				2	5
195		1	1	4	2		3	1		7	1	4	3		3		8				1				3					14	10
205				1	1		2	2		6			1				2	1				1	x							5	2
215		2				1				2			1		1	3	1								1					11	2
225			x			x	2	x	1	1		1	1			2	1							x				1		4	1
235		x		1	1	x		x		4			x			2		1		1	1		1	2			1			x	x
245		1			2					3			x	1				1						1	1	1	x			x	x

Table v Supplement to Diagrams vi and vii

Potamogeton natans, *Phragmites*, *Scirpus multicaulus*, *Nuphar luteum*, *Nymphaea alba*, *Myriophyllum verticillatum* and *M. alterniflorum*, *Hottonia*, *Littorella* and *Lobelia*. In the mud of the "Uddeler Meer" (Diagram I, VI, Table II, V) several of these species were found in company of *Trapa natans*.

In the Netherlands finds of *Trapa* fruits from the Post-Glacial are rare and they are not dated. In recent historic times however, *Trapa* still occurred in this country. In the Flora of de GORTER (1781) the species is mentioned for ponds and stagnant water. In 1861 OUDEMANS stated in his Flora that *Trapa* had not been found in the Netherlands since DE GORTER.

In the "Uddeler Meer" the *Trapa* pollen disappears in the Subatlanticum; but whether the species was driven away by a detoriation of the climate or by an edaphic alteration in the environment, cannot be ascertained. However, considering its present distribution, it seems likely that during the period of its occurrence the climate was more continental than nowadays. The presence of *Viscum* points in the same direction.

ALGAE

No *Cyanophyceae* of the *Gloeotrichia* type were encountered, but a few colonies of the *Gloeothece* type occurred regularly. Diatoms were scarce. *Chara* oospores, slightly differing in shape from those found in Zone I, are present.

Botryococcus is high; *Tetraedron* nearly absent; *Scenedesmus* is low, and consists mostly of the species *costata* and *quadricauda*; *Pediastrum* fluctuates.

CEREALS AND WEEDS

Since long, the "Uddeler Meer" has been an attraction object for archaeological investigations. As early as 1909, 1911 and 1912 HOLWERDA published the results of his excavations in this region. He unearthed dwelling pits and different kinds of burial sites. No megalithic graves were found, but megalithic earthenware and artefacts were met within the region. Funnel beakers, beakers with protruding foot and especially bell beakers, the latter being characteristic for the Late Neolithic of the Veluwe, occurred. It appeared that different cultures followed each other and became mixed. The bank and the surroundings of the water have been inhabited from Early Neolithic up to Carolingian times. The well known "Hunneschans" is an artificial mound erected upon natural sandridges round the lake; it enclosed a Saxon stronghold (Fig. 2).

It was the particular situation of the "Uddeler Meer" that attracted prehistoric people. According to VAN DER WAALS and GLASBERGEN (1955), in the Netherlands Neolithic remains are found especially on sand hills which formerly were bordered by extensive bogs or by low swampy regions and which usually were accessible only by way of narrow ridges. For the Beaker immigrants, accessibility, habitability, soil type and the presence of an older population, will have been determining factors. Several of these conditions were fulfilled in the vicinity of the "Uddeler Meer", which became a focus of Beaker cultures.

Human occupation is reflected in the diagrams. A gradual rise of the N.A.P. coincides with a decrease in the extent of the forest; especially the oakforest goes gradually back. However, the curves, for forest and herbs undergo some corresponding fluctuations (Diagrams I, IV, VI and VII), pronounced clearance spectra succeeded by a regeneration of the forest, as described by IVERSEN (1941, 1949), could not be established, neither is a temporary progress of birch or hazel to be seen. In sample 45, Diagram IV, however, a slight advance of alder accompanied by a retrogression in the mixed oakforest can be observed, which may have been due to a deforestation which denuded the dryer parts of the area, but left the more humid sections intact. The tendency of the alder pollen to increase at the cost of the oak pollen continues in Zone IX. This picture of forest growth on poor soil, retreating under human influence, corresponds very well with the situation depicted for western Jutland by IVERSEN (1941, 1949) and by JONASSEN (1950).

A slow rise in the N.A.P. curve, mainly caused by grasses and a gradual decrease of the Q.M., is already seen in Zone VII (Diagram I and IV). A few pollen grains of the *Hordeum* type occur in this section, together with some scattered grains of *Rumex* and *Plantago*. In Zone VIII cereals are still scarce. From a few pro mille in the lower deposit they increase slowly to a maximum of 0.7, resp. 1 % in the upper part of the section. Most pollen grains are of the *Hordeum* type; very few of the *Triticum* type are found. It proved impossible to distinguish *Triticum monococcum*, which may have been present.

HELBAEK (1952) states for southern Britain that in Neolithic and Early Bronze times *Triticum dicoccum* was the main crop on fertile calcareous soils. But "as later new and inferior areas had to be opened up to accomodate the growing population, *T. dicoccum* may have been unable to hold its own against barley, which is less susceptible ecologically". JESSEN and HELBAEK (1944) give figures with regard to the ratio of occurrence of *Triticum* and *Hordeum* in the Neolithic and Bronze Age. They conclude that in prehistoric times for long periods barley must have been the most important cereal, but that in the Neolithic Age *Triticum dicoccum* evidently equalled it. Their conclusions are based on the finding of fruits which in these selffertilising genera give still better evidence than pollen grains do.

Nevertheless it seems quite possible that in the northern part of the Veluwe *Hordeum* may have superseded *Triticum* already in the Neolithicum because of the soil conditions prevailing in this part.

In Zone VIII *Plantago*, *Rumex* and *Pteridium* increase and begin to show continuous curves. *Plantago* maxima precede those of *Rumex*, the highest values for *Plantago* being 2.4, resp. 3 %. It is most *P. lanceolata*, but there are also a few grains of *P. major*, *P. coronopus* and *P. media*. At the top of the Zone *Rumex* begins to surpass *Plantago*, attaining 2.6, resp. 8 %.

Gramineae and *Calluna* increase slowly, the *Gramineae* remaining ahead of the *Ericaceae* during the entire period. *Calluna* rises from 2.8, resp. 3.4 %, to 6.4, resp. 9 %; *Gramineae* from 8.7, resp. 10 %, to 11, resp. 16 %. Extensive fields of heather which according to VAN GIFFEN (1941) began to develop in the Subboreal, were not present in this part of the country; probably there were open spaces covered with grasses and patches of heather.

Artemisia occurs regularly with a few pro mille; *Polygonum persicaria*, *P. convolvulus*, *Sambucus* and *Rhamnus cathartica* are found too (Tables II, V).

SUBATLANTICUM (Zone IX, Diagrams VI and VII, Table V)

During this period the sediment undergoes a change; it grows thinner and thinner, and so the youngest deposits can not be sampled, the deposit flowing out of the auger. At the same time the colour lightens up; the deeper samples are still dark brown, the younger and thinner ones pale green.

The boundary line between Zone VIII and IX is not very distinct. It is placed were *Fagus* increases, *Corylus* recedes slightly, and grasses and heather expand. *Carpinus* stays very low, but begins to show a continuous curve. *Fagus* attains 2.9, resp. 5 %, Carpinus 0.4, resp. 0.9 %. The poor quality of the leached sands prevents the expansion of those trees, and may also be the cause that *Corylus* maxima are lacking in our diagrams. *Myrica* is very scarce, only a few pro mile.

N.A.P. increases to 55.4 %. *Alnus* expands, and sometimes surpasses or equals the mixed oak forest, in which *Quercus* predominates very strongly; *Tilia* and *Ulmus* fall down to a few pro mille only.

AQUATIC VASCULAR PLANTS AND ALGAE

In this period *Trapa natans* disappears. Next to a change in the climate it seems likely that a change in the chemical composition of the water may have been responsible. *Potamogeton* expands; high values for pollen are found together with several fruits. Some could be identified as *P. obtusifolius*, *P. acutifolius* and *P. natans*, JESSEN (1955). *Littorella* and *Isoetes* recide (Diagram VI); *Ceratophyllum* and *Nymphaeaceae* are still present; according to IVERSEN (1929), they occur in all types of water.

It looks as if the water becomes eutrophic. The green *Algae*, *Scenedesmus*, *Pediastrum* and *Tetraedron* show a considerable rise, and reach very high values in the uppermost deposits. The bulk consists of *Scenedesmus* among which *S. bijugatus* is the main component, but *S. costatus* and *S. quadricauda* occur too. The pale green colour of those upper deposits is mainly caused by *Scenedesmus*. Among the *Tetraedron* species *T. muticum* predominates, but a new species comes up, viz. *T. caudata.*, *Pediastrum boryanum*, *P. duplex f. subgranulatum* and *P. angulosum* occur too, the first species being most abundant. The dark brown dy gradually changes into a gyttja in *statu nascendi*. This coincides with the cultivation of rye and with the expansion of the fields of heather; i.e. with the time when human occupation is at its peak.

Owing to the deforestation the content of sand in the deposit increases. It seems highly probable that the water became eutrophic because of man and his refuse.

CEREALS AND WEEDS

During the Subatlanticum the cereals continue to increase slowly. *Hordeum* is still the main component, but some *Triticum* occurs too. In sample 5 at 2.05 m under the surface *Secale* makes its appearance with two grains. The values for cereals are then 1, resp. 2 %, *Secale* included. According to MIKKELSEN (1954), the first appearance of *Secale* coincides with the Roman Iron period, RY II. At the same time a slight regeneration of the forest and a recession in the N.A.P. may be observed (Diagram VI and VII). Archeological finds are rare in this period; this together with the behaviour of the vegetation might lead to the conclusion, that the region was more or less abandoned in the Roman Iron time. MIKKELSEN (1954) supposes that this period was warmer and drier than the previous one, so that the cultivation of dry soils declined, and the more fertile humid areas became arable, which caused a migration of the inhabitants. MODDERMAN (1955) states that in the first two centuries of our era, the Betuwe (south of the Veluwe, a silt-covered region between the branches of the river Rhine) became densely inhabited. In that time the water level fell, and the higher parts, i.e. the sand ridges and river banks, became habitable. In the first half of the third century many dwelling places were abandoned because of the greater humidity of the climate and the rising water level, a situation which favoured the drier soils. Could it be that there was a migration from North to South and vice versa?

While *Hordeum* and *Triticum* maintain the same level, *Secale* at first rises slowly and more quickly in the upper samples. Cereals, *Secale* included, reach maxima of 5, resp. 7 %. *Centaurea cyanus* does not occur in our samples. According to MIKKELSEN (1954, 1955) this species did not appear in rye fields before about 1300; its arrival probably coincided with the introduction of wintercorn. In the upper three samples a single pollen grain of *Fagopyrum* is found. Buckwheat, was recorded by VAN ZEIST in the Bronze Age (in VAN GIFFEN 1954), by MIKKELSEN at the close of Iron Age on Bornholm (1954). In the same year DIECK published a study on the history of buckwheat in which he states that in the Middle Ages *Fagopyrum* has been imported from Eastern Europe. In 1396 it was mentioned for the first time in the archives of Nürnberg.

It seems that in our case *Fagopyrum* occurred at the close of the Iron Age, before *Centaurea cyanus* appeared in the rye fields.

Together with cereals, there is a pronounced rise in the values for weeds. *Rumex* surpasses *Plantago* and attains maxima of 5, resp. 11 %, *Plantago* 2, resp. 4.6 %. According to WATERBOLK (1958) this might indicate a change from cattle breeding and grazing to agriculture. *Spergula* occurs regularly; *Polygonium persicaria*, *P. convolvulus* and *P. aviculare* are present. A new element is the pollen either of *Humulus* or *Cannabis*, which appears in the form of a regular curve with maxima of 1, resp. 3 %.

During the Subatlanticum the *Ericaceae* rise sharply from 6.4, resp. 9 % to 19.6, resp. 44 % in the uppermost sample. In this section they surpass the grasses, which rise from 11, resp. 16 %, to 13.5, resp. 30 %. For *Calluna* no percentages of over 100 are met with. The very high values for *Ericaceae* in many Netherlands diagrams, however, are from peat, where local influence is considerable (BROUWER, 1947, VAN ZINDEREN BAKKER, 1948, VAN ZEIST, 1955). We could not continue our sampling up to younger historic times and had to stop at approximately the early Middle Ages. It is supposed that the very great expansion of the fields of heather took place at the beginning of the nineteenth century (JONASSEN, 1935, 1950).

At the time of our upper samples the landscape showed oak forest, heath, cultivated fields and grassy plains, maybe heather interspersed with grasses. This picture of the region is in good agreement with EDELMAN's interpretation of the name "Veluwe" (1958, 1959). He points out that "Betuwe" and "Veluwe" are names often heard at old dwelling places, and that they apply to grass fields on former forest soil. "Veluwe" to this sense means "yellow meadow", in contrast to heath or to green grass fields. As grasses on sandy soils after flowering soon turn yellow, the landscape will have had this colour during most of the year.

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SUMMARY

The diagrams of the "Uddeler Meer" cover the history of the vegetation from Late-Glacial (Dryas I) to early historic times. All the analyses have been made from organic sediment (mud).

Late-Glacial

The zonation of JESSEN and IVERSEN (FAEGRI and IVERSEN, 1950) is used. In ZONE I (Older Dryas time) no Bølling oscillation could be detected. *Juniperus* attains high values (over 20 %), *Artemisia* 5 %.

ZONE II (Allerød) is characterised by a *Pinus* maximum in the upper section. At that time *Pinus* forests must have occurred near the bank, as *Pinus* stomata are found in the samples.

In ZONE III (Younger Dryastime) *Juniperus* stays low, *Artemisia* increases, *Empetrum* attains a maximum of 3.9 %, and *Dryopteris linnaeana* shows a continuous curve (maximum 12 %).

The sediments of Zone I and III are greyish green in colour; the Allerød sediments (Zone II) are olive. The deposits of Zone I are rich in lime.

Post–Glacial

ZONE IV (Preboreal) is hardly developed.

ZONES V and VI (Boreal), with maxima of *Pinus* and *Corylus*. Again stomata of *Pinus* are found; only in Zone II and V *Pinus* was important. After Zone VI *Corylus* has no more maxima.

ZONE VII (Atlanticum). In this section the most remarkable feature is that *Quercus* predominates over *Alnus*, as this is quite exceptional in the Netherlands. *Viscum* and *Hedera* occur in a few pro mille only.

ZONE VIII (Subboreal). After the *Ulmus* fall, *Fagus* begins to show a continous curve with low values. *Fraxinus* fluctuates between 2 and 3 %, but shows no distinct maximum.

ZONE IX (Subatlanticum). *Carpinus* stays under 1 %, and of *Myrica* only scattered pollen grains were found in the youngest deposits. In the last samples some pollen grains of *Juniperus* and *Hippophaë* were met with.

Cereals and Weeds

Traces of cereals and weeds occur already in the Atlanticum, in the Subboreal however they become numerous. Among the cereals *Hordeum* predominates, *Triticum* is scarce; together they attain a maximum of 1 %. In the Subatlanticum cereals rise, mainly due to the arrival of *Secale*; the first pollen grains appear towards the middle of this section. In the uppermost samples *Fagopyrum* occurs, *Secale* rises to 4.3 % and the other cereals to 2.8 %.

The N.A.P. curve rises gradually, but shows a rapid increase in the Subatlanticum. The main components are grasses and *Ericaceae*; the *Gramineae* surpass the *Ericaceae* till the point is reached where *Secale* begins to expand. At the end of the Subboreal the *Ericaceae* attain 23 %, in the Subatlanticum 44 %. The final expansion of *Calluna* must have taken place in late historic times.

Plantago, *Rumex* and *Pteridium* begin to show continuous curves in the Subboreal. At first *Plantago* surpasses *Rumex*; in the Subatlanticum *Rumex* (maximum 11 %) exceeds *Plantago* (maximum 4.6 %). *Polygonum persicaria*, *P. convolvulus* and *P. aviculare* occur. In the younger samples *Spergula* appears; a kind of pollen which may be either *Humulus* or *Cannabis* shows a continuous curve.

Aquatic flora

The "Uddeler Meer" started as a hard water pond, rich in *Characeae*. In the Older Dryas time *Chlorophyceae* and *Cyanophyceae* were present to such an extent that they gave colour to the sediment.

Pediastrum, *Scenedesmus*, *Tetraedron* and *Botryococcus* have been counted.

Tetraedron has a peak in Zone I, and decreases rapidly in Zone II, but in the Subatlanticum it reappears with high values.

Scenedesmus stays high up to the Atlanticum; thereafter it falls to low values, and reappears in very great numbers in the Subatlanticum.

Pediastrum is very high in the Late-Glacial, especially in Zone I. During the Post-Glacial it fluctuates around rather high values, and increases strongly in the upper Subatlanticum.

Botryococcus is high throughout the entire series; it increases still further towards the end.

Cyanophyceae occurred especially in the Late-Glacial; they could not be identified with certainty, and have not been counted.

As to the aquatic Vascular Plants, *Littorella* and *Isoetes* show continuous curves in the Atlanticum with relatively high values.

The most remarkable find is that of *Trapa natans* pollen in the upper section of the Subboreal; it is represented there by one or two grains pro slide. It vanishes in the Subatlanticum.

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