FBA Translation (NS) No. 59

QUENNERSTEDT N. (1955) The diatoms of Långans lake-vegetation. Fossil Diatom flora. Acta phytogeogr.suec. 36, 73-86.

Translated by I.B. Talling.

p.73

Fossil diatom flora

The fossil diatoms described here come entirely from the sediment samples taken from the profile-line BP I - IV. (Samples taken from other parts of the lake (with a tube sampler) have not been fully worked out and will not be considered here).

It is important - as has been pointed out earlier - that the fossil thanatocoenoses be fitted into a chronological framework. The material, which is being studied, on the other hand, should be embracing enough to assure the representation of the main species compositions in the bygone diatom flora of the lake. Whether the latter demand is fulfilled in this study where analyses are used from a certain part only of the lake, can be debated; but if the present day conditions of the Upper Oldlake are accepted as a standard(norm), then one feels justified in saying that here this is the case.

Methods.

A varying number of sediment samples from the 4 series, BP I - IV, were only qualitatively analysed. Quantitative analyses were carried out on a total of 29 fossil and 3 modern samples in BP I, II and IV (see the diagrams and appendix).

For the quantitative analysis of the diatoms, 2 mm^3 were used from each sample (with the exception of samples from the topmost not consolidated layer), in some cases 2+2 mm^3 were used (as done in the Lundqvist(1925a) method with a stainless steel rod with a cavity in one end, which contained this volume), then carefully mixed with a few drops of distilled water on a cover glass, the size of which is 21 x 26 mm. After repeated additions of 20% H_2O_2 and boiling on a stainless steel hotplate, the sample is finally completely evaporated by heat, made red-hot for a few minutes and then immediately mounted on a slide with "sirax". In this way hardly any of the resistant biogenic parts of the sample (diatoms, spicules and some rhizopods) are destroyed but a much better opportunity gained for carrying through an acceptable analysis.

Though I am fully aware of the weakness of the method, I have used definite volumes of the consolidated sediments, as did Lundqvist. In this analysis each approximately complete diatom shell (except for Melosira) has been calculated as a unit, regardless of whether both parts of the original diatom cell were combined or separated. The valves of many diatoms separate, when the cell content dissolves, and these might therefore be in close proximity to each other in the sediment sample and thus end up in the same sample; consequently such species will be overrepresented if individual cells are counted. Here belong, for example, Frustulia, and some species of Achnanthes, Navicula and Pinnularia. I have not found it necessary to introduce any sort of correction factor for such species when their numbers are calculated as to their contribution to the thanatocoenoses; one reason is that many species will vary considerably in this respect. For the Melosira species, two semi-cell frustules have been accepted as one unit. About 700 - 900 frustules were counted in each preparation (at least 2 mm^3) and this number gives the base for the % calculations of respective species. The total number of Frustulia frustules in the sample is also determined, and finally a thorough screening for taxa not observed earlier. In several cases many preparations were studied from one sediment sample but the % calculation done on only one of these.

Lundqvist (1925 a, P.445 ff)has, as already mentioned, used absolute numbers in his microfossil analysis. But the condition of the sample (water and glycerin) becomes a limiting factor, as glycerin, to a great extent, reduces the possibility of a reliable species determination for diatoms.Were all the biogenic components of the sample to be recorded, each embedded in a satisfactory material, then the time demanded for this would become unreasonable, and in the end only give doubtful results.To illustrate what is meant by unreasonable time; one may consider that with a Leitz objective number 7a (magnification of 58X) and an ocular with a magnification of 10x, about 15000 fields of vision must be studied to cover the area of 21 X 26 mm. A great deal of the content can not be determined with the abovementioned objective, but requires oil immersion, which again considerably lengthens the time of analysis.

A complete inventory of diatom frustules was done for two samples (prepared in the same way as the rest of the fossil material).These results appear elsewhere in this paper and they can be used for comparison with the relative values for other samples. Considering the errors of this pseudo- precise method (the same sediment volume can be of varying significance in different parts of the layer-series), I do not feel that the result justifies the work - time and - effort and I have therefore simplified the preparation of all the other fossil samples in the following way.

The reason for counting all frustules of Frustulia in each $2mm^3$ sediment, is, firstly, that this genus is easily recognisable, secondly, it is represented in nearly all fossil (except for clay samples) and present day samples of Upper Oldlake and it dominates now-a-days to a very great extent the microvegetation of the lake, but it exhibits clearcut fluctuations in the fossil layers. Frustulia appears indeed to possess a considerable ecological plasticity but there is a quantitative increase in an environment with a low concentration of salts resp. within a pH of 5.5 - 6 in the water system of Långa. It might then be justified to give the total number of frustules for this genus, as well as the % value, though these figures must be accepted with a certain reservation and at the most only show the trend.

The diatom content of the sequence of layers.

The oldest parts of the studied layer-sequence give little information about the diatomflora which then existed in the Upper Oldlake. The clay, which appears to have been deposited at a comparatively fast rate(in BP II about 70 cm in less than 1000 years), contains quantitatively insignificant amounts of biogenic material, up to the vicinity of the clay and the clay-mud border and it consists mostly of unidentifiable diatom frustule fragments along with the pollen. The environmental conditions at that time most likely did not allow for much diatom production because the turbid clay mixture inhibits algal growth. In the upper parts of the clay (about 10 - 40 cm under the boundary of clay and clay-mud; in BPI just under this boundary) the flora, poor in number and species, consists among others of: Anomoeneis exilis, A.serians v. brachysira, Cymbella hebridica, Eunotia exigua, E. robusta v. diadema, Fragilaria construens, Frustulia rhomboides and v. saxonica, Gomphonema acuminatum v. coronatum, G. longiceps v. sumclavatum f.gracile, Navicula cocconiformis, Pinnularia gibba, P. interrupta P. maior v. linearis, Stauroneis phoenicenteron, Tabellaria flocculosa (see diagram, Appendix)

A change occurs in the uppermost part of the clay (BP II, III, IV) and in the mud-clay over it (BP I) where the number of species and of individuals increases greatly and the main part of the fossil layer-sequence starts to appear. This indicates a considerable change in the environment during a relatively short time. The transition in BP I from the characteristically poor diatom flora of the clay to the rich flora of the mud-clay, appears to be caused by the lowering of the water table, which, among other things, stopped the sedimentation (of the clay) for a time at BP I, while it continued at greater depths of the water. When the water table rose again to its former level, and the sedimentation started again at BP I, the diatom flora of the lake had already changed and thus the diatom rich layers are deposited straight on to the fossil-poor clay.

While the diatom flora was changing, the lake level was somewhat lowered and the mud-clay addition gradually decreased, then clay-sediments were gradually replaced by mud-clay and mud and the water level rose again to at least the same level as prior to the lowering.

The change in the diatom flora brought out, firstly, several species which from then recur in nearly every sample to the present day; secondly, those which appeared for a short or a long period in the developmental history of the lake, but are missing from the present-day vegetation. A third group is formed by such diatoms which appear irregularly and sporadically, with a diatom here and there in the layers, some only as fossils, even a few in the present-day vegetation.

1. Species with a characteristic occurrence.

Fragilaria leptostauron v. dubia has a place apart among the taxa which occur with a large number of individuals within a limited part of the layer-series. This diatom appears first, a few frustules, in the uppermost 10 - 15 cm (BP II, IV), but, gradually, as the clay is replaced by mud sediment, it increases rapidly in number, reaches its peak in the clay-mud and then disappears in the lowest part of the fine-detritus-mud. At the peak its part of the thanatocoenoses is 15 % in BP IV, 10 % in BP I (immediately above the clay).

No other diatom shows such a characteristic occurrence in the fossil flora of Upper Old-lake and the specific environmental conditions required to induce this sudden and short bloom, cannot even be guessed at. Hustedt (1931 b, p. 155) offers for Fragilaria leptostauron v. dubia only " sehr zerstreut" (very dispersed). A. Cleve-Euler (1953 a, p. 36) only gives one contemporary and two fossil discoveries (Finland), and Foged (1947, p. 54; 1948 pp. 16, 45, 50) a few present day discoveries in Denmark. When the manuscript for this paper was ready for the printer (1954/55 transition), a work appeared by Fjerdingstad (1954, p.6, table II) mentioning Fragilaria leptostauron v. dubia. This diatom, as well as Fragilaria pinnata, is important in a fossil layer-sequence in Jytland which dates back to early Dryas- time.

In the water system of Långan Fragilaria leptostauron v. dubia has been found even in the present-day vegetation, namely in the Outer Old-lake and Landö-lake, though in very small amounts.

Several of the species, which lived at the same time as this Fragilaria in Upper Old-lake, but later died out there, have been found in the present day vegetation of Outer Old-lake and Landö-lake.

The composition of this fossil diatom flora in the Upper Old-lake follows, as well as the known occurence in the present (recent) day vegetation in Upper Old-lake, Outer Old-lake and Landö-lake. (Fossil samples: in BP IV no. 123, 125, 126, 127 - resp 157, 162, 167, 172 cm under the sediment surface; in BP II no. 46, 48, - resp. 90, 97 cm under the sediment surface; in BP I no. 11, 12 - resp. 30,35 cm under the sediment surface). Table p. 75,76,77.

pp 75-76

Fossil diatoms in deposits of lake Övre Oldsjön contemporary with *Fragilaria leptostauron* v. *dubia* (zone V), and the same taxa recorded in the recent vegetation of Övre Oldsjön, Yttre Oldsjön and Landösjön.

Fossilt Övre Oldsjön	Ö. Oldsj.	Y. Oldsj.	Landösj.
Achnanthes			
affinis	—	+	—
austriaca v. *helvetica*	+	+	+
depressa	+	+	+
flexella	+	+	+
— v. *alpestris*	+	+	+
Holstii	+	—	+
linearis	+	+	+
marginulata	+	+	+
microcephala	+	+	+
minutissima	+	+	+
— v. *cryptocephala*	+	+	+
montana	+	—	+
Amphicampa			
hemicyclus	+	+	+
Amphora			
ovalis	—	+	+
— v. *libyca*	—	+	+
Anomoeoneis			
exilis	+	+	+
— v. *lanceolata*	+	+	+
follis	+	—	—
serians	+	—	+
— v. *brachysira*	+	+	+
— — f. *thermalis*	+	+	+
subtilissima	+	+	+
zellensis	+	+	+
— v. *linearis*	+	+	—
Caloneis			
obtusa	+	+	+
silicula v. *truncatula*	+	+	—
Campylodiscus			
hibernicus	—	—	—
Ceratoneis			
arcus	—	+	+
Cyclotella			
antiqua	—	—	—
comta	—	—	+
— v. *oligactis*	—	—	—
kützingiana	+	+	+
— v. *planetophora*	+	+	+
— v. *radiosa*	—	—	+
— v. *Schumannii*	+	+	+
Cymbella			
affinis	—	+	+
amphicephala	—	+	+
angustata	—	—	—
aspera	—	+	+
Cesatii	+	+	+
cistula	—	+	+
cuspidata	—	+	+
cymbiformis	—	+	+
delicatula	—	—	+
gracilis	+	+	+
hebridica	+	+	+
helvetica	—	—	+
incerta	+	+	+
naviculiformis	+	+	+
perpusilla	+	+	+
ventricosa	+	+	+

Fossilt Övre Oldsjön	Ö. Oldsj.	Y. Oldsj.	Landösj.
Denticula			
tenuis	—	—	—
— v. *crassula*	—	+	+
Diploneis			
elliptica	+	+	+
finnica	+	+	+
Epithemia			
argus	—	+	+
— v. *alpestris*	—	—	—
sorex	—	—	—
Eunotia			
alpina	+	—	—
arcus	+	+	+
— v. *bidens*	+	—	—
bidentula	+	+	—
diodon	+	+	+
exigua	+	+	+
— v. *compacta*	+	+	+
faba	+	+	+
flexuosa	+	+	+
lapponica	+	+	+
Meisteri	+	+	+
monodon	+	+	+
— v. *bidens*	+	+	+
— v. *maior*	+	+	+
parallela	+	—	—
pectinalis	+	+	+
— v. *minor*	+	+	+
— — f. *intermedia*	+	+	+
praerupta	+	+	+
— v. *inflata*	+	+	+
robusta v. *diadema*	+	+	+
— v. *tetraodon*	+	+	+
tenella	+	+	+
triodon	+	+	+
valida	+	+	—
Fragilaria			
construens	+	+	+
— v. *venter*	+	+	+
leptostauron v. *dubia*	—	+	+
pinnata	—	—	+
virescens	+	+	+
— v. *exigua*	+	+	+
Frustulia			
rhomboides	+	+	+
— v. *saxonica*	+	+	+
— — f. *capitata*	+	+	+
— — f. *undulata*	+	+	+
Gomphonema			
acuminatum v. *Brebissonii*	—	—	+
— v. *coronatum*	+	+	+
angustatum	—	—	—
constrictum	—	+	+

Fossilt Övre Oldsjön	Ö. Oldsj.	Y. Oldsj.	Landösj.
gracile	+	+	+
intricatum v. *pumilum*	—	—	+
longiceps v. *subclavatum*	+	+	+
— — f. *gracile*	+	+	+
subtile	—	—	+
Hantzschia			
amphioxys v. *vivax*	—	+	—
Melosira			
distans	+	+	+
— v. *lirata*	+	+	+
italica ssp. *subarctica*	—	—	—
Navicula			
anglica	—	+	+
bacillum	—	+	—
— v. *gregoryana*	—	—	—
cocconeiformis	+	+	+
cryptocephala	+	+	+
dicephala	—	—	—
hungarica	—	—	—
— v. *capitata*	—	—	—
lobeliae	+	+	+
pseudoscutiformis	—	—	+
pupula	—	—	+
— v. *capitata*	—	+	—
— v. *rectangularis*	+	+	+
radiosa	+	+	+
— v. *tenella*	+	+	+
scutiformis	+	+	—
vulpina	—	—	—
Neidium			
affine v. *amphirhynchus*	+	+	+
— v. *longiceps*	+	—	+
bisulcatum	+	+	+
Hitchcockii	—	+	+
iridis	—	—	+
— f. *vernale*	+	—	+
— v. *amphigomphus*	+	—	+
— v. *ampliatum*	—	—	—
Nitzschia			
angustata v. *acuta*	+	+	+
denticula	—	—	—
fonticola	+	+	+
gracilis	+	+	+
hantzschiana	+	+	+
romana	—	—	+
Pinnularia			
dactylus	+	+	+
divergens	+	—	—
— v. *undulata*	+	+	—
divergentissima	+	+	—
gentilis	+	+	—
gibba	+	+	+
— v. *linearis*	+	+	—
— v. *parva*	+	—	—
interrupta	+	+	+
lata	+	+	+
maior	+	+	+
— v. *linearis*	+	+	—
mesolepta	+	+	+
microstauron	+	+	+
— v. *Brebissonii* f. *diminuta*	+	+	—
nobilis	—	—	—
nodosa	—	—	—
platycephala	+	+	—
stomatophora	—	+	—
subcapitata	+	+	—
— v. *hilseana*	+	+	+
tenuis f. *subundata*	+	+	+
undulata	+	+	+
viridis	+	+	+
Rhopalodia			
gibba	+	+	+
Stauroneis			
anceps	+	+	+
— f. *gracilis*	+	+	+
— v. *hyalina*	+	+	—
legumen	+	+	+
phoenicenteron	+	+	+
Stenopterobia			
intermedia	+	+	+
Surirella			
linearis	+	+	+
robusta	+	+	+
tenera	—	+	—
Synedra			
acus	+	+	+
amphicephala	+	+	+
parasitica	—	—	—
— v. *subconstricta*	—	—	—
ulna v. *danica*	+	+	+
Tabellaria			
flocculosa	+	+	+
quadriseptata	+	+	+
Tetracyclus			
lacustris	—	+	+

Only that part of the layer-sequence to which Fragilaria leptostauron v. dubia is tied has 153 out of the 179 taxa in this fossil flora, that is 85.5 % in common with Outer Old-lake, Landö--lake or the present day vegetation of both lakes, but not more than 125 (hardly 70%) with Upper Old-lake. Of the 54 fossil taxa, which so far have not been found in the present day vegetation of Upper Old-lake, 34 (63 %) are found now in the vegetation of Outer Old-lake and/or Landö-lake.

It should especially be pointed out in this context that the material studied from the present times Outer Old-lake and Landö--lake is far from as comprehensive as that for the Upper Old-lake, and positive similarities, therefore, between the fossil flora of Upper Old-lake and that of the present day flora of the other two lakes, are most likely larger than that which the material brings out. This could therefore indicate that even the difference between Upper Old-lake on one side and Outer Old-lake and Landö-lake on the other side is larger than so far shown with respect to the present-day species composition.

Contemporary with Fragilaria leptostauron v. dubia, three other taxa in Upper Old-lake reached their highest % part of the thanato-coenoses of the sediment, namely, Amphora ovalis (4%), Anomoeoneis Zellensis (12%) and Denticula tenuis v. crassula (3%).(These are the highest percent-values found). All three were of little quantitative importance once Fragilaria leptostauron v. dubia had died out. Denticula disappeared completely just before the time of the big Betula-climax, while Amphora continued still some way up the layer-sequence, rarely reaching the rational pine-pollen level. (The very few discoveries of Amphora above this level in in PP I are most likely there through the erosion of older sediments and a relocation of the fossils.) Anomoeoneis zellensis has even been found in present-day sediments, and exists most likely, though rare, now in Upper Old-lake.

The species list shows that these 3 diatoms can now be found in the present-day vegetation of Outer Old-lake and Landö-lake, but only in small quantities.

Nearly all the taxa, which occur in the same thanatocoenosis as Fragilaria leptostauron v. dubia, have clearly lived on in the Upper Old-lake after this diatom disappeared and most of these continued for quite some time up through the sediment series. But Cyclotella comta and v. oligactis, Fragilaria pinnata, Navicula bacillum and N. hungarica and v. capitata have only been found in those samples which contain Fragilaria leptostauron v. dubia. But the above mentioned taxa, with the exception of Fragilaria pinnata, are very few in numbers and it is uncertain if they really have only this limited distribution in the sediments. Cyclotella comta and Fragilaria pinnata now live in Landö-lake, Navicula bacillum in Outer Old-lake.

At the time of the Fragilaria leptostauron v. dubia climax, Frustulia rhomboides v. saxonica was both absolutely and relatively of sub-ordinate importance in BP IV, somewhat more prominent in BP I amd II, but still definitely low.

Frustulia is, at least in Landö-lake, considerably less frequent now than it is in the present-day vegetation of Upper Old-lake.

Other taxa, which appear to be limited to a definite part of the older parts of the layer-sequence, are: Cyclotella antiqua Navicula pseudoscutiformis and Nitzschia denticula found at the same level as Fragilaria leptostauron v. dubia and at the most up to d-level; Pinnularia also reaches this high up but with a delayed start. They are all represented only by one or a few frustules.

From the lower part of the fine detritus mud and on up past the d-level but not up to c-level, the following occur: Campylodiscus hibernicus, Cymbella cistula, Epithemia sorex, Gomphonema subtile, Hantzschia amphioxys v. vivax, Melosira italica ssp. subarctica, Navicula anglica, N. bacillum v. gregoryana, N. cuspidata N. pupula and v. capitata, Neidium Hitchcockii and Pinnularia lata, P. nobilis.

With the same beginning as the above but with the addition of surpassing the c-level, above which they obviously have died out in the Upper Old-lake, are the following: Cyclotella kützingiana v. radiosa, Cymbella affinis, C. cuspidata, C. cymbiformis, Epithemia argus, Gomphonema constrictum, Neidium iridis and v. ampliatum and Tetracyclus lacustris.

Of the abovementioned taxa(from Cyclotella antiqua)about 2/3 are found in the present day vegetation of Outer Old-lake or Landö-lake or both.

Apart from such diatoms which only are found sporadically in the sedimenta - such as Cymbella amphioxys and C. Ehrenbergii only at the d-level, Cymbella equalis and Eunotia crista galli immediately above this level, Eunotia bactriana and Tabellaria binalis on resp. just above the c-level, as well as present time. - only Eunotia denticulata v. fennica remains, the occurrence of which can be relatively easily delimited to a certain portion of the latter part of the layer-sequence. Starting with the c-level it has been found in nearly every sample up to present-day, but is obviously missing in the older sediments.

Eunotia lunaris and Peronia Heribaudii are not found xxxxxxthe below the d-level, but at that level the oldest specimens are found and from then on sporadically to the present time.

It is worth noticing here that Peronia, which is very prominent in the present-day vegetation, did not exceed 1/2 % in any sample, and usually not that much.

Solitary frustules of Anemoeoneis serians have been found in the uppermost part of the clay at BP II all the way to the very youngest sediments. But at BP IV the earliest appearance of this species is just under the d-level. In the three profiles which have been studied quantitatively, Anomoeoneis serians shows a steadily increasing percentage of the thanatocoenoses in the younger parts of the sediments and has a climax close to the c-level.

2. Species which occur repeatedly in the layer-sequence.

The following are present nearly everywhere in the layer-sequence, at least from the uppermost part of the clay(zone V) and to our present day and only in exceptional cases not found in the samples.

p. 79-80

A comparison of this list with the diatom diagrams shows that less than half of the taxa on the list are represented among those which reach 2% or more in the respective thanatocoenoses. Most of diatoms, which reappear regularly in all the samples,represent thus a quantity less than 2% in the observed thanatocoenoses, and often even less than 1 %.

Among the taxa which occur repeatedly, Achnanthes flexella, Eunotia arcus and Melosira distans v. lirata reach their highest % values approximately at the same time or somewhat later than the climax for Fragilaria leptostauron v. dubia. For Cyclotella kützingiana v. planetophora the climax is higher but still under the d-level.

Anomoeoneis exilis and v. lanceolata is more important in the thanatoceonoses under the d-level than above this in BP IV and II. Similar conditions are found in BP I, with the exception of the present-day sample(taken with a tube sampler(?)), which is not fully comparable to the rest.

The shape of the curve for Anomoeoneis serians v. brachysira, which is generally of quantitative importance, shows diffuse alternations of maxima and minima and nothing specific, which would allow for correlation with certain levels in the layer-sequence.

Amphicampa hemicyclus and Eunotia triodon show a vague trend to a relative increase above the d-level towards a maximum in the proximity of the c-level.

The diagrams of the absolute numbers of frustules of Frustulia rhomboides and v. saxonica per 2 mm^3 of sediment clearly show fluctuations. All three profiles show the minimum for v. saxonica in the mud-clay (zone V, sample no. 125, 46, and 12). A small maximum was found close to the d-level in zone IV and then first a decrease and then an increase in the number in zone III. The absolute maximum is reached above the c-level.

Somewhat similar but more irregular is F. rhomboides , but the number of frustules is considerably lower.

Obly isolated frustules have been found of f. capitata, some more of f. undulata, but much lower in number than v. saxonica.

The difference in the numbers of Frustulia in the three profiles could be by pure chance and the differences are not such that they can directly be related to differences in depth of water at the different sampling stations.

3. The total diatom content in two fossil samples.

The total content of two samples from the sediment series BP IV, one of 4mm^3 and the other 2 mm^3,were studied. The percentage values - calculated from the absolute number of frustules in the resp. sediment volumes- are presented at and from 1%

Totala mängden diatoméskal pr 4 resp. 2 mm³ sediment i prov nr 117 (147 cm under sedimentytan) och nr 94 (22 cm under sed.-ytan) i BP IV, Övre Oldsjön.

Total number of diatom frustules recorded in two samples resp. 4 and 2 mm³ sediment. Sample no. 117: 147 cm below sediment surface; no. 94: 22 cm below sediment surface, BP IV, lake Övre Oldsjön.

	Nr 117 (147 cm under sed.-ytan) Antal pr 4 mm³	Antal beräkn. pr 2 mm³	%	Nr 94 (22 cm under sed.-ytan) Antal pr 2 mm³	%
Achnanthes					
affinis	16	8			
depressa	42	21		14	
elliptica	2	1		—	
flexella	243	121		108	
— v. *alpestris*	37	18		6	
Holstii	—			1	
minutissima	28	14		—	
— v. *cryptocephala*	26	13		5	
Amphicampa					
hemicyclus	10	5		859	4
Amphora					
ovalis	19	9		—	
Anomoeoneis					
decipiens	3	1		—	
exilis et v. *lanceolata*	2244	1122	8	444	2
follis	8	4		40	
serians	—			378	
— v. *brachysira* et f. *thermalis*	4135	2067	14	2067	9
subtilissima	4	2		6	
zellensis	3	1		3	
Caloneis					
obtusa	2	1		—	
Campylodiscus					
hibernicus	3	1		—	
Cyclotella					
antiqua	3	1		—	
kützingiana	317	158	1	7	
— v. *planetophora*	7820	3910	26	1458	6
— v. *radiosa*	170	85		—	
stelligera	4	2		—	
Cymbella					
affinis	18	9		—	
Cesatii	8	4		—	
cistula	5	2		—	
cuspidata	7	3		—	
cymbiformis	2	1		1	
gracilis	250	125		500	2
hebridica	—			364	1
incerta	—			120	
naviculiformis	13	6		1	
perpusilla	130	65		131	
ventricosa	60	30		6	
Denticula					
tenuis v. *crassula*	49	24		—	
Diploneis					
elliptica	2	1		1	
finnica	3	1		1	
Petersenii	2	1		—	
Epithemia					
argus	—			1	
sorex	2	1		—	
Eunotia					
arcus	88	44		195	
bactriana	—			1	
bigibba	2	1		—	
denticulata	—			10	
diodon	2	1		95	
exigua	21	10		155	
— v. *compacta*	—			18	
faba	63	31		209	1
flexuosa	5	2		19	
lapponica	—			11	
lunaris	—			4	
Meisteri	14	7		7	
— v. *bidens*	—			5	
monodon	—			11	
— v. *bidens*	—			49	
— v. *maior*	1			8	
paludosa	2	1		3	
parallela	2	1		—	
pectinalis	1			—	
— v. *minor*	3	1		149	
— — f. *impressa*	—			103	
— — f. *intermedia*	8	4		29	
polyglyphis	1			—	
praerupta	26	13		185	
— v. *inflata*	1			22	
robusta	1			28	
— v. *diadema*	170	85		188	
— v. *tetraodon*	43	21		—	
septentrionalis	9	4		—	
Steineckei	—			5	
sudetica	—			6	
tenella	8	4		54	
triodon	—			63	
valida	1			5	
veneris	2	1		2	
Fragilaria					
construens	40	20		3	

	Nr 117 (147 cm under sed.-ytan) Antal pr 4 mm²	Antal beräkn. pr 2 mm²	%	Nr 94 (22 cm under sed.-ytan) Antal pr 2 mm²	%
virescens	10	5		1	
— v. *exigua*	40	20		46	
Frustulia					
rhomboides	625	312	2	265	1
— v. *saxonica* et f. *undulata*	8580	4290	29	10715	47
— — f. *capitata*	35	17		121	
Gomphonema					
acuminatum	2	1		2	
— v. *Brebissonii*	1			—	
— v. *coronatum*	123	61		133	
constrictum	13	6		3	
intricatum v. *pumilum*	8	4		—	
longiceps v. *subclavatum* f. *gracile*	60	30		108	
subtile	2	1		—	
Melosira					
distans	123	61		214	1
— v. *lirata*	1655	827	6	118	
— — f. *lacustris*	—			13	
— — f. *seriata*	10	5		3	
italica ssp. *subarctica*	290	145	1	—	
Navicula					
bacillum v. *gregoryana*	4	2		—	
cocconeiformis	232	116		426	2
cryptocephala	33	16		1	
— v. *exilis*	15	7		—	
lobeliae	550	275	2	292	1
pseudoscutiformis	3	1		—	
pupula	4	2		—	
— v. *rectangularis*	7	3		—	
radiosa	27	13		4	
— v. *tenella*	7	3		3	
söhrensis v. *inflata*	—			2	
tuscuoides	1			—	
Neidium					
affine v. *amphirhynchus*	26	13		8	
— v. *longiceps*	12	6		—	
bisulcatum	30	15		75	
iridis f. *vernale*	7	3		—	
— v. *ampliatum*	3	1		15	
Nitzschia					
angustata v. *acuta*	26	13		30	
denticula	2	1		—	
fonticola	73	36		22	
hantzschiana	20	10		2	
Peronia					
Heribaudii	—			1	

	Nr 117 (147 cm under sed.-ytan) Antal pr 4 mm²	Antal beräkn. pr 2 mm²	%	Nr 94 (22 cm under sed.-ytan) Antal pr 2 mm²	%
Pinnularia					
brevicostata	—			2	
crucifera	—			1	
dactylus	5	2		10	
divergens	3	1		6	
— v. *elliptica*	—			1	
divergentissima	1			—	
gentilis	1			—	
gibba	48	24		218	1
— v. *linearis*	—			100	
— v. *parva* (?)	—			3	
gracillima	4	2		—	
hemiptera	—			7	
interrupta	225	112		378	2
— f. *minutissima*	35	17		6	
legumen	1			—	
maior	4	2		32	
— v. *linearis*	—			22	
mesolepta	13	6		3	
microstauron	43	21		291	1
— v. *Brebissonii*	1			22	
— — f. *diminuta*	14	7		182	
nobilis	7	3		—	
platycephala	8	4		4	
subcapitata	2	1		—	
— v. *hilseana*	86	43		27	
tenuis f. *subundata*	12	6		9	
undulata	35	17		39	
viridis	5	2		16	
— v. *sudetica*	2	1		23	
Rhopalodia					
gibba	—			2	
Stauroneis					
anceps	24	12		13	
— f. *gracilis*	20	10		38	
legumen	4	2		1	
phoenicenteron	6	3		96	
Stenopterobia					
intermedia	2	1		7	
Surirella					
linearis	4	2		1	
robusta	6	3		3	
— v. *splendida*	3	1		—	
Synedra					
ulna	4	2		—	
Tabellaria					
flocculosa	90	45		415	2
quadriseptata	38	19		49	
Tetracyclus					
lacustris	7	3		—	
— v. *strumosus*	2	1		—	
Summa	29628	14785		22814	

List, p. 83.

Achnanthes
kryophila (rec.)
linearis v. *pusilla* (rec.)
Caloneis
bacillum (rec.)
schumanniana v. *biconstricta*
Cocconeis
cholnokyana
Cymbella
bouleana (rec.)
cistula v. *maculata*
microcephala (rec.)
Diatoma
elongatum v. *tenue*
vulgare
— v. *productum*
Eunotia
alpina (rec.)
elegans (rec.)
exigua v. *bidens* (rec.)
gracilis (rec.)
lunaris v. *capitata* (rec.)
— v. *subarcuata* (rec.)
pectinalis v. *ventralis* (rec.)
Fragilaria
virescens v. *mesolepta*
Melosira
distans v. *lirata* f. *lacustris* (rec.)
roeseana
Meridion
circulare (rec.)
Navicula.
americana (ett skal, zon III)
atomus (rec.)
Neidium
affine
Nitzschia
palea f. *minuta* (rec.)
Pinnularia
appendiculata (rec.)
— v. *budensis*
Brandelii
Braunii v. *amphicephala* (rec.)
gibba f. *subundulata*
leptosoma f. *Grunowii*
striata (rec.)
subsolaris
Surirella
delicatissima (rec.)
lapponica (rec.)
linearis v. *constricta* (rec.)

Achnanthes
austriaca
Levanderi
nodosa
rupestris
trinodis (skal)
Actinella
punctata
Caloneis
ladogensis
— v. *densestriata*
Cocconeis
placentula
Cymbella
lanceolata
turgida
Diatoma
anceps (skal)
Eunotia
bigibba v. *pumila*
pectinalis v. *undulata*
praerupta v. *bidens*
sudetica v. *bidens*
Fragilaria
constricta
— f. *stricta*
Melosira
distans v. *alpigena*
Navicula
cari
Hustedtii
Krasskei
minima
— v. *atomoides*
minuscula
rotaeana
Neidium
bisulcatum f. *undulatum*
Nitzschia
dissipata
Pinnularia
borealis
gibba v. *mesogongyla*
microstauron f. *biundulata*
molaris
Stauroneis
anceps f. *linearis*
pygmaea
Stenopterobia
intermedia v. *capitata*
Surirella
angusta
Synedra
ulna v. *amphirhynchus*

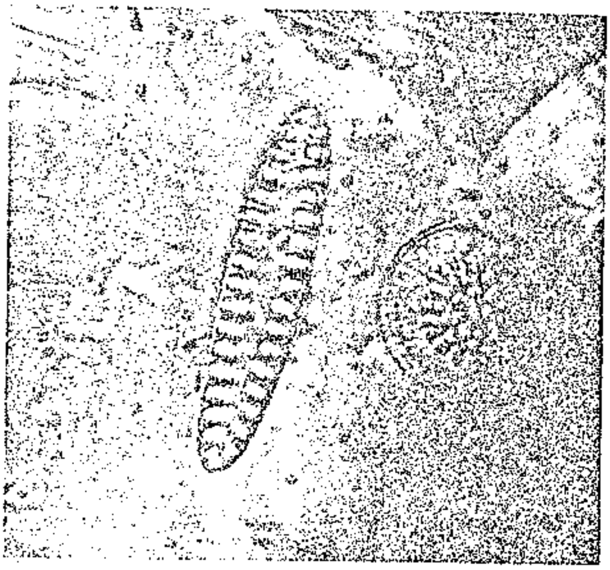
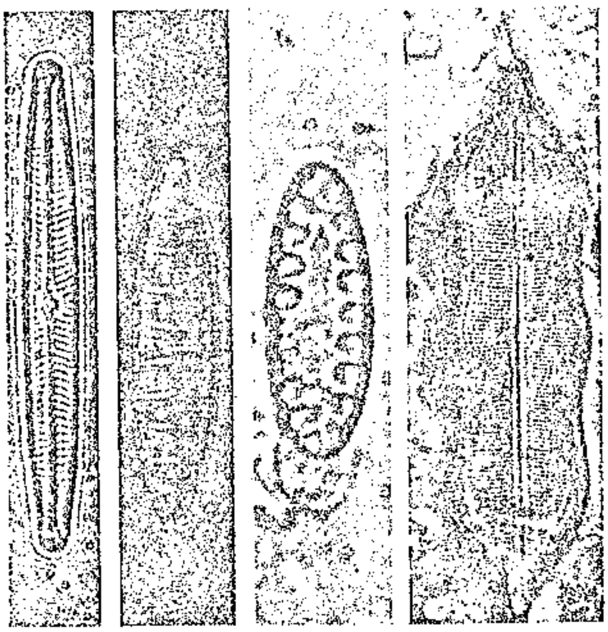


Fig. 22. *Fragilaria leptostauron* v. *dubia* (27 × 7 μ, 7 str./10 μ) och *Cyclotella comta* (t.h.) i lergyttja (zon V), Övre Oldsjön. Först. ca 1800 ×.

Fragilaria leptostauron v. *dubia* (27 × 7 μ, 7 str./10 μ) and *Cyclotella comta* (right) from clay-mud (zone V), Övre Oldsjön. Magnification c. 1800 ×.



a b c d

Fig. 21. Diatoméer från samma prov: lergyttja, 162 cm under sedimentytan (BP IV; zon V, Övre Oldsjön).

Diatoms from the same sample: clay-mud, 162 cm below the sediment surface (BP IV, zone V, Övre Oldsjön).

a. *Navicula lobeliae* (56 × 6,3 μ, 12 str./10 μ). 1150 ×.
b. *Denticula tenuis* v. *crassula* (22,5 × 5 μ, ca 27 str./10 μ). 2100 ×.
c. *Fragilaria leptostauron* v. *dubia* (15 × 5,5 μ, 7 str./10 μ). 2500 ×.
d. *Neidium Hitchcockii* (69 × 19 μ, 18–19 str./10 μ). 1050 ×.

This species list shows, among other things, clearly the usual situation in the thanatocoenoses of the Upper Old-lake - and even in the bioceanoses, namely, that obly a very small part of all the present taxa have an individual percentage number of one or over.

Table : p. 81 -82 here.

4. Other diatoms in the layer-sequence and in the present day vegetation of the lake.

In addition to the diatoms mentioned in the diagrams or in the text, are a further 40 odd taxa, which occur more or less sporadically in the fossil layers. More than half of these have, furthermore, been observed in the present vegetation of Upper Old-lake (specially pointed out in the following list), but none reaches any significant quantitative importance. The diatoms in the fossil sediments of Upper Old-lake, which so far have not been mentioned are as follows:

List (p. 83) here

A total of 36 sediment samples of the fossil diatom material were studied in reasonable detail and a further 20 samples rather superficially. 300 - 400 samples have been studied from the present day vegetation of Upper Old-lake and of these > 200 in more detail than the rest. Considering this difference between the fossil and present day material, it is surprising that only about 40 out of the round-about 200 present day ~~samples~~ diatom taxa - and only those that are rare - are missing from the content list of the fossil flora. It is thus probable that the content of the rather few fossil samples from this limited part of the lake still may represent the main points of the changing diatom floror during the postglacial time in the Upper Old-lake.

The following taxa are now present in the vegetation of Upper Old-lake, but have bot been found in the fossil material.

List

5. The diatom-thanatocoenoses as indicators of environment.

However imperfectly the autecology of the diatoms is known, the changes in the thanatocoenoses of the layer-sequence, through to our time, can really only be interpreted as reflecting changes in trophic level.

The species composition of the upper part of zone V, resembles, as earlier mentioned, more the present day vegetation of Outer Old-lake and Landö-lake than that of Upper Old-lake; this indicates that the environmental conditions which existed then resemble less the present day conditions of the lake than the conditions of the other two lakes. There is, in addition, the presence of such taxa, which have not been found in the present day vegetation within the lake system and their demand for a specific trophic level considerably higher than that offered by the Långan lakes at this time, such as Campylodiscus hibernicus, Cyclotella antiqua, C. comta v. oligactis, Cymbella angustata, Denticula tenuis Epithemia sorex, Melosira italica ssp. subarctica, Nitzschia denticula, Pinnularia nobilis.

These diatoms now live in other locations in Northern Scandinavia under environmental conditions which differ in some aspects much from the environmental conditions of the Långan lakes, with respect to pH, conductivity and calcium. Campylodiscus hibernicus is found in the upper part of the Skellefte-river water system (the lakes Vuoggatjålmejaure and Sädvajaure: pH resp. 6.8 and 7.0; x_{18} 33 - 34 . 10^{-6} ; Ca 2.10, 2.04 mg/l; Na 5.98, 5.56 mg/l and more(Quennerstedt unpublished data)). Cymbella angustata was found by Hustedt (1942, p. 130) in the Abisko area (pH 6.5 - 9)" (heufig (frequent) bei 7.7 - 9)". Denticula tenuis I found in 1946 in Ånn-lake(Ph 7.6 - 7.7; x_{18} 30 . 10^{-6}; CaO about 10 mg/l) and also very plentiful - along with Cymbella Ehrenbergii ĕ the very calsium rich lake, Öj-lake (NE of Östersund) (pH 9.0; x_{18}125 10^{-6}; for further data about this lake and Ånn-lake see K. Thomasson 1952a; 1951 ,p.337). Nitzschia denticula is common in the Abisko area, especially at pH > 7 and has also been found at pH 6.2 - 9 (Hustedt 1942, p. 150).

The present differences in environmental factors between Upper Old-lake, Outer Old-lake and Landö-lake are clearcut in pH, conductivity and cation content of the water (see the table for the three lakes). The extreme values for pH are 5.7 - 6.0 (Upper Old-lake), 6.1 - 6.6 (Outer Old-lake), 6.5 - 6.6 (Landö-lake). The values for conductivity lie between X_{18} 7 and 8 in Upper Old-lake, 8.7 - 12 in Outer Old-lake, and 15.6 - 17 in Landö-lake. The variation in the Ca content was 0.24 - 0.50 in Upper Old-lake, 0.73 -1.48 Outer Old-lake, while Landö-lake only had 1.66 mg/l.

This reflection of a successively increasing nutrient level downstream from Upper Old-lake is expected and it is rather surprising that the differences are not even greater.

When species, which only are known from more nutrient-rich environments than the present one in Upper Old-lake, disappear completely in the layer-sequence or are much reduced in number and frequency - then the prime reason for this must be the decreasing nutrient level. Upper Old-lake has thus undergone a meiotrophication towards the present time.

The gradual disappearance of such diatoms has evidently happened rather slowly and most of them survived to just after the large Betula climax (d-level). Furthermore, at the d-level appeared a diatom, Cymbella Ehrenbergii, which has not been found in the older sediments. If isolated discoveries of this species, which "Gehört zu den charakteristischen Leitformen alkalischer Seen" (belong to the characteristic indicators of alkaline lakes) (Hustedt 1942, p. 133) and which lives in the Abisko area within a pH range of 7.7 - 8.4 (l.c.) can be used as indicators at all, then one might say that Cymbella Ehrenbergii rather indicated an auxotrophication.

It is even reasonable to assume that auxotrophication occurred in Upper Old-lake at the time before the Betula Climax, namely, as a result of lowering of the water level which took place then. This considerable lowering of the water level, caused some of the sediments of the lake to erode, whereby nutrients were mobilized and thus benefitted the free water of the lake, which again influenced the vegetation(see Thunmark 1937, p. 132; 1945, p. 141 ff, 1948, p. 33, Collini 1939, p. 19, Lillieroth 1950). This might explain why so many of the more assuming parts of the vegetation have been able to survive for a considerable longer time.

Sediments above the c-level (the rational pine pollen limit) still contain some species, which now are missing from the present day vegetation of the lake but present in Outer Old-lake and Landö-lake, namely, Cyclotella kützingiana v. radiosa, Cymbella affinis, C. cuspidata, C. cymbiformis, Epithemia argus, Gomphonema constrictum, Neidium iridis and Tetracyclus lacustris.

The 50 odd taxa, which are found in every sample throughout the whole series, along with the more demanding diatoms, are such, which now generally occur within the greater part of the lake system and which obviously posess a considerable ecological flexibility.

footnote p. 84

(1) From the Greek μειόω to make less; the term (in consultation with Prof. Du Rietz) proposed as opponents to Thunmark's (1948, p.32, 33:, see Lillieroth 1950,p.8) "auxotrophication" (greek αὔξω increase) These terms, which are meant to replace the past and inconsistently used "oligotrophication" resp. "eutrophication" indicate thus a change in the trophic level, regardless of point of origin and regardless of the distance on the trophication scale. (The term meiotrophication was first proposed at a limnological seminar in Uppsala, 20-5-,1952)

6. Summary. The diatoms in the post-glacial layer-sequence of the Upper Old-lake.

Zone VI and V, the older part. While the Upper Old-lake was fed by glacial water and a fast clay sedimentation took place (Zone VI and the older part of zone V)the diatom flora appears to have been rather poor in species and composed mainly of such taxa, which presently are widely distributed within the water system.

Zone V, the younger part. The younger part of zone V shows a gradual lowering of the water level(most probably coinciding with the maximal distribution of Hippophaë by the lake) and a successive increase in species and numbers of the mikroflora containing diatoms, which are at present missing from the lake (in addition to a considerable part of the present day species composition); such as Amphora ovalis, Cyclotella antiqua, C. comta, Cymbella cistula, Denticula tenuis v. crassula, Epithemia argus, Fragilaria leptostauron v. dubia,F. pinnata, Gomphonema constrictum, G. subtile, Melosira italica ssp. subarctica, Navicula bacillum, N. hungarica and v. capitata, N. pseudoscutiformis, N. pupula, Nitzschia denticula,Pinnularia nobilis, Tetracyclus lacustris.

In the mud-clay, which brought about the transition from clay to fine detritus-mud, and which was deposited during a new rise in the water level, Fragilaria leptostauron v. dubia had its climax along with Amphora ovalis, Anomoeoneis zellensis and Denticulata tenuis v. crassula. At this time or shortly thereafter Achnanthes flexella, Eunotia arcus and Melosira distans v. lirata had their peaks in the thanatocoenoses of the layer-sequence.

In addition to the abovementioned diatoms, one finds some, which appear to be missing from the present-day vegetation of the lake: Campylodiscus hibernicus, Ceratoneis arcus, Cyclotella comta, v. oligactis, Cymbella angustata, Cymbella helvetica,Hantzschia amphioxys v. vivax, Navicula anglica, N. vulpina, Neidium

Hitchcockii, N. iridis and v. ampliatum, Pinnularia lata. Frustulia was then remarkably unimportant in the vegetation. Immediately when the fine detritus mud had replaced the mud-clay, Fragilaria leptostauron v. dubia and F. pinnata disappeared and with these possibly a few of the diatoms limited to zone V in Upper Old-lake.

Zone IV. When the large Alnus climax occurred at the beginning of zone IV, the water level had reached at least the same height as before the lowering at zone V.

Most of the diatoms from the previous zone were still there. Frustulia rhomboides v. saxonica became quantitatively more important, as did Cyclotella kützingiana v. planetophora. Anomoeoneis exilis and and A. serians v. ~~brachysira~~ brachysira were also important members of the vegetation..

Close by the d-level, thus immediately after the Alnus climax, were found small balls (not more than 1/2 mm in size) of limonite (brown iron ore, I:T:)here and there in the dark olive-colored fine detritus mud. A new addition to the flora (?) was Pinnularia episcopalis as well as P. subsolaris and earlier Navicula tusculoides slightly higher, and at the d-level and only there Cymbella amphioxys and C. Ehrenbergii. Eunotia lunaris and Peronia Heribaudii make their appearance, sparsely and irregularly, at and from the d-level, and in their place disappear many of the older members of the flora, namely, Cyclotella antiqua, Denticula tenuis v. crassula, Navicula pseudoscutiformis, Nitzschia denticula and Pinnularia episcopalis.

The large lowering of the water level happened at this time, and the sedimentation limit was moved down about 1 m.

Zone III. This low water level persisted generally in the Upper Old-lake during the 3000 years to follow, whereby sediments which belong to zone III are missing in BP I (and III) and incomplete in BP II.

The diatom flora probably changed slowly during this time, primarily through a decrease in number of species. Several more species disappeared, namely, Campylodiscus hibernicus, Cymbella cistula, C. helvetica, Epithemia sorex, Gomphonema subtile, Hantzschia amphioxys v. vivax, Melosira italica ssp. subarctica, Navicula anglica, N. bacillum v. gregoryana, N. cuspidata, N. pupula and v. capitata, N. tusculoides, Neidium Hitchcockii, Pinnularia lata and P. nobilis. (Cymbella aequalis, Eunotia crista galli, E. sudetica and Navicula americana were among the few new arrivals and only E. sudetica has been found in the present day vegetation of the lake.)

Amphicampa, Anomoeoneis serians and Eunotia triodon, on the other habd, seem to have acquired a somewhat increased quantitative importance in the upper part of zone III.

Zone II and to the present day. The height of the water level had not increased to the present day level, while the sediments which belong to the older part of zone II were still being deposited, and the diatom flora still contained elements now missing from the vegetation of the Upper Old-lake but which still can be found in Outer Old-lake and Landö-lake. Even these species disappeared soon and the composition became more or less that of the present-day flora. Here follw the species, which disappeared: Cyclotella kützingiana v. radiosa, Cymbella affinis, C. cuspidata C. cymbiformis, Epithemia argus, Gomphonema constrictum, Neidium iridis and v. ampliatum and Tetracyclus lacustris. Frustulia, at this same time, increased in number.

Eunotia denticulata v. fennica was a new arrival in the beginning of zone II and is found rather regularly in the sediments at and after c-level and is nowadays common, though poor in number. Eunotia bactriana and Tabellaria binalis have been found sporadically only at c-level as well as in the present day vegetation.

END

Notice

Please note that these translations were produced to assist the scientific staff of the FBA (Freshwater Biological Association) in their research. These translations were done by scientific staff with relevant language skills and not by professional translators.