The Post-glacial development of Grane Langsø

by

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The lake Grane Langsø is situated in Jylland in a SE–NW running valley to the south of the village Vrads, near to the main borderline of the Würm glaciation. The direction of the valley indicates, that the last ice cover in this district has moved from SE to NW, which is strange because this valley and a couple of other valleys in the neighbourhood cross an older sandur parallel to its contour curves.

The lake is situated 74 m above sea level, the sides of the valley rise steeply to 86 m and are covered with coniferos forest (Fig. 1). The shore is mostly narrow. Only on the eastern side it is 10 metres wide and covered with *Sphagnum, Erica tetralis, Drosera* and *Lycopodium*. The map, fig. 2 shows that the lake bottom slopes steeply downwards to 10 m below water level. Only in the southern end the dip is more gradual. From 10 metres the bottom is flat with only two depressions down to 11,1 m.

The Grane Langsø is an oligotrophic lake (HANSEN 1957, 1959, 1962) with very clear water. The transparency is occasionally 12 metres or more and if the lake had been 28 metres deep 1% of subsurface green light would occasionally have been able to reach the bottom (NYGAARD 1955).

Table I shows some chemical analyses of the water (JØRGENSEN 1948, NYGAARD 1955).

Table I

Conductivity	$49{,}50 \times 10^6$
Ionconcentration	1–2 milliequiv.
pH	5–5,5
Alkalinity	5,4
Ca	1,8 mg/l.

The higher vegetation consists in shallow water (0,3–3 m) of *Lobelia Dortmanny* and *Litorella uniflora*, in deeper water (3–4 m) of *Isoëtes lacustris* and from 8 metres the bottom is covered by *Fontinalis, Drepanocladus exannulatus* and *Nitella flexilis*. In depths between 5–7 metres the bottom is nearly free from any vegetation. (NYGAARD 1958). The phytoplankton production is very small, 0.62 g glucose per square metre surface (NYGAARD 1955) which corresponds with 0,248 g C.

The zooplankton consists of a few species and only 13 animals pr. liter water. The beach fauna is rich, but rather different from other Danish

Fig. 1. View of the northern end of the lake Grane Langsø.

lakes (RØEN 1954). Most remarkable is the large numbers of crayfish (*Astacus fluviatilis*) in a lake with water so poor in calcium.

The bottom is sand out to a depth of 4 m. Farther out it is a sandy Gyttja. Table II shows the chemical composition of this sediments.

Table II

No	I %	C %	N %	C/N	D %	M %	$CaCO_3$ %
457	11,0	2,4	0,14	8,8	2,4	73,8	1,3
459	14,7	4,3	0,6	7,8	1,6	69,0	1,4
460	9,3	3,1	0,3	9,6	2,8	72,8	

I = loss on ignition, C = organic carbon, N = organic nitrogen, D = diatoms, M = mineral matter. The sample numbers see p. 449.

The very low content of organic matter 9,3 and 14% and the low content of diatoms 1,6–2,8% corresponds very well with the oligotrophic nature of the lake. Fig. 3 and table III show the granulometric composition of the sand in these bottom deposits.

Table III

No	Md μ	Q_3 μ	Q_1 μ	So	$> 62\mu$ %	$< 4\mu$ %
456	240	360	180	1,415	99,2	
457	45	75	11	2,65	35,6	10,3
459	35	52	8	2,52	15,9	2,2
460	45	87	18	2,65	35,2	4,4
496	23	42	10	2,25	13,4	7,9

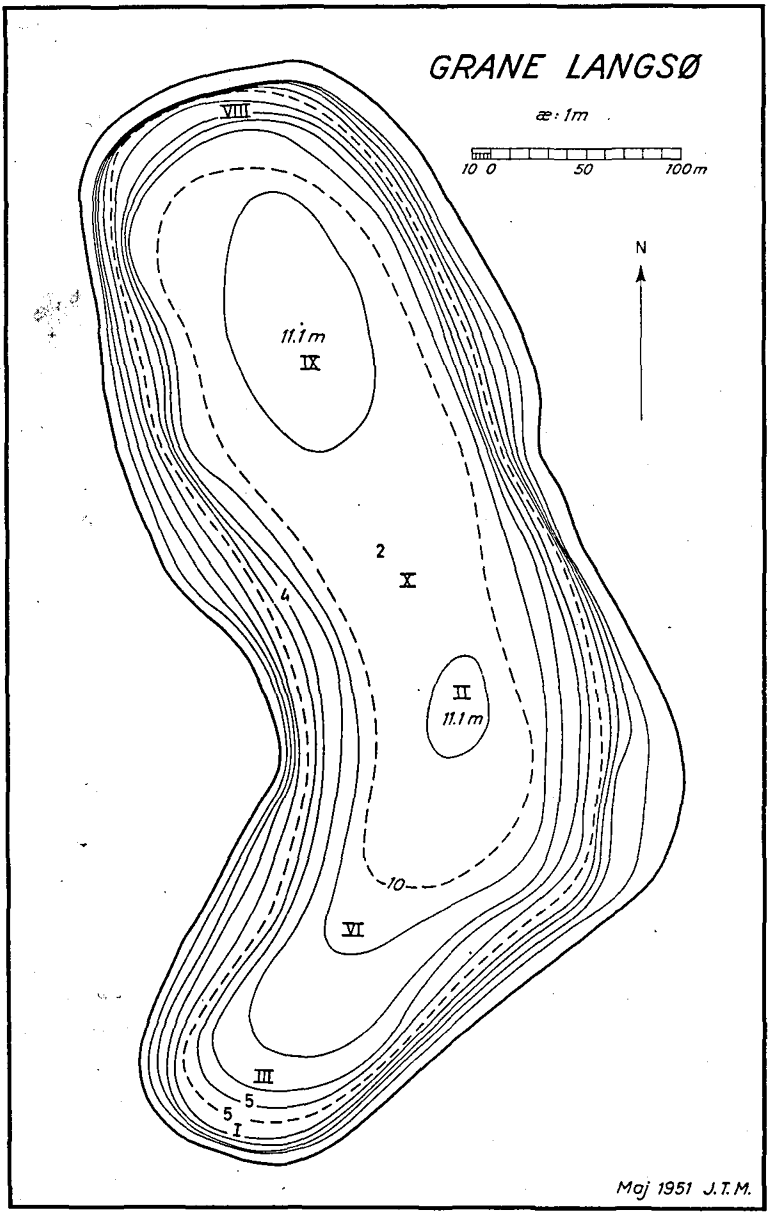


Fig. 2. Map of Grane Langsø measured and drawn 1951 by JENS TYGE MØLLER. Roman numeral indicate boring no.

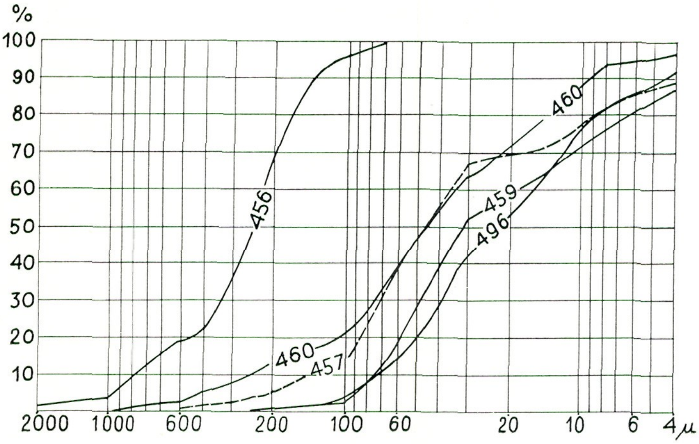


Fig. 3. Granulometric diagram of the bottom sediments.

Fig. 4. The boring platform in Grane Langsø 1953.

456 was taken on the steep slope on the eastside of the lake at a depth of 4 m.
457 was from the more gentle slope in the southern end at a depth of 6 m.
459 was from the flat bottom at a depth of 10 m.
460 was from the western side of the lake at a depth of 6 m.
496 was fetched with a syringe from the boring II representing only the uppermost surface layer.

456 is a medium to fine grained sand with nearly the same granulometric composition as the sediments in the hills surrounding the lake.

All the other samples are much finer and are probably windblown sand and dust.

Intending to study the postglacial development of the lake, ten borings were made in the lake in 1953. The borings took place with a Djos drill of the Hiller pattern from a platform made of two boats held together by a joint deck of timber (fig. 4). From an opening in the deck the drill could be lowered into the lake bottom. The boats were fastened to a wire drawn across the lake. As several of the borings took place in deep water, the drill rod was guided through a $2^1/_2''$ iron tube hanging down from the platform always with its lower opening half a meter above the depth to which the drill should reach.

The uppermost samples were so watery, that the drill chamber had lost most of its content during the hauling. Therefore samples from the surface layers were fetched with a syringe fastened to the drill rod.

From all samples material was taken out for pollen analyses, which were to be made by Mr. PER WOLTHERS. However, these have as yet not been finished. The rest of each of the half a meter long samples were treated as a whole.

Plate I shows a longitudinal section through the lake (The borings I, III, VI, II, X, IX and VIII). Further three supplementary borings were put down across the southern end of the lake. The strata penetrated in the borings were as follows.

Boring I.

Sounding 4,5 m

4,5 –4,67 m	Dark grey very sandy detritusgyttja.
4,67–4,68 -	Coarse sand.
4,68–7,05 -	Dark almost black peat with wood.
	Sand.

Boring III.

Sounding 7,35 m

7,35– 8,35 m	Olive grey green gyttja.
8,35–11,29 -	The same gyttja, downward more peaty with wood.
11,29–11,55 -	Dark silty gyttja.
11,55–11,80 -	Grey finely sandy silt.

Boring VI.

Sounding 9,38 m

9,38–12,33 m	Dark olive grey brown gyttja or dy.
12,33–13,46 -	Light grey silty sand.
13,46–13,56 -	Sand.

Boring II.

Sounding 11,16 m

11,16–17,50 m	Dark olive grey green now and then sandy gyttja.
17,50–17,75 -	Dark silty gyttja.
17,75–18,55 -	Grey sandy silt.
18,55–18,70 -	Sand.

Boring X.

Sounding 11,20 m

11,20–13,87 m	Olive grey green sandy gyttja.
13,87–13,97 -	Dark silty gyttja.
13,97–14,22 -	Grey sandy silt.
	Sand.

Boring IX.

Sounding 11,49 m
11,49–17,08 m Dark olive grey green gyttja.
17,08–17,38 - Dark silty gyttja.
17,38–17,43 - Grey silt.
Sand.

Boring VIII.

Sounding 7,20 m
7,20–8,57 m Dark olive grey green gyttja.
8,57–8,59 - Sand.
8,59–8,90 - Dark olive grey green gyttja.
8,90–9,20 - Dark silty gyttja.
9,20–9,35 - Grey silt.
9,35–9,75 - Sand.

These borings show, that in the bottom of the valley there are two basins with their bottoms 17,6 and 17,55 m, respectively below the water level. The threshold between them is situated at a depth of 14,5 m. The thickness of the sediments is 7,6 and 6,5 m over the basins and 3,3 m over the threshold.

With the exception of the borings I and III in the southern end of the lake the strata is nearly the same in all borings

Uppermost Olive grey green sandy gyttja
Dark silty gyttja
Grey downwards sandy silt
Sand.

Table IV

Sample	Boring	Depth m	Md μ	Q_3 μ	Q_1 μ	So	> 62 μ %	< 4 μ %
462	VI	13,46–13,56	145	300	50	2,45	71,3	6,9
463	II	18,50–18,70	185	250	90	1,67	80,9	2,4

The fig. 5 and the table IV show the granulometric composition of the sand in the bottom of the borings. It is medium—very fine grained sand with 20–30% silt. It is strongly different from the samples from the lake bottom. Organic matter is present in form of vegetable tissue, pollen-grains and chitin but of secondary importance. However, sample 462 contains several circular diatom frustules.

The grey silt.

Upwards the sand become more and more silty and change into a rather pure silt. Fig. 5 and Table V show the granulometric composition of these layers.

Table V

Sample	Boring	Depth m	Md μ	Q_3 μ	Q_1 μ	So	> 62 μ %	<4 μ %
461	VI	13,06–13,46	40	95	15	2,6	35	2,7
466	II	17,90–18,55	46	105	19	2,34	39,6	2,9
467	X	13,97–13,22	21	40	12	1,8	13,1	4,6
468	VIII	9,20– 9,35	22	48	12	2	18,2	12,0

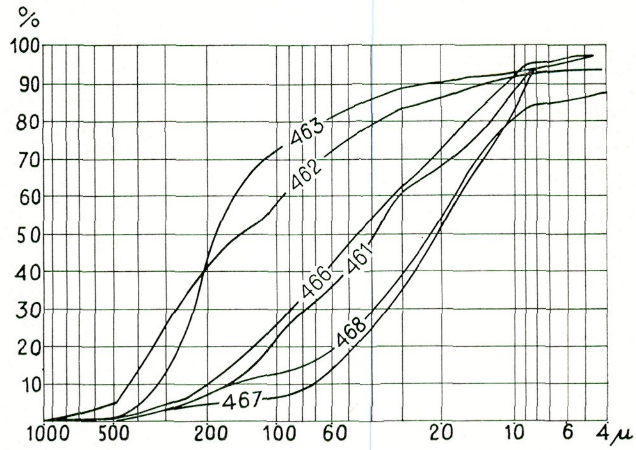


Fig. 5. Granulometric diagram of some of the strata in the borings.

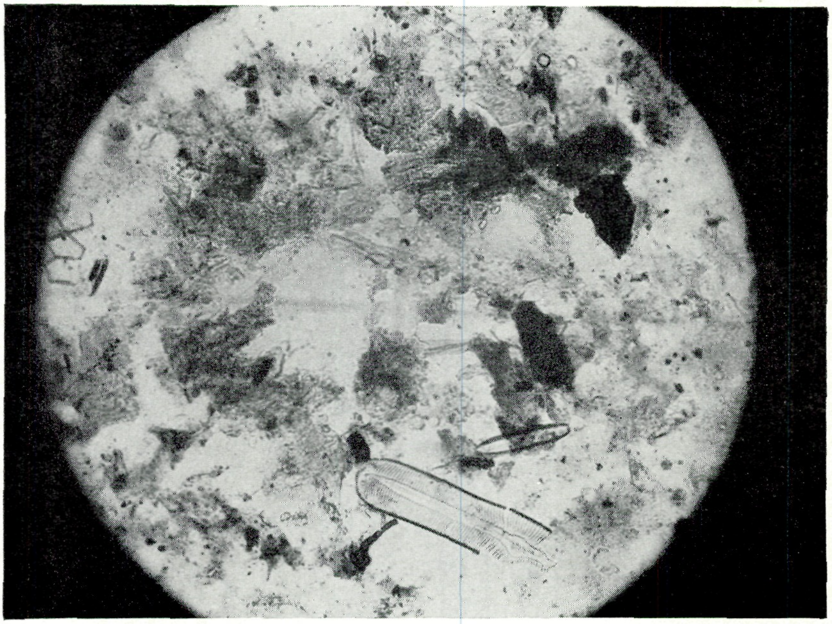


Fig. 6. Microphoto of the olive grey green gyttja in boring II. 11,7–12,2 m. Præp. 1457. 188 ×.

The four samples may be characterized as silt with varying contents of fine sand. The clay contents ($< 4\ \mu$) however is very low. The grey silt contains some organic matter. In boring II, 17,75–17,90 m 4,6 % and in boring X 13,97–14,22 m 11,3%. In both these examples the contents of organic carbon in the organic matter is very low, less than 25 per cent.

The dark silty gyttja.

Above the grey silt follows a silty layer, dark or black when fresh, but when dried the black colour disappears and the colour changes to a dirty yellow or pale brown. The thickness is 25 cm in boring II, 10 cm in boring X and 30 cm in boring IX. In the microscope it was seen, that the dominating constituents are very fine mineral grains with a very strong birefringence, however, there was no calciumcarbonate. In the lower part several diatoms were present, higher up there was only very few. Besides, the gyttja contains fragments of vegetable tissues, pollen grains and chitin.

The olive grey green gyttja.

The uppermost and main part of the borings was a soft sandy detritus-gyttja with a thickness of 6,34 m in boring II, of 5,60 m in boring IX and of 2,67 m in boring X. Fresh it is soft, very aqueous and olive grey green, Dried it is very dark, nearly black, and so hard, that it can barely be crushed by the fingers. The dominating part is organic detritus, mostly homogeneous, structureless, but also fragments of vegetable tissues are frequent (fig. 6). Mineral grains and diatoms are present in various quantities. In boring II the mineral grains are particularly numerous in the samples from 15–18 m.

The three borings I, III and VI from shallow water in the southern part of the lake have a somewhat different development. In the boring I the basal sand is covered directly by a 2,97 m thick layer of peat, which, when dried, is black and very hard. Under the microscope it is seen, that the dominating constituent is vegetable tissues with a covering of brown homogeneous structureless detritus. In the lower part mineral grains and diatoms are totally absent. Higher up, mineral grains are present in steadily increasing numbers. Above, the peat is covered by a gyttja also with numerous fragments of vegetables tissues. However, also with several chitin and mineral grains.

In the boring III the sand also is covered directly by a brown dy or tyrfopel (torfpelit) which, dried, is also black and hard. Vegetable tissues are present but badly destroyed. Mineral grains are rather numerous and increasing downwards. The lower part of the sediment has also a more peaty character.

In the boring VI the grey silt is covered directly by a gyttja which also has the character of containing more humus acid than the gyttja farther out in the lake.

To get an idea of the Postglacial development of the lake the same determinations of the total SiO_2, and the alkali-soluble SiO_2 as known from the investigations of the bottom deposits in other Danish lakes (Hansen 1959, 1960) were made for fixing the trophic standard, and a determination of organic carbon and nitrogen for fixing the humus standard.

Table VI

No	Depth	I %	C %	N %	C in % of I	C/N	T %	M %	D %	CaO %	Fe_2O_3 %
12	11,7–12,2	42,0	21,8	2,1	48,5	9,6	46,0	42,3	3,7	1,23	1,92
11	12,2–12,7	60,0	32,5	2,8	54,0	11,6	32,6	28,1	4,5	1,51	1,72
10	12,7–13,2	64,0	34,7	2,7	54,5	12,9	29,0	24,9	4,1	1,66	1,54
9	13,2–13,7	67,3	36,7	2,5	54,5	14,7	20,9	15,9	5,0	2,41	1,53
8	13,7–14,2	67,0	35,2	2,5	52,8	14,0	20,2	14,1	6,1	2,18	1,65
7	14,2–14,7	62,0	32,7	2,4	52,3	13,5	31,1	24,8	6,3	1,84	1,77
6	14,7–15,2	41,2	21,5	2,8	52,0	11,9	45,4	39,4	6,0	1,51	2,08
5	15,2–15,7	44,3	20,9	1,8	48,6	10,2	44,0	39,6	4,4	2,07	2,27
4	15,7–16,2	47,4	26,4	2,3	55,5	11,8	41,5	36,2	3,4	1,94	2,45
3	16,2–16,7	59,4	32,9	2,5	55,4	13,2	27,3	22,8	4,5	1,66	2,09
2	16,7–17,2	72,0	37,3	3,0	51,7	12,4	19,3	12,4	6,9	2,48	3,00
1	17,2–17,5	72,0	37,8	3,1	52,5	12,5	18,5	11,2	7,3	2,11	4,72

Depths are in m below the water table. I = loss on ignition, C = organic carbon, N = organic nitrogen, T = total SiO_2, D = alkali soluble SiO_2 (diatomes), M = T—D (mineral matter). — Boring II.

Fig. 7 shows the evolution of the trophic standard. The diagram seems to indicate, that the Grane Langsø in the two arid pollenzones VI (the boreal periode) and VIII (the subboreal period, bronze age) has been more eutrophic than to day, whereas it in the two humid zones VII (atlantic periode) and IX (subatlantic periode) has been oligotrophic. The eutrophy has not been very strong, nearly the same as in some other lakes in the Middle of Jylland to day (Almind Sø and Slauen Sø, or the classical lake Stråken in Southern Sweden.) However, these variations between the mineralogical matter, and the contents of diatom frustules may have two origins. Either a variation of the plancton production, and this give a real variation in the trophy, or a variation of the supply of mineral grains, and this latter origin must, in these parts of Jylland with its very sandy soils on the old sandurs from the Würm Glaciation, be included in the calculations, because wind drift now and before is very common in these districts. In spring the water in the lake may be strongly turbid and milky from windborne sand and dust in spite of the lake being situated in a deep valley with coniferos forests all around.

From the neighbourhood sanddrift in the two humid periods is described by V. MILTHERS (1925) and K. JESSEN (1939). MILTHERS refers to the following two sections in peatbogs.

Tranekær

Peat with remains of oak birch and hazel
Dune Sand
Moss peat with fruits of Potamogeton and beetle-wings. Many branches of birch
Dune Sand
Stony Sand

Klostermose

Peat with remains of oak and other plants
Dune Sand
Peat 10–20 cm with a lot of birch stumps
Sand

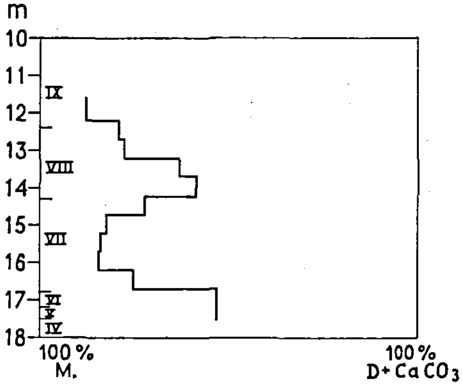


Fig. 7

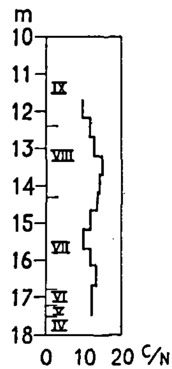


Fig. 8

Fig. 7. Diagram showing the development of the trophic standard of the lake Grane Langsø. The abscissa is the contents of alkalisoluble SiO_2 (diatoms)$+CaCO_3$ in per cent of the total SiO_2+CaCO_3. The ordinate is the depth in meter below the water level. The cifres IV–IX are the pollenfloristic zones according to K. Jessen.

Fig. 8. Diagram showing the development of the humusstandard in Grane Langsø. The abscissa is the rate C/N, the ordinate the depth below water level. If the rate C/N is higher than 10 it indicates that the sediment contains acid *humus*.

Milthers do not date the sand layers in the peat. However the contents of oak, birch and hazel in the peat above the sand indicates that the sand must be from the transition between the pollenzones VI and VII.

Jessen refers to a peat bog near Nørre Kollemorten with the following section.

A. 0 –0,6 m Dune sand.
B. 0,6 –0,65 - Poorly sandy transition layer.
C. 0,65–0,75 - Light brown strongly humified Sphagnum peat.
D. 0,75–1,2 - Dark brown strongly humified Sphagnum peat with tussocks of *Eriophorum vaginatum*.
E. 1,2 –1,75 - Dark brown birch forest peat with some Sphagnum.
F. 1,75–1,95 - Greybrown peaty sand.
G. 1,95–2,35 - Dark brown strongly humified Spagnum peat.
H. 2,35–2,55 - Brown Sphagnum peat with seeds of *Menyanthes trifoliata* and fruits of *Carex lasiocarpa*.
I. 2,55–2,65 - Sandy gyttja.
K. Hard sand without stones.

Jessen thinks, that the sand layer F. must have been transported by the wind, because both the layers below and above it are terrestrial deposits grown up above the groundwater level. The sandlayer Jessen dates to the transition between the pollenzones VI and VII and he states, that other peatbogs in the district also have sandlayers of the same age in the peat.

The uppermost sandlayer A, to which corresponding layers of dune sand are also found in other peat bogs, Jessen dates to zone IX.

JESSEN holds it difficult to believe, that human intensions may be the cause of the sand drift in the atlantic periode. However, it may very well be the cause in the subatlantic period and later. Probably the desolations by sand drift in Jylland in the 15th and 16th centuries are direct continuations of the upper sand drift period in the peat bogs.

This idea is totally confirmed by the investigations in Grane Langsø. In a letter of 19/10 - 62 WOLTHERS writes:

"In the boring II there is very little herbaceous pollen in the zone VII and VIII. The *plantago* curve begins at a depth of 13,97 m. At 13,50 m there is a strong rising of the culture-conditioned herbaceous pollen with a maximum at 13,32 m. They decrease at 12,92 m and rise again at 12,53 m and fall at 12,18 and at 12,00 m. At 11,77 m there is again a rising to a maximum at 11,44 m, which is in that part of the zone IX, where the sand drift is strongest.

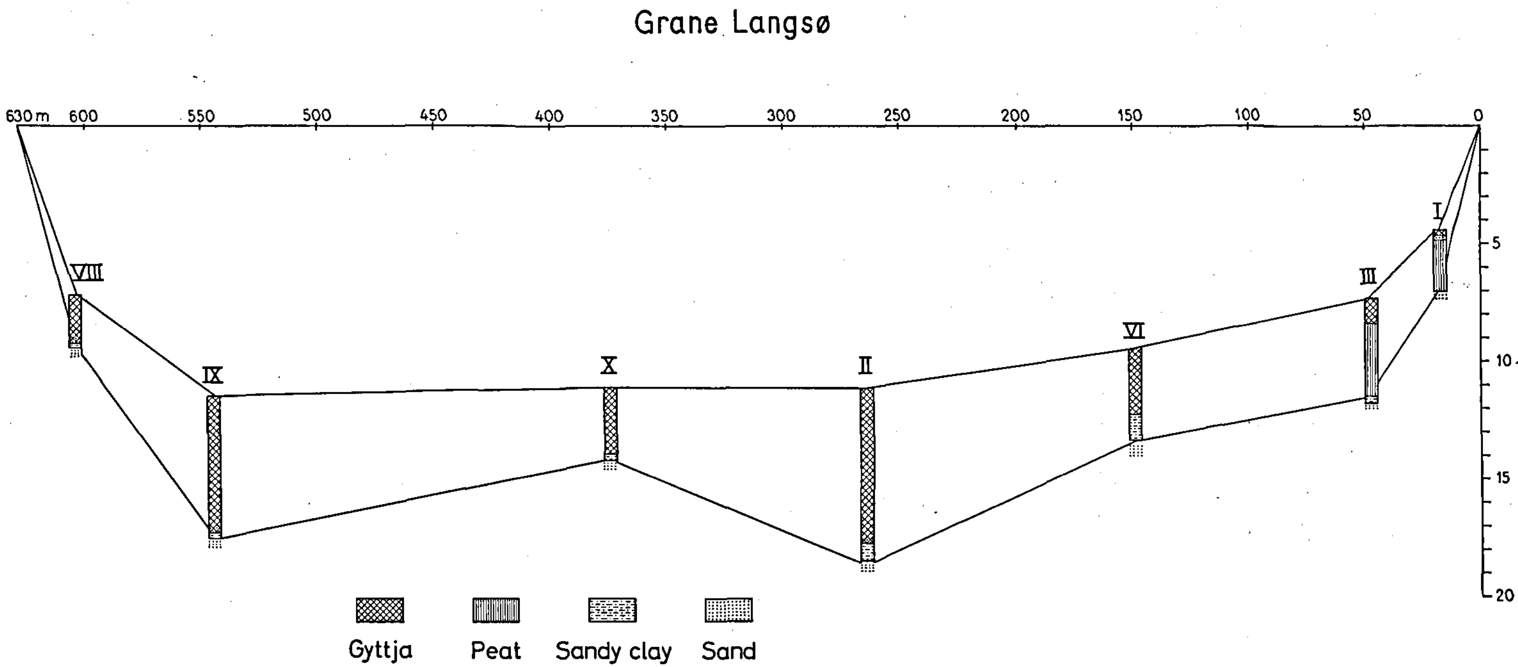
The curves for graminea and Calluna, and all the herbs collectively runs nearly parallel to this. The maximum of the curve for the herbaceous pollen is situated between 13,32–13,11 m. This indicates forest clearings at 13,50 m, 12,5 m and finally at 11,9 m. Maximum of the herbaceous pollencurve at 11,5–11,44 m.

The mixed oak forest curve is lying high the whole time. In the reduced diagram there is a fall which may confirm the supposition of a clearing fase about 13,5 m where also a rising of the hazel curve is seen. Considerable falls do not occur until after a maximum (73%) at 12,0 m. At 11,52 and 11,44 m the mixed oak forest consists mostly of oak (53 and 47% reduced trepollen diagram) and the beech rises from 5% at 11,77 m to 18%. At the same time all the curves for herbaceous pollen and Calluna rises and the quantity of herbaceous and Calluna pollen at last surpass that of the treepollen (non reduced). However, not before 11,44 m. the variations in the rate between treepollen and herbs and Calluna pollen are so large, that they indicate considerable clearings close to the lake.

At 11,52 a pollengrain of Centauria is found. This would indicate that this sample is younger than 1300 DC. In one of the samples taken with the syringe (the very surface of the lake bottom) containing spruce pollen and representing the time after the growing up of the plantation (1895 D.C.) the quantity of non tree pollen (mainly Calluna and Graminea) is twice the quantity of tree pollen. However, so high is this rate not in any of the borings samples."

Fig. 8 and Table VI show the variation of the humus standard, characterized by the rate C/N in boring II. The rate do not vary very much, and it is a question how much it is possible to deduce from it, because after the deposition of the gyttja humification processes will change the rate. However, taken by and large it has a maximum at a depth of 13,3–13,7 m, that is in the pollenzone VIII and from here it decreases to less than 10.

The explanation to that is to be found in the borings I, III and VI in the southern end of the lake. In boring I the whole strata is peat up till 17 cm below the surface. In the borings III and VI the gyttja is mixed with peaty material. The pollenfloristic development in the boring I is according to WOLTHERS the following.



Cross section through borings in Grane Langsø (see map fig. 2)
Vertical exaggeration 10:1.

5,20 m Zone IX
5,55 - - VIII
6,56 - - VII, equivalent to 15,8–16 m in Boring II
6,85 - Upper part of zone VI.

As the peat is grown up very near to the surface of the ground-water table this indicates, that the water level in the lake in the beginning of zone IX rose 4,68 m. This enlargement of the lake basin probably also has caused decrease of the trophy standard. From zone VII there is nothing in the strata which allow us to presume a similar changing of the water surface of the lake.

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