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## Holocene diatomites in central Finland, with special reference to *Aulacoseira* (*Melosira*) species

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**HOLOCENE DIATOMITES IN CENTRAL FINLAND,  
WITH SPECIAL REFERENCE TO *AULACOSEIRA (MELOSIRA)* SPECIES**

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Diatomite and diatom gyttja have deposited in the basal parts of mires in the areas of Petäjävesi, Keuruu, Kuorevesi and Jämsä, central Finland. The diatom stratigraphy, chemical composition, particle size distribution, melting temperature and specific surface area of these deposits are given. Diatoms of the genus *Aulacoseira* predominate at all twelve sites studied. At most sites, deposition of diatoms started with alkaliphilous diatoms as the prevailing species but in the course of deposition the diatom flora became predominantly acidophilous. *Aulacoseira ambigua* and *A. granulata* are the dominant alkaliphilous species and *A. lirata*, *A. lirata* var. *lacustris* and *A. distans* var. *alpigena* the dominant acidophilous diatoms.

Key words: diatoms, diatom flora gyttja, chemical composition, physical properties, *Aulacoseira*, *Melosira*, Holocene, Finland.

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## INTRODUCTION

Diatomite is soft porous sediment deposited in water and is mainly composed of microscopic tiny silica frustules of diatoms. The frustules of the diatoms are of amorphic silica ( $\text{SiO}_2 \times n \text{ H}_2\text{O}$ ). The hardness of the frustule is 4 1/2—6 1/2 on Mohr's scale but the thickness varies with the species. The frustules derive from diatoms of the order *Centrales* or *Pennales*, the former being rounded, resembling a pillbox in shape, and the latter elongated (see Plates X and XV). Abundant general information about diatoms is available e.g. in the works of Patric and Reimer (1966) and Krammer and Lange-Bertalot (1986), and about diatomites in the paper of Kadey (1975).

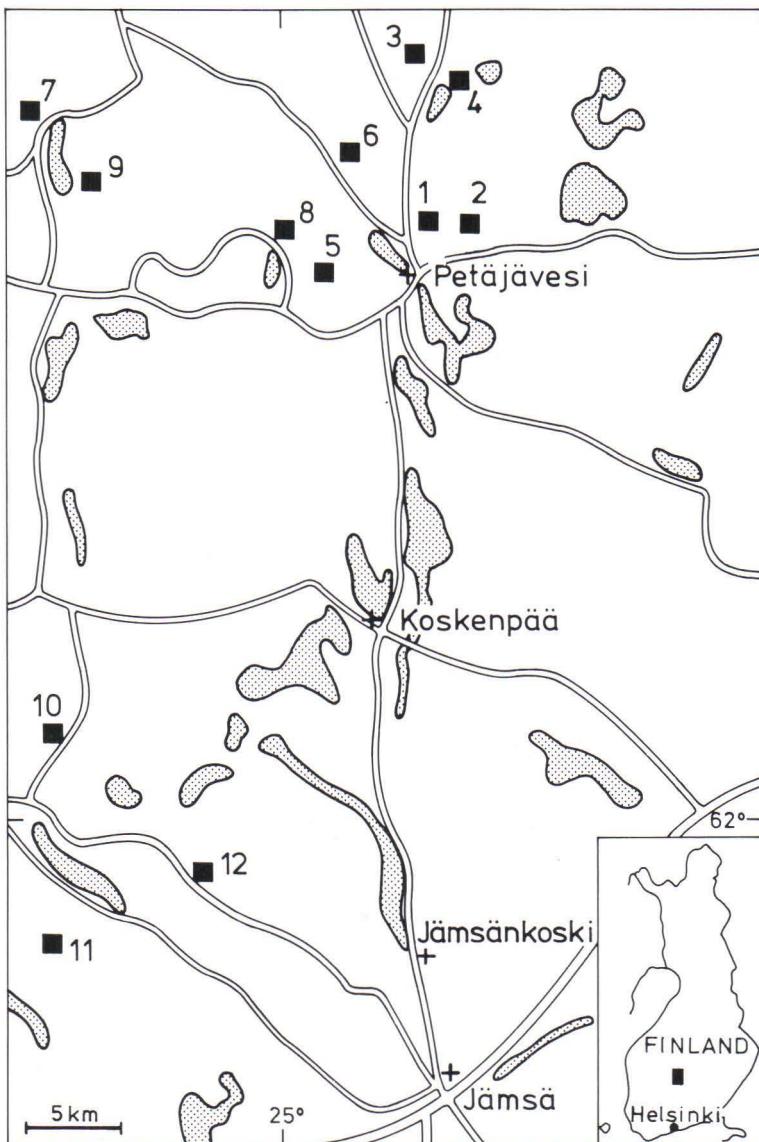


Fig. 1. Location map of the diatomite and diatom gyttja sites investigated.  
 1. Ihakkilammensuo mire, 2. Iso Rautasuo mire, 3. Joutavanmäen suo mire,  
 4. Kurkisuo mire, 5. Maunusuo mire, 6. Pengerjoensuo mire, 7. Heton-  
 suo mire, 8. Hinkkasuo mire, 9. Ukonmurronsuu mire, 10. Housujärven-  
 suo mire, 11. Kuljunsuo mire, 12. Kelaojansuo mire.

Fresh diatomite is white at its purest, but in nature it is frequently coloured by impurities. Depending on the humus content, it may be brown or greenish and resemble mud or gyttja. On ignition, however, the organic matter disappears and the diatomite becomes pale. Drying also lightens the colour of diatomites in a natural state. The reddish brown colour, which is intensified on ignition, is due to the iron content.

Owing to the weight of the overlying sediments, the old diatomites deposited during the Tertiary or Pleistocene have been compacted and lithified material, the organic matter having been almost totally eliminated by oxidation since the deposits emerged from water. Most of the diatomites encountered in Finland are young, i.e. they have deposited since the last glaciation, and are often covered by layers of peat or gyttja.

In the course of peat geological studies undertaken in 1981 — 1983 (Stén, Korhonen & Svahnback 1982, Ristaniemi 1984, Ristaniemi & Stén 1984, Korhonen 1986, 1988) diatomites and diatom gyttja were encountered in the parishes of Petäjävesi, Keuruu, Kuorevesi and Jämsä in Central Finland between Lat  $61^{\circ} 57'$  and  $62^{\circ} 22'N$ , Long  $24^{\circ} 48'$  and  $25^{\circ} 15'E$  (Fig. 1).

## DIATOMITE RESEARCH IN FINLAND

Research into Finnish diatomites has been rather modest. The oldest studies are those undertaken by Ehrenberg in 1838 and 1840 on the diatom assemblages of diatomites in Savitaipale and around Kymi. In 1861 Nylander published a list of fossil diatoms in Finland on the basis of the 10 diatomite occurrences studied by Brébisson. P.T. Cleve (1891) and later his daughter Astrid Cleve Euler (1951 — 55) studied the diatoms in Finland including the assemblages of some diatomite occurrences. The Atlas by Schmidt (1874 — 1959) also deals with diatoms identified from some Finnish diatomites. According to Ramsay (1909 p. 224) diatomites were known already at the beginning of this century in the areas of Sovajärvi and Kuolajärvi and at Brödtorp in Pohja.

Later reports of diatomite deposits are to be found in studies on the history of vegetation and climate and on shoreline displacement. The often rather thin diatomite deposits encountered in the course of these studies were dated with pollen analysis (e.g. Aario 1943, Donner 1957, Lappalainen 1962, Sauramo 1939, 1949, 1951, 1968). Thicker diatomite deposits (about 0.2—4.0 m) were found by Kanerva (1956) in Hyrynsalmi. Nieminen (1976) has described some diatomite occurrences of potential commercial value, the most important, even today, being that at Komu, Pyhäjärvi. With the intensification of peat research, numerous diatomite deposits have recently been discovered at the bottom of mires in Finland (Grönlund 1982, 1986a, b).

All the above diatomites are young occurrences deposited on the bottom of freshwater basins during the Holocene. However, some old diatomites have also been encountered in Finland. For example, the diatomite at Naruskajärvi, Salla (Hirvas *et al.* 1977, Tynni 1982) is late-Tertiary and was probably moved from its original site by the continental ice. The diatomite discovered in the Sokli area, Savukoski (Ilvonen 1973) is Eemian in age. This deposit, with its diatoms of freshwater species, was found in a 20 — 30 m deep basin in bedrock, and is evidently in its original site. Aario (1966) encountered diatomite in a secondary position at Haapajärvi. According to him, the diatomite deposited in rather cool interglacial or interstadial water. Some salt water and brackish water diatoms are found among the freshwater species. At Oulainen there is a diatomite with freshwater species that has been interpreted as interstadial (Forsström 1982, 1988).

## DIATOMITE RESEARCH IN EUROPE

Elsewhere in Scandinavia, too, there is a shortage of research into diatomites. Foged (1960) investigated an interglacial diatomite occurrence in Denmark and a postglacial deposit in Norway (1970).

South of the Baltic and in Central Europe there are abundant diatomite occurrences, and many of them, including their diatom assemblages, have been submitted to com-

hensive studies. Among the earliest are those undertaken by Krasske in the 1930s (Krasske 1933, 1937). In later studies the emphasis has been on diatomite deposits older than Holocene, for example, those of Pleistocene age encountered in Germany. Holsteinian and Eemian diatomites have been studied by Hustedt (1954), Behre (1962), Benda (1963, 1964, 1974) and Müller (1974a, b). In places the German diatomites exhibit varved structure, which makes them suitable for chronological research. Numerous diatomite occurrences have also been found in Austria and Hungary, for example, those studied by Hajos (1970, 1977a, b).

## METHODS

The determination of diatomites, which was undertaken under the microscope using material in a natural state, was based on the abundance of diatom frustules. The material was considered to be diatomite if the field of view of a preparate was almost completely covered with diatoms and if mineral grains were virtually lacking. Material that contained conspicuously fewer diatoms and possibly also mineral matter was called diatom gyttja. The microscopic determination of diatomite and diatom gyttja was further checked by submitting a sample taken from the central part of the deposit to chemical analysis. The concentration of  $\text{SiO}_2$  was then decisive. The  $\text{SiO}_2$  concentration of diatomite should exceed 60% and that of the diatom gyttja 20%. The  $\text{SiO}_2$  value of diatom gyttja also includes any silica incorporated in minerals (quartz). The above procedure was applied in the Geological Survey of Finland's diatomite studies (Grönlund 1986a) and investigations of the Soijärvi deposit (Grönlund 1986b).

The diatomites were sampled with the cooperation of peat researchers. Most of the samples were taken with a piston sampler and a version of piston sampler designed for taking undisturbed samples of known volume was also used (Korpilaakko 1981). The geologist in charge of peat research in a particular area is responsible for estimating the diatomite resources in the mires in that area. Some mires were surveyed only at random points, and for them the estimates of the diatomite and diatom gyttja resources are little better than indicative owing to the scarcity of research sites.

The emphasis of the present study is on diatomites. They are described from five mires in Petäjävesi, two mires in Keuruu, one mire in Kuorevesi and one mire in Jämsä.

The diatom gyttja observed in association with these diatomites are usually simply marked in the stratigraphic column and, apart from the diatom analysis, are left at that. The exceptions are the diatom gyttja deposits at Petäjävesi, Keuruu and Kuorevesi, which were studied in as much detail as the diatomites.

For a few samples, the sintering point, softening point, melting point and fluidizing point were determined with a Leitz Wetzlar heating microscope (DIN 5173). However, with a maximum temperature of only 1400°C, the microscope was of limited use.

The particle size distributions of the samples were determined with an automatic particle analyzer (Sedigraph 5000 D). The procedure is based on accelerated sedimentation and the use of X-rays. Before measurement the material is treated with hydrogen peroxide to eliminate humus and is water-sieved on a 62 µm screen. The maximum particle size measured by the analyzer is 60 µm.

The specific surface area of each diatomite and diatom gyttja was determined at the Laboratory of Engineering Geology of Tampere University of Technology. The nitrogen adsorption technique was used on materials ignited at 700°C (cf. Nieminen 1982, Grönlund 1986b).

The chemical composition of each diatomite and diatom gyttja deposit was determined from the middle of the deposit.

The diatoms from each diatomite and diatom gyttja deposit were analysed at intervals of 20 cm to establish the diatom stratigraphy. At least 500 diatoms were named from each sample. The diatom stratigraphies are given as diagrams (Figs. 3 — 14) in which all the diatoms exceeding one per cent of the total population in abundance follow the data on lithostratigraphy and depth. The next column gives the pH spectrum of the diatoms and the curve of the ratio of *Centrales* to *Pennales* diatoms. This ratio reflects in broad outline the ratio of plankton diatoms to littoral diatoms in an assemblage. It also gives a rough

estimate of the water depth, as plankton species generally live in deeper water than littoral species. The last column in the diagram shows the concentration of humus in diatomite. This was determined with a spectrophotometer from samples taken at three different depths from four mires in Petäjävesi — Ihakkilammensuo, Iso Rautasuo, Joutavanmäensuo and Kurkisuo, and two mires in Kuorevesi — Housujärvensuo and Kuljunsuo.

According to their pH preference (Hustedt 1937 — 39), the diatoms were grouped into five classes as follows:

Alkalibiontic (alkb) — forms which occur at pH values above 7

Alkaliphilous (alkf) — forms which occur at about pH 7, but mainly at pH above 7

Indifferent (ind) — forms which occur at about pH 7

Acidophilous (acf) — forms which occur at about pH 7, but mainly at pH below 7

Acidobiontic (acb) — forms which occur at pH below 7 with optimal occurrences at pH 5.5 and below.

For each site, the pH that prevailed during deposition was determined from the formula of Renberg and Hellberg (1982):

$$\text{index B} = \frac{\% \text{ind} + 5\% \text{acf} + 40\% \text{acb}}{\% \text{ind} + 3.5\% \text{alkf} + 108\% \text{alkb}}$$

$$\text{pH} = 6.40 - 0.85 \log \text{index B}$$

$$r^2 = 0.91, S_e = \pm 0.30$$

The diatomites at Ihakkilammensuo, Hinkkasuo and Housujärvensuo were dated with the  $^{14}\text{C}$  method. The ages are given in the diatom diagrams of these sites (Figs. 3, 10 and 12).

## **DESCRIPTION OF THE SITES, RESOURCES OF DIATOMITE AND DIATOM GYTTJA**

### **I Petäjävesi**

#### **1) Ihakkilammensuo mire**

Ihakkilammensuo (map sheet 2234 08, x = 6907.5; y = 562.1) is an overgrown ancient lake, about 3 km north of Petäjävesi church. Topographically the mire is located in a depression between till-covered hills (Fig. 1). It lies at 126—130 m a.s.l. and slopes southwestwards. The brook flowing through the mire drains into Lake Jämsänvesi (Stén, Korhonen & Svahn-bäck 1982).

Diatomite was studied at peat research site P6 in the northern part of the mire (Stén *et al.* 1982). At the research site the diatomite layer is 275 cm thick and is underlain by 15 cm of peat, below which there is mineral gyttja. Ihakkilammensuo contains an estimated 162 500 m<sup>3</sup> of diatomite within an area of about 13 hectares. The humus concentration in the upper part of the diatomite is 17.0% and in the basal part 17.3% (Fig. 3).

#### **2) Iso Rautasuo mire**

Iso Rautasuo (map sheet 2234 08, x = 6909.1; y = 566.0) lies about 6 km northeast of Petäjävesi church (Fig. 1). Topographically the mire is surrounded by till-covered hills. Its surface is at about 135—144 m a.s.l. and slopes southwards, where the mire is bounded by Lake Saarijärvi (Stén *et al.* 1982).

Diatomite was studied at peat research site P7, which is located on the western shore of Lake Pieni Saarijärvi (Stén *et al.* 1982). At this study site the diatomite is about 130 cm thick. It is overlain by about 65 cm of peat and underlain by diatom gyttja. Iso Rautasuo contains an estimated 99 000 m<sup>3</sup> of diatomite within an area of about 11 hectares. The humus concentration in the upper part of the diatomite is 30.5% and in the middle 25.0%. The humus concentration in the diatom gyttja below the diatomite is 7.75% (Fig. 4).

### 3) Joutavanmäensuo mire

Joutavanmäensuo (map sheet 2234 09, x = 6917.0; y = 562.3) lies about 10 km north of Petäjävesi church (Fig. 1). Topographically the mire is surrounded by gently sloping till-covered hills. The surface of the mire is at 165–175 m a.s.l. and slopes partly southeastwards, partly northwestwards (Stén *et al.* 1982).

Diatomite was studied at peat research site P4, which is located southeast of Lake Kuivaslampi (Stén *et al.* 1982). At the study site, the diatomite is 120 cm thick. It is overlain by 20 cm of diatom gyttja, which in turn is overlain by 130 cm of peat. Below the diatomite there is mineral gyttja underlain by sand. The Joutavanmäensuo contains an estimated 16 000 m<sup>3</sup> of diatomite within two hectares. The humus concentration in the upper part of the diatomite is 34.8% and in the basal part 25.5%. The corresponding figure for the diatom gyttja is 20.3% (Fig. 5).

### 4) Kurkisuo mire

Kurkisuo (map sheet 2234 09, x = 6916.6; y = 564.1) lies about 11 km north of Petäjävesi church (Fig. 1). Topographically the mire is located in a depression between moraines. Its surface is at 166–175 m a.s.l. and it drains into the river flowing through the mire (Stén *et al.* 1982).

Two profiles were sampled to study diatomite, one at site P1 in the northern part of the mire and another at P2 on the western shore of Lake Kurkilampi (Stén *et al.* 1982). At site P1 the diatomite is 80 cm thick and is underlain by about 115 cm of diatom gyttja. At site P2 the diatomite is thicker, extending from 205 cm to 590 cm in depth. Owing to confusion in sampling at site P2 there is a gap of about 1 m in the sample profile, and so the diatom analyses and other procedures are based on samples from P1. Kurkisuo contains an estimated 411 600 m<sup>3</sup> of diatomite within about 12 hectares. The upper part contains 25.5%, the middle part 26.3% and the basal part 20.0% humus (Fig. 6).

### 5) Maunusuo mire

Maunusuo (map sheet 2234 05, x = 6907.6; y = 556.3) lies about 6 km west of Petäjävesi church (Fig. 1). Topographically the mire is located in a valley between steep hills. The surface of the mire is at about 171–181 m a.s.l. and slopes sharply northwards, excluding the southernmost part, which slopes southeastwards (Ristaniemi 1984).

The diatomite at Maunusuo was studied at point A500 of the basic line of peat research (Ristaniemi 1984). At the study site, the diatomite is 2 m thick (150–350 cm) and is overlain by gyttja and peat. Below the diatomite there is 20 cm of diatom gyttja underlain by silty gyttja. The estimated diatomite content at Maunusuo is 86 400 m<sup>3</sup> (Fig. 7).

### 6) Pengerjoensuo mire

Pengerjoensuo (map sheet 2234 06, x = 6912.5; y = 556.8) lies about 8 km northwest of Petäjävesi church (Fig. 1). Topographically the mire is located in a clay-silt area of the Pengerjoki river valley. The surface of the mire is at about 123–126 m a.s.l. and slopes southeastwards, the same direction in which the waters drain (Ristaniemi 1984).

The diatom gyttja found in Pengerjoensuo was studied at peat research site A400+0, which is in the middle of the mire. At the site the diatom gyttja layer is about 220 cm thick and is overlain and underlain by fine-grained detrital gyttja. Pengerjoensuo contains an estimated 67 500 m<sup>3</sup> of diatom gyttja (Fig. 8).

## II Keuruu

### 7) Hetonsuo mire

Hetonsuo (map sheet 2234 03, x = 6914.0; y = 2541.2) lies about 10 km northeast of the centre of Keuruu (Fig. 1). The mire covers an area of 39 hectares at 134–137 m a.s.l.. In the west it is bounded by Kypärävuori, a hill over 200 m high; elsewhere it is rimmed by moraines. The surface of the mire slopes southwards, the same direction in which the waters drain through Lake Kypärälampi, a pond in the mire (Korhonen 1988).

Diatomite was studied at peat research site A400 + 200. At this site diatomite and diatom gyttja alternate, the maximum thickness of the diatomite being 70 cm (at a depth of 120–190 cm). The estimated diatomite content at Hetonsuo is about 40 000 m<sup>3</sup> (Fig. 9).

### **8) Hinkkasuo mire**

Hinkkasuo (map sheet 2234 05, x = 6908.1; y = 2553.4) lies about 20 km west of the centre of Keuruu (Fig. 1) and covers an area of 56 hectares. The surface of the mire is at 166–171 m a.s.l. and slopes north-northwestwards (Korhonen 1988).

Diatomite was studied at peat research site A1500, where the diatomite layer is 160 cm thick and is underlain by 130 cm of diatom gyttja. The estimated content of diatomite is about 80 000 m<sup>3</sup> (Fig. 10).

### **9) Ukomurronsuo mire**

Ukomurronsuo (map sheet 2234 06, x = 6912.5; y = 2554.4) lies about 20 km northeast of Keuruu church (Fig. 1) and has a surface area of 201 hectares. Its surface is at 139–150 m a.s.l. and slopes northeastwards, the same direction in which the waters also drain. In the east the mire is bounded by an esker, Syrjänharju, in the southwest by a hill Ukomurronmäki, and elsewhere by moraines (Korhonen 1988).

Diatom gyttja was studied at peat research site B1, where its thickness is about 130 cm. It is overlain by 150 cm of peat and underlain by silt. The estimated diatom gyttja content in the mire is 1000 m<sup>3</sup> (Fig. 11).

## **III Kuorevesi**

### **10) Housujärvensuo mire**

Housujärvensuo (map sheet 2233 03, x = 6882.1; y = 2543.6) lies about 20 km north of Kuorevesi (Fig. 1). It covers 17 hectares and slopes southwestwards. The mire's waters drain through another mire, Heräsuo, into Lake Sammalisjärvi. The surface of Housujärvensuo is at 131–137 m a.s.l. (Korhonen oral comm.).

Peat research was conducted at five sites. Diatomite was studied at site P1, where it is about 2 m thick and underlain by gyttja. The estimated diatomite content is 48 000 m<sup>3</sup>. The concentration of humus in the upper part of the diatomite is 17.5%, in the middle 22.5% and in the basal part 17.8% (Fig. 12).

### **11) Kuljunsuo mire**

Kuljunsuo (map sheet 2233 02, x = 6872.9; y = 2544.9) lies about 10 km north of Kuorevesi (Fig. 1). The mire covers 81 hectares and its surface slopes gently westwards at 105–108 m a.s.l. (Korhonen oral comm.).

Diatomite was studied at peat research site B500 + 0, where it is 40 cm thick and is underlain by 130 cm of diatom gyttja. The estimated diatomite content is about 12 750 m<sup>3</sup>. The concentration of humus in the upper part of the diatomite is 45.5%; in the upper part of the diatom gyttja it is 32.8%, in the middle 31.3% and in the basal part 16.3% (Fig. 13).

## **IV Jämsä**

### **12) Kelaojansuo mire**

Kelaojansuo (map sheet 2233 02, x = 6875; y = 2549.3) lies about 18 km northwest of Jämsä church and covers 59 hectares. Two brooks, Kelaoja and Ruotsinoja, flow through the mire, and Lake Kelalampi, a small pond, is located at its western margin. The surface of the mire is at 105–108 m a.s.l. (Korhonen 1986).

Diatomite was studied at peat research site A100, where its thickness is about 140 cm. The estimated diatomite content of the mire is 88 000 m<sup>3</sup> (Fig. 14).

## PHYSICAL AND CHEMICAL PROPERTIES

The use of diatomite is based on its characteristic physical and chemical properties. The purity of diatomite also affects its commercial value. Diatomite has a number of uses (Mölder 1960, Kadey 1975, Grönlund 1986), the most important (about 60%) being as a filter aid owing to its high mechanical filtering capability. Diatomite is also used as an absorbent because of its high absorptive capacity. It can absorb water 1/2—3 times its weight. The absorptive capacity increases if the water bound to silica is removed, e.g. with calcination (Durham 1973). Recently diatomite has increasingly been used as a filler, particularly in the building industry. It is also used as an insulator and abrasive, and as an extender in fertilizers and ceramics.

Diatomite is comparable to quartz in hardness and can only be dissolved by strong alkalies and hydrofluoric acid.

### Melting temperature

The melting point of diatomites generally varies between 1400 and 1750°C, depending on the composition. Some impurities lower the melting point a great deal (Durham 1973). Owing to the high melting points, diatomite is an excellent fireproof insulator. It also has low thermal conductivity.

Table 1. Sintering points, softening points, melting points and fluidizing points of diatomites studied.

Mires studied	Depth cm	1.	2.	3.	4.
1. Ihakkilammensuo	200—220	1120°	1160°	1410°	1450°
2. Iso Rautasuo	140—160	1140°	1450°	>1400°	>1400°
3. Joutavanmäensuo	210	>1400°	>1400°	>1400°	>1400°
4. Kurkisuo	400—420	1200°	1240°	>1400°	>1400°
5. Maunusuo	210	1180°	1440°	>1400°	>1400°
10. Housujärvensuo	240—260	1390°	1440°	>1400°	>1400°
11. Kuljunsuo	240	>1400°	>1400°	>1400°	>1400°
12. Kelaojansuo	200—220	1220°	1400°	>1400°	>1400°

1. Sintering temperature      3. Fusion temperature  
 2. Softening temperature      4. Fluid temperature

Melting points were determined with a heating microscope and the results obtained are listed in Table 1. Since the equipment could not be used at temperatures exceeding 1400°C, the melting points were only determined for eight sites. At each site the melting point and the fluidizing point exceeded 1400°C, which prevented us from obtaining precise values. The sintering point and the softening point of the diatomite at Joutavanmäensuo and of the diatom gyttja at Kuljunsuo were also high and exceeded the range of the heating microscope.

### Particle size distribution

The particle size distributions of the sites studied are shown in Fig. 2. In Table 2 the grains are grouped into three classes: those with a diameter of less than 2 µm, those with a diameter between 2 µm and 20 µm, and those with a diameter exceeding 20 µm. Only the diatomite at Soijärvi had been submitted to grain size distribution measurements before (Grönlund 1986a). In that paper, Grönlund (1986a) discussed the difficulty of determining the correct grain size distribution of diatomites. The present findings corroborate the results from Soijärvi. It is evident that when the technique developed for ball-like grains is used, the proportion of diatoms or diatom chains, 20 µm in size, is underestimated, and, correspondingly, the proportion of diatoms measuring less than 2 µm is overestimated. What is more, diatoms may break during the measurement, thus further increasing the number of small grains.

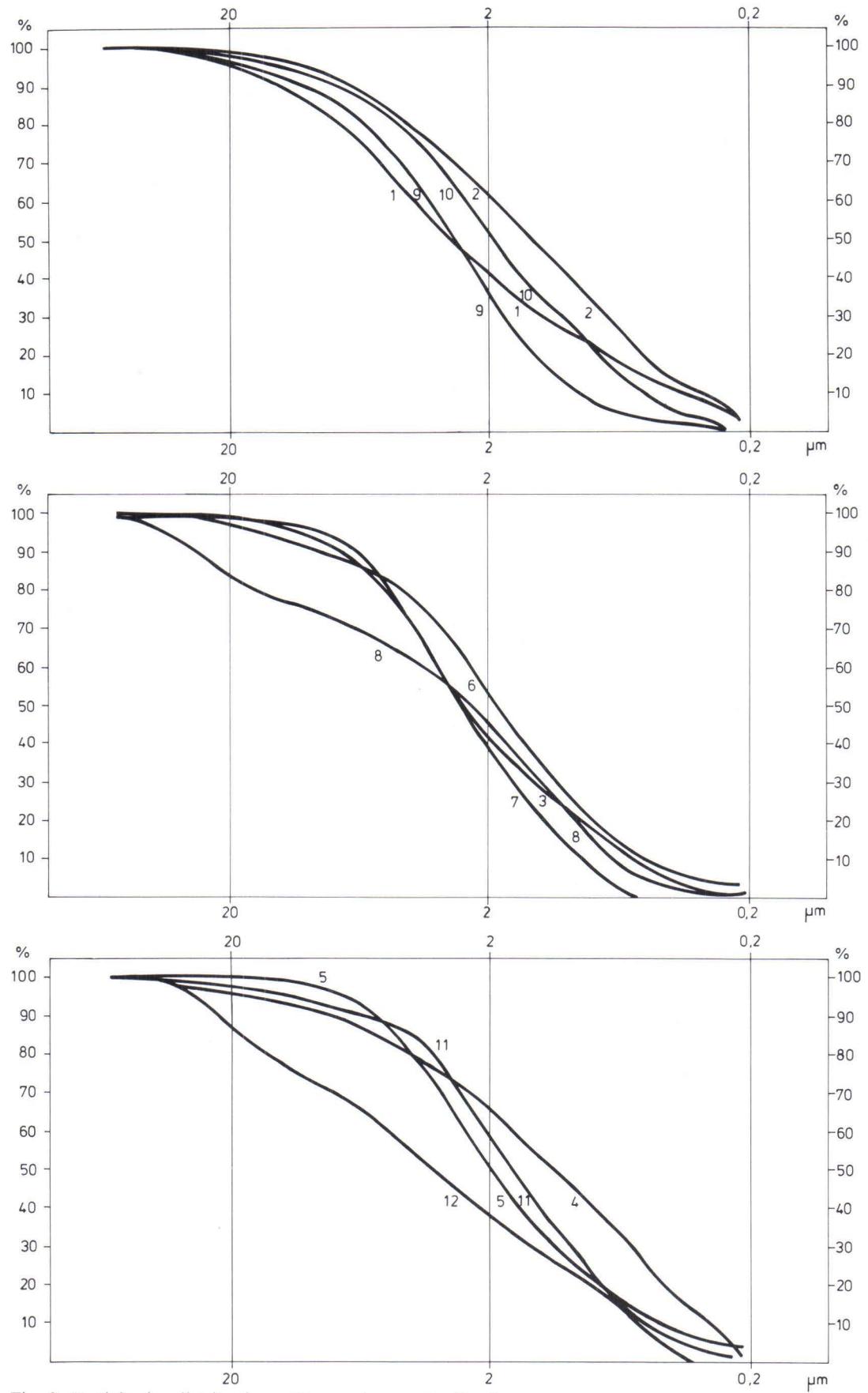


Fig. 2. Particle size distributions. Site numbers as in Fig. 1.

Table 2. Particle size distributions of diatomites at sites studied.

Mires studied	Depth cm	< 2 µm	2—20 µm	> 20 µm
1. Ihakkilammensuo	200—210	40%	55%	5%
2. Iso Rautasuo	150—160	60%	39%	1%
3. Joutavanmäensuo	230—240	42%	57%	1%
4. Kurkisuo	270—280	65%	30%	5%
5. Maunusuo	370—375	50%	50%	0%
6. Pengerjoensuo	370—380	54%	43%	3%
7. Hetonsuo	150—160	40%	59%	1%
8. Hinkkasuo	160—170	45%	40%	15%
9. Ukonmurronsuo	220—230	35%	61%	4%
10. Housujärvensuo	220—230	51%	47%	2%
11. Kuljunsuo	250—260	57%	41%	2%
12. Kelaojansuo	220—240	37%	50%	13%

### Specific surface area

The adsorption method is based on measurement of the gas adsorbed on the surface of the sample at low pressure and temperature. The method gives an accurate surface area of the particles and also allows the surface structures of the particles to be estimated (Nieminén 1982). The specific surface area is affected by porosity, grain size, iron compounds, organic matter, mineralogical composition and weathering degree (Nieminén 1982). The specific surface area is usually only large if the matter is porous. It can be used to classify fine-grained (fractions less than 1 mm in grain size) soils.

The specific surface areas of the diatomites and diatom gyttja studied are given in Table 3. The highest values were recorded from diatom gyttja at Pengerjoensuo and Ukonmurronsuo, 28 500 m<sup>2</sup>/kg and 33 100 m<sup>2</sup>/kg, respectively. The specific surface areas of the diatomites at Maunusuo and Hinkkasuo are somewhat higher than 20 000 m<sup>2</sup>/kg, and those of the other sites are from 10 300 to 14 400 m<sup>2</sup>/kg. There is thus a marked fluctuation in the specific surface areas measured. Since the sites are very similar in terms of diatom assemblages the difference in specific surface areas must be due to some other factor. One may be the difference in degree of frustule fracturing between the sites. The proportion

Table 3. Specific surface area of diatomites determined with a nitrogen adsorption method from samples ignited at 700°C.

Mires studied	Depth cm	m <sup>2</sup> /kg
1. Ihakkilammensuo	240—260	~ 10 300
2. Iso Rautasuo	135—140	~ 10 800
3. Joutavanmäensuo	240	~ 14 100
4. Kurkisuo	240—260	~ 14 300
5. Maunusuo	190	~ 21 000
6. Pengerjoensuo	350—355	~ 28 500
7. Hetonsuo	180—185	~ 13 000
8. Hinkkasuo	195—200	~ 22 500
9. Ukonmurronsuo	250—255	~ 33 100
10. Housujärvensuo	220—240	~ 12 500
11. Kuljunsuo	210	~ 14 400
12. Kelaojansuo	260—280	~ 14 200

of fragments in the assemblage is difficult to establish, but the higher the number of fractured diatoms the higher the specific surface area.

Reference material on the specific surface areas of diatomites is lacking. The diatomite at Soijärvi (Grönlund 1986) is the only one with data on specific surface area. Its specific surface area of 28 800 m<sup>2</sup>/kg was obtained from diatomite ignited at 700°C. The basal part of the Soijärvi diatomite occurrence contains alkaliphilous diatoms, and the bulk of the deposit is characterized by acidophilous *Melosira lirata* and *M. distans*. Fragments account for a high proportion of the assemblage (Grönlund 1986).

### Chemical composition

Table 4 gives the chemical compositions at the sampling sites. The samples were taken from material in a natural state. The chemical composition was always determined from diatomite, even in those successions that contain diatomite and diatom gyttja. The only exception was Kuljunsuo, where the determination was done on a sample taken from immediately below the diatomite. As well as silica, the samples were analysed for aluminium, iron, calcium, magnesium, sodium, potassium and organic matter. A common feature shared by all the results is the high abundance of organic matter (14.3—41.8%), as shown by the loss — on — ignition (Table 1) and concentrations of humus (Figs. 3—14), and the low abundances of accessories. Only the diatomite at Ihakkilammensuo has aluminium and iron concentrations clearly higher than those in the other diatomites. The samples from Pengerjoensuo, Ukomurronsuo and Kuljunsuo mires classified as diatom gyttja also exhibit high silica abundances. Microscopic examination showed that the samples from Pengerjoensuo and Ukomurronsuo contained some mineral grains but that the Kuljunsuo sample did not. It is thus clear that, once the organic matter is eliminated, the diatom gyttja at Kuljunsuo could be converted into a high quality diatomite. On the other hand, in certain applications, for example, as a soil improvement agent, mineral matter is no obstacle. Clayey diatomite is also very suitable as raw material for the brick industry.

Table 4. Chemical compositions of the diatomites studied.

Mires studied	Depth cm	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	Na <sub>2</sub> O	K <sub>2</sub> O	Loss on ignition %
1. Ihakkilammensuo	200—205	65.4	7.54	3.07	1.81	1.21	1.65	1.54	16.9
2. Iso Rautasuo	150—155	70.0	2.23	0.99	0.58	0.28	0.38	0.35	23.5
3. Joutavanmäensuo	230—235	71.5	2.07	0.66	0.42	0.08	0.06	0.07	25.1
4. Kurkisuo	270—275	72.2	2.24	0.96	0.53	0.19	0.28	0.26	23.6
5. Maunusuo	190—195	64.8	0.76	0.50	0.34	0.08	0.04	0.03	31.4
6. Pengerjoensuo	350—360	58.7	2.33	2.05	0.24	0.23	0.25	0.28	34.5
7. Hetonsuo	170—180	60.8	2.01	1.37	0.18	0.22	0.19	0.19	34.1
8. Hinkkasuo	150—160	60.2	1.38	1.50	0.11	0.23	0.17	0.12	35.7
9. Ukomurronsuo	200—210	53.5	1.72	0.79	0.13	0.25	0.18	0.18	41.8
10. Housujärvensuo	220—225	62.2	1.86	1.09	0.41	0.13	0.17	0.17	34.1
11. Kuljunsuo	250—255	57.5	2.92	2.68	0.54	0.13	0.10	0.10	32.5
12. Kelaojansuo	220—240	75.7	3.77	1.71	0.80	0.42	0.76	0.69	14.3

### DIATOM STRATIGRAPHY

A large number of freshwater species previously classified as *Melosira* are now referred to the genus *Aulacoseira*. The abundance of *Aulacoseira* species is a feature that characterizes all the above diatomite or diatom gyttja sites some *Aulacoseira* species being dominant at every depositional stage. Despite many useful recent studies (Florin 1982, Camburn & Kingston 1986, Haworth 1988) the genus *Melosira/Aulacoseira* is very difficult to identify.

fy. In this work the main diatom identification was made under a light microscope. The species of the genus *Aulacoseira* were identified according to Hustedt (1930), Crawford (1975), Renberg (1976), Florin (1980), Camburn and Kingston (1986) and Haworth (1988). These species were named according to Simonsen (1979) and Hartley (1986).

### **1) Ihakkilammensuo mire**

The diatom stratigraphy of Ihakkilammensuo is shown in Fig. 3. The profile of this mire is dominated by species of the genus *Aulacoseira*. The basal part of the diatomite layer is characterized by a decline in *Aulacoseira granulata* and a simultaneous increase in *A. ambigua*. Both species are alkaliphilous in pH ecology and are typical of the plankton of eutrophic lakes. Halfway up the sequence *A. granulata* disappears from the assemblage, and *A. ambigua* does the same a little later at a depth of about 80 cm. At a depth of 200 cm in addition to these species acidophilous species of the genus *Aulacoseira*, are also present, including such as *A. distans*, var. *alpigena*, *A. lirata* and *A. lirata* var. *perglabra*. Of these, the abundance of *A. lirata* exceeds 80% in the upper part of the deposit. Other *Aulacoseira* species are *A. italicica*, *A. italicica* var. *subarctica* and *A. italicica* var. *valida*. The deposit also contains littoral species, of which the most significant are the genus *Pinnularia*, *Cymbella hauckii*, *Diploneis finnica* and *Tabellaria fenestrata*, which is common throughout virtually the whole deposit.

A total of 147 taxa and 109 species of 29 genera were encountered in the deposit. The diatomite contained 133 taxa, 98 species and 28 genera. Calculated from the formula of Renberg and Hellberg (1982), the pH that prevailed during deposition was 5.8 at a depth of 160 cm and 6.8 at a depth of 280 cm.

The  $^{14}\text{C}$  age of the bottom part of the diatom deposit is  $7760 \pm 90$  years BP (Su-1794) at a depth of 270 to 280 cm and  $2760 \pm 70$  years BP (Su-1743) at a depth of 50 to 60 cm. The sediment thickness between the dated layers is 230 cm, indicating a sedimentation rate of 0.5 mm per year.

### **2) Iso Rautasuo mire**

The diatom stratigraphy of Iso Rautasuo is shown in Fig. 4. At this mire, diatomite deposited with acidophilous diatoms as the prevailing species. The diatomite deposit is characterized by an abundance of species of the genus *Aulacoseira*. *Aulacoseira lirata* dominates in the lower and middle parts of the deposit. In the upper part it is joined by *A. lirata* var. *lacustris*. Other *Aulacoseira* species are *A. lirata* var. *perglabra*, *A. italicica* and *A. ambigua*. The two last mentioned are alkaliphilous. Diatoms of the genus *Achnanthes* are also common in the deposit, e.g. the indifferent species *A. conspicua*, *A. levanderi* and *A. recurvata*.

A total of 141 taxa and 110 species of 30 genera were found in the Iso Rautasuo deposit. The diatomite contained 106 taxa, 75 species and 24 genera. Calculated from the formula of Renberg and Hellberg (1982), the pH that prevailed during deposition was 5.7 at a depth of 150 cm.

### **3) Joutavanmäensuo mire**

The diatom succession at Joutavanmäensuo is shown in Fig. 5. The diatomite deposit at this mire, too, is dominated by acidophilous diatoms of the genus *Aulacoseira*, with *A. distans* var. *alpigena* and *A. lirata* as the prevailing species. Other species of the genus *Aulacoseira* found in this deposit are *A. lirata* var. *lacustris*, *A. lirata* var. *perglabra*, *A. italicica* and *A. italicica* var. *valida*. Littoral species, such as *Frustulia rhombooides*, *Cymbella gracilis* and *Anomoeoneis serians* var. *brachysira* are also encountered. The Joutavanmäensuo deposit contained 128 taxa and 99 species from 25 genera. The diatomite had 116 taxa, 87 species and 24 genera. Calculated from the formula of Renberg and Hellberg (1982), the pH during deposition was 6.5 at a depth of 210 cm.

## IHAKKILAMMENSUO, Petäjävesi

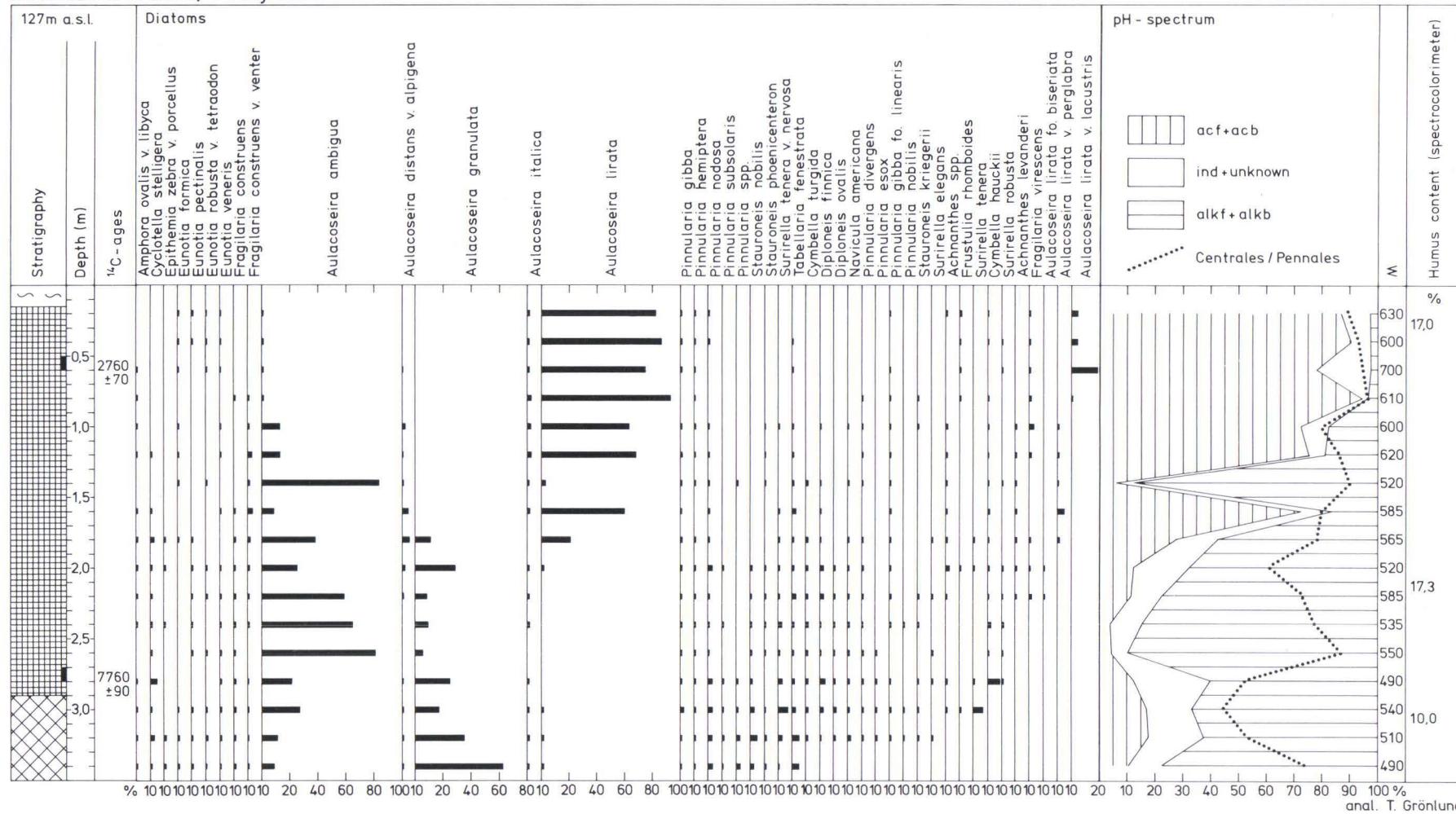


Fig. 3. Diatom diagram of Ihakkilammensuo mire. Selected species, pH spectrum and humus concentration. Radiocarbon ages are 7760 ± 90 yr BP (Su-1794) and 2760 ± 90 yr BP (Su-1743). Symbols as in Fig. 14.

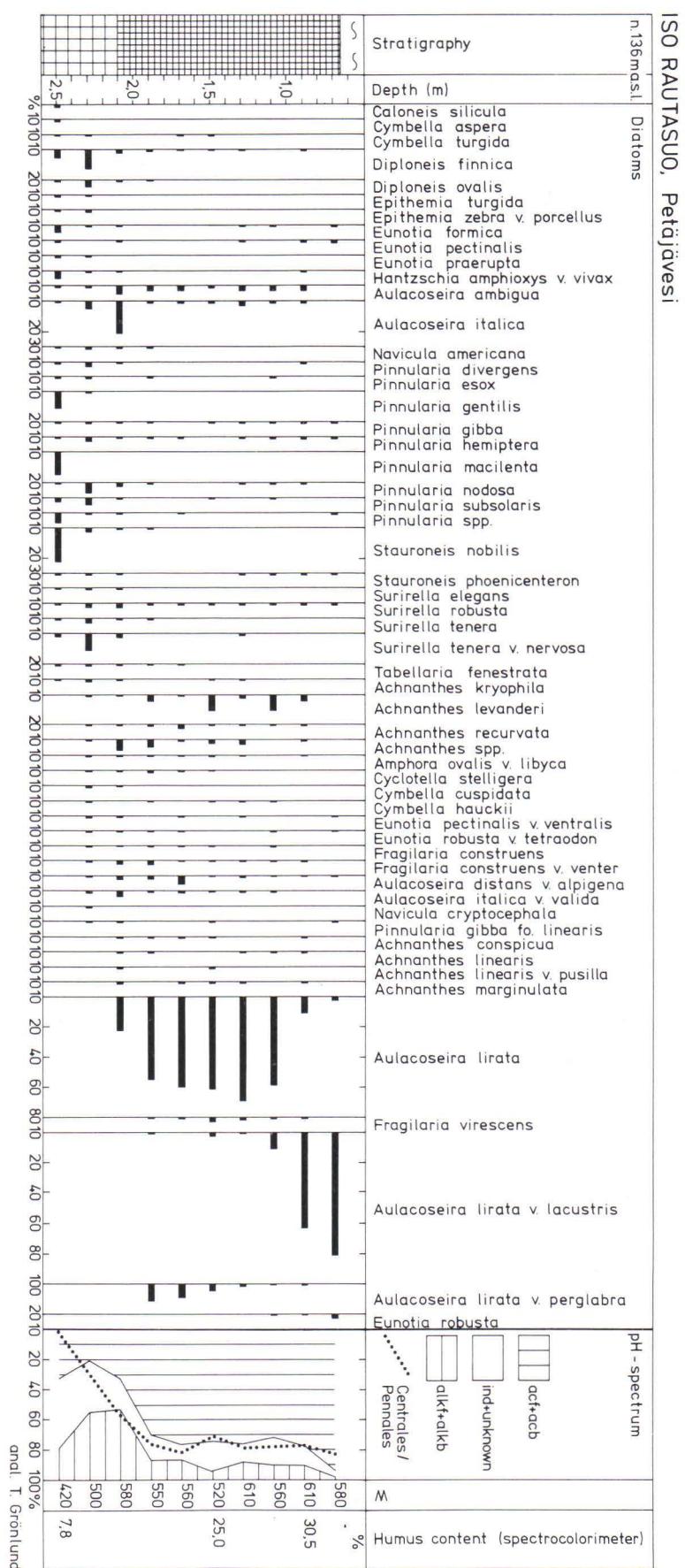


Fig. 4. Diatom diagram of Iso Rautasuo mire. Selected species, pH spectrum and humus concentration. Symbols as in Fig. 14.

## JOUTAVANMÄENSUO, Petäjävesi

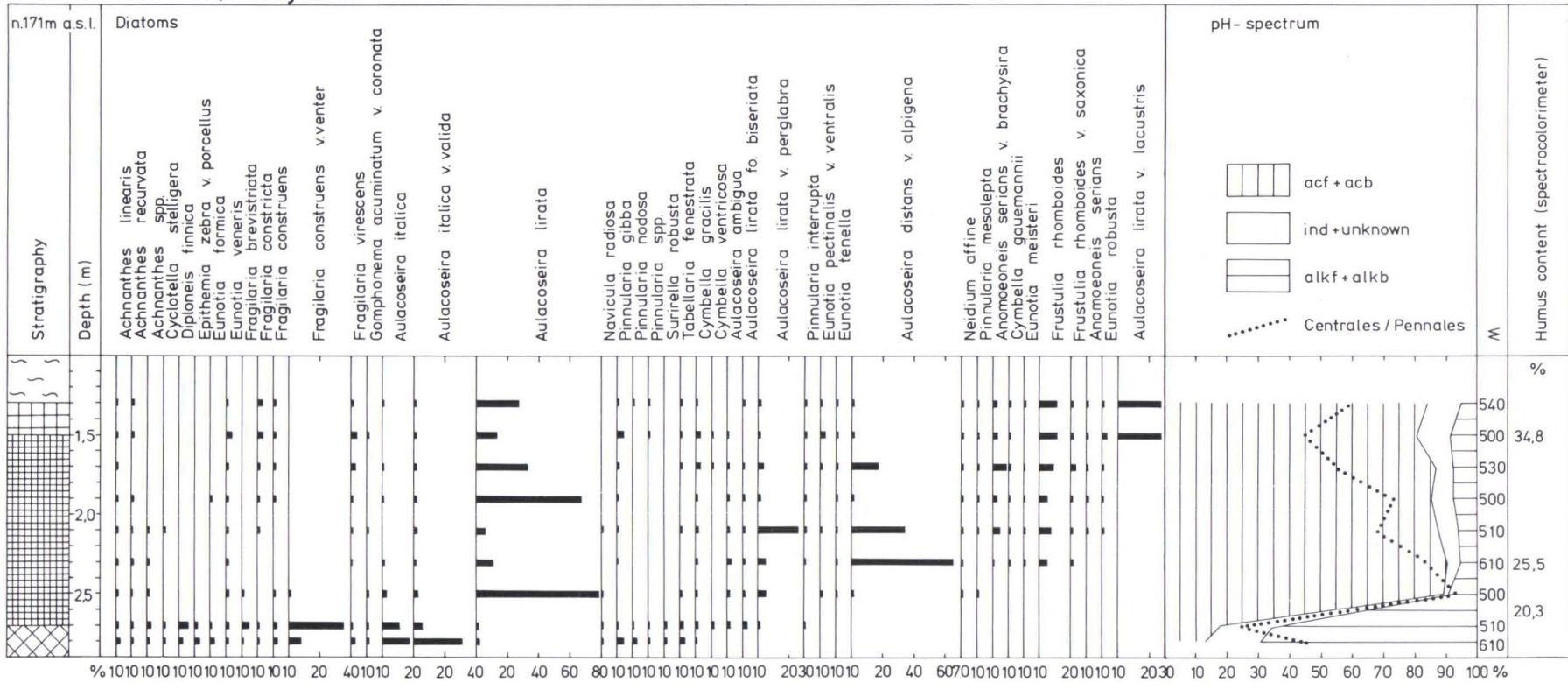


Fig. 5. Diatom diagram of Joutavanmäensuo mire. Selected species, pH spectrum and humus concentration. Symbols as in Fig. 14.

Anal. T. Grönlund

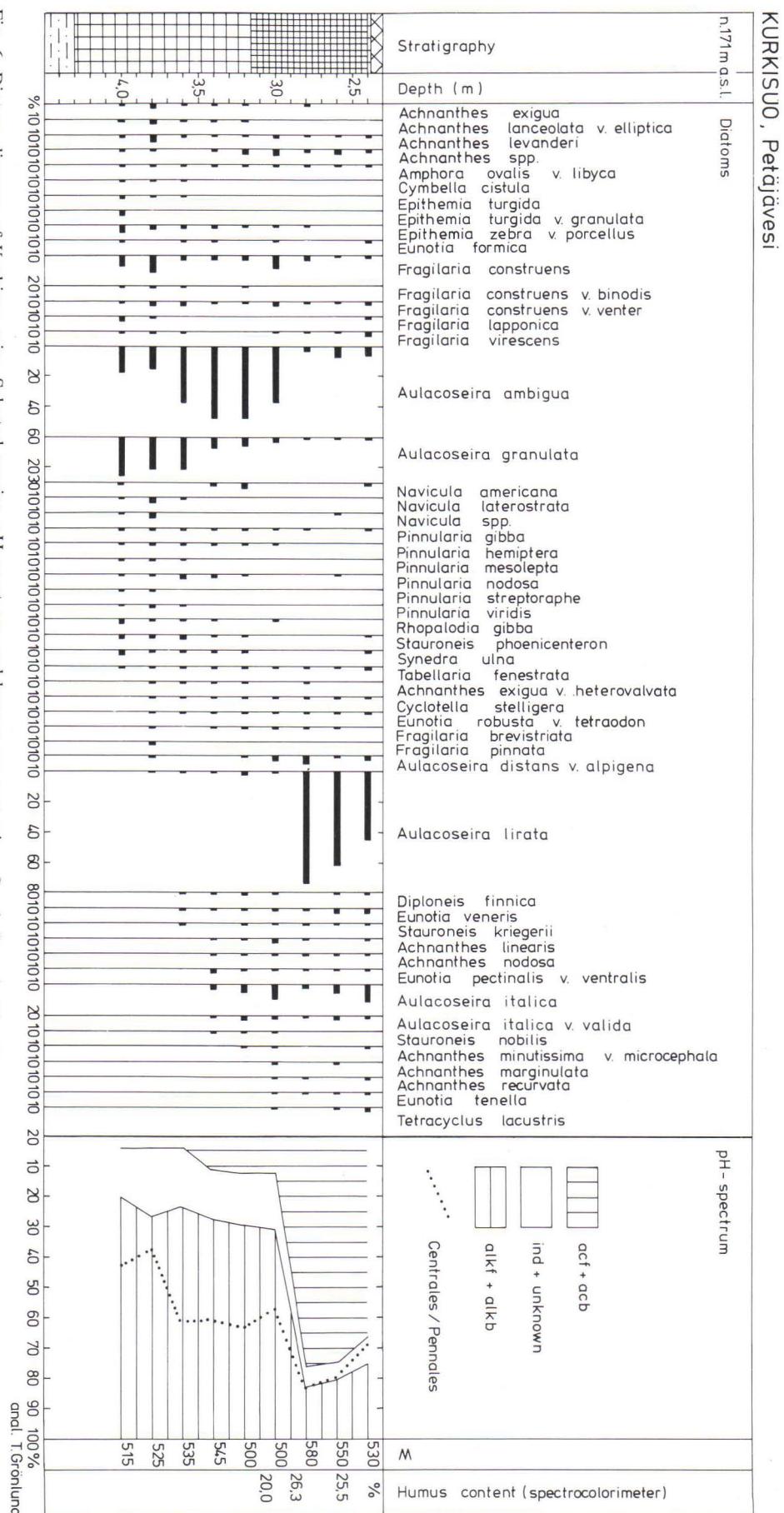


Fig. 6. Diatom diagram of Kurkisuo mire. Selected species, pH spectrum and humus concentration. Symbols as in Fig. 14.

#### 4) Kurkisuo mire

The diatom succession at Kurkisuo is shown in Fig. 6. The basal part of the diatomite deposit is dominated by alkaliphilous *Aulacoseira ambigua*, *A. granulata*, *Amphora ovalis* var. *libyca* and *Fragilaria construens*, which also predominate in the diatom gyttja at the bottom of the mire. At a depth of about 290 cm the situation changes, and the upper part of the diatomite deposited with acidophilous diatoms as the prevailing species. *Aulacoseira lirata* is dominant. Other species encountered in the upper part of the deposit are *Tabellaria fenestrata*, *Eunotia veneris* and the alkaliphilous *A. italicica*. The Kurkisuo deposit contained 169 taxa and 136 species from 30 genera. The formula of Renberg and Hellberg (1982) gives pH 5.7 for the diatomite (depth 280 cm) and pH 7.3 for the diatom gyttja (depth 360 cm).

#### 5) Maunusuo mire

The diatom stratigraphy at Maunusuo is shown in Fig. 7. The deposition of diatomite at this mire started with alkaliphilous diatoms as the prevailing species. *Aulacoseira ambigua* predominated along with *A. italicica*, *A. italicica* var. *valida*, *Fragilaria construens* and *F. construens* var. *venter*. In the surficial part of the diatomite there is a shift in species as *A. ambigua* declines rapidly and the acidophilous diatoms gain ground. *A. lirata* dominates in the surficial part of the deposit with an abundance exceeding 60%. It is accompanied by *A. lirata* var. *lacustris*, *A. distans* var. *alpigena* and the alkaliphilous *A. italicica*, which is a persistent member of the assemblage.

A total of 147 taxa and 117 species from 24 genera were found in the Maunusuo deposit. The diatomite contained 135 taxa, 109 species and 24 genera. Calculated from the formula of Renberg and Hellberg (1982), the pH that prevailed during deposition was 5.7 at a depth of 170 cm and 7.0 at a depth of 310 cm.

#### 6) Pengerjoensuo mire

The diatom stratigraphy of the diatom gyttja at Pengerjoensuo is shown in Fig. 8. Only minor changes took place during deposition of the diatom gyttja in this mire. Virtually the whole deposit is dominated by the alkaliphilous *Aulacoseira ambigua* with an abundance of 90%. It is accompanied by two alkaliphilous species: *Fragilaria construens* and *F. construens* var. *venter*.

The diatom gyttja at Pengerjoensuo contained 105 taxa and 83 species from 23 genera. Calculated from the formula of Renberg and Hellberg (1982), the pH prevailing during deposition was 6.8 at a depth of 420 cm and 7.8 at a depth of 320 cm.

#### 7) Hetonsuo mire

The diatom succession in the diatomite/diatom gyttja at Hetonsuo is shown in Fig. 9. The lower part of the diatomite/diatom gyttja layer in this mire is characterized by an alkaliphilous diatom flora. *Aulacoseira ambigua*, *A. italicica*, *A. italicica* var. *subarctica* and *Fragilaria construens* are the dominant species. *A. ambigua* remains fairly abundant in the assemblage throughout deposition. Similarly, *A. lirata* is a common species in virtually the whole deposit. At a depth of about 4 m the acidophilous diatoms start to increase in abundance. Up to a depth of about 2 m they account for 30—40% of the assemblage. From this depth upwards they continue to increase in abundance, until right at the surface of the diatomite deposit they account for 80% of the diatom population. *Centrales* diatoms, which prevailed throughout deposition, decline in the very uppermost part of the deposit. *Eunotia pectinalis*, *E. pectinalis* var. *ventralis*, *E. robusta* and *E. veneris* are the species of the order *Pennales*, and, at the same time, littoral species in the surficial part of the deposit.

A total of 199 taxa and 155 species from 31 genera were encountered in the deposit studied at Hetonsuo. Calculated from the formula of Renberg and Hellberg (1982), the pH that prevailed during deposition was 5.9 at a depth of 140 cm (diatomite) and 6.4 at a depth of 220 cm (diatom gyttja).

## MAUNUSUO, Pettäjävesi

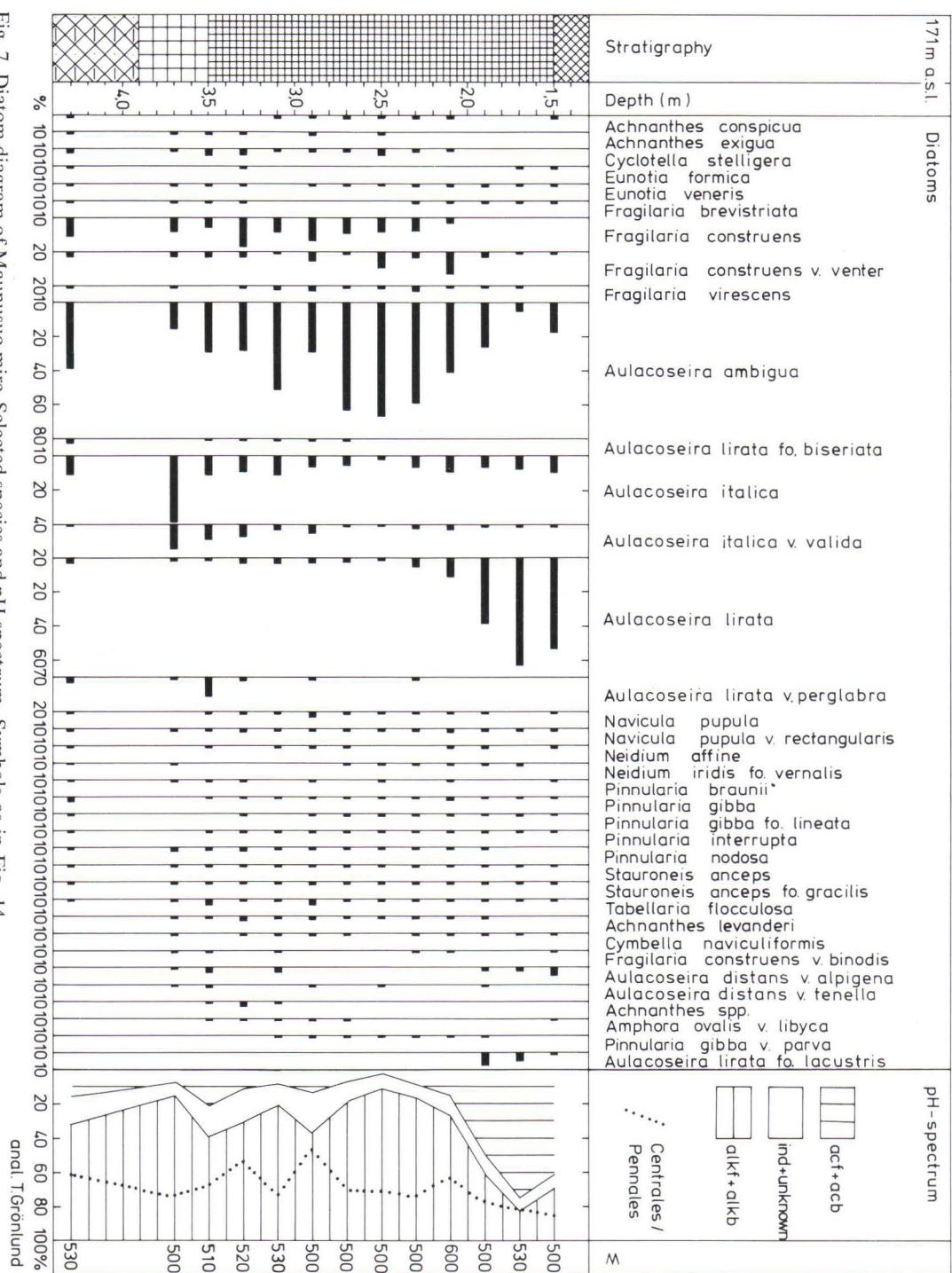


Fig. 7. Diatom diagram of Maunusuo mire. Selected species and pH spectrum. Symbols as in Fig. 14.

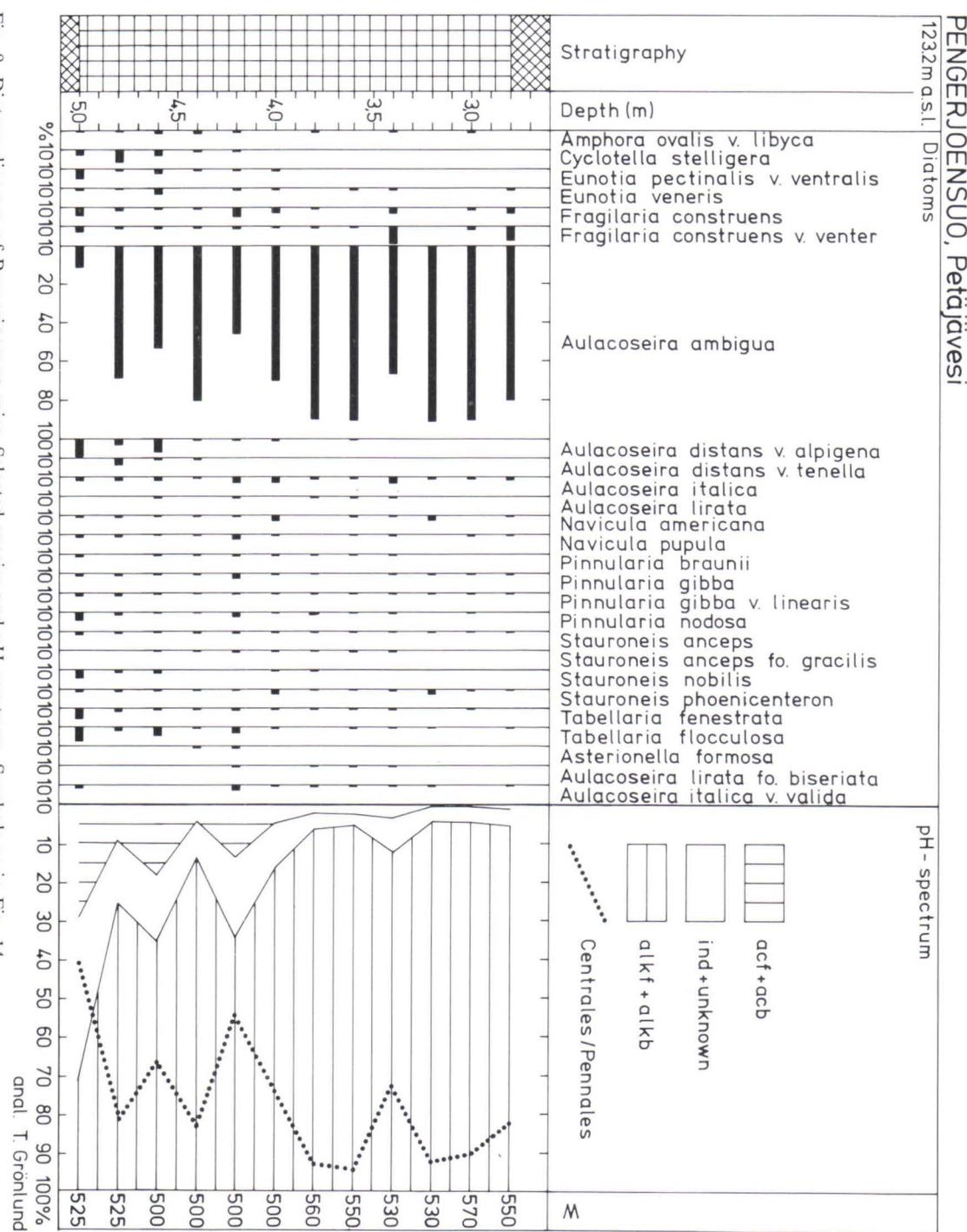


Fig. 8. Diatom diagram of Pengerjoensuo mire. Selected species and pH spectrum. Symbols as in Fig. 14.

## HETONSUO, Keuruu

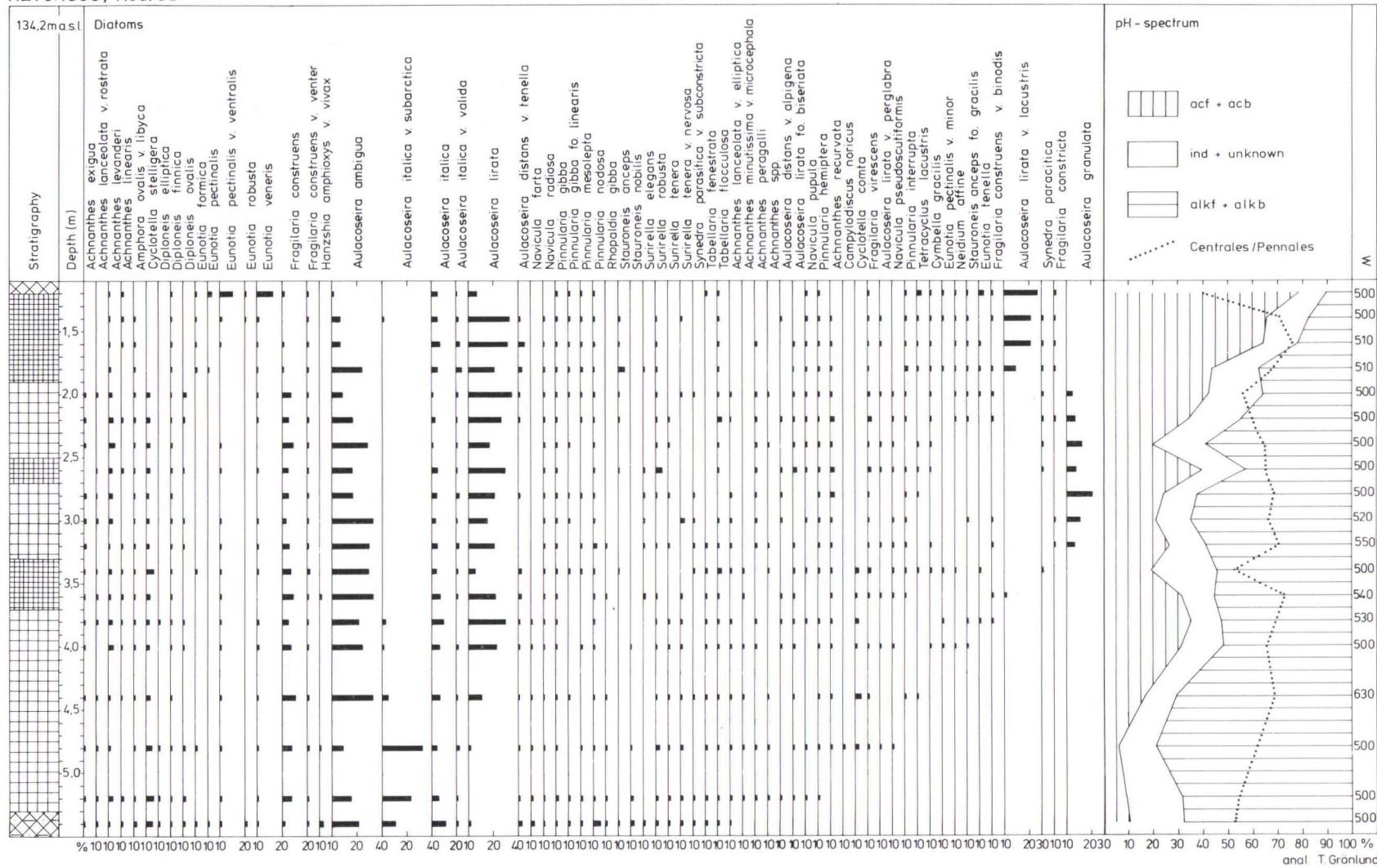


Fig. 9. Diatom diagram of Hetonsuo mire. Selected species and pH spectrum. Symbols as in Fig. 14.

## HINKKASUO, Keuruu

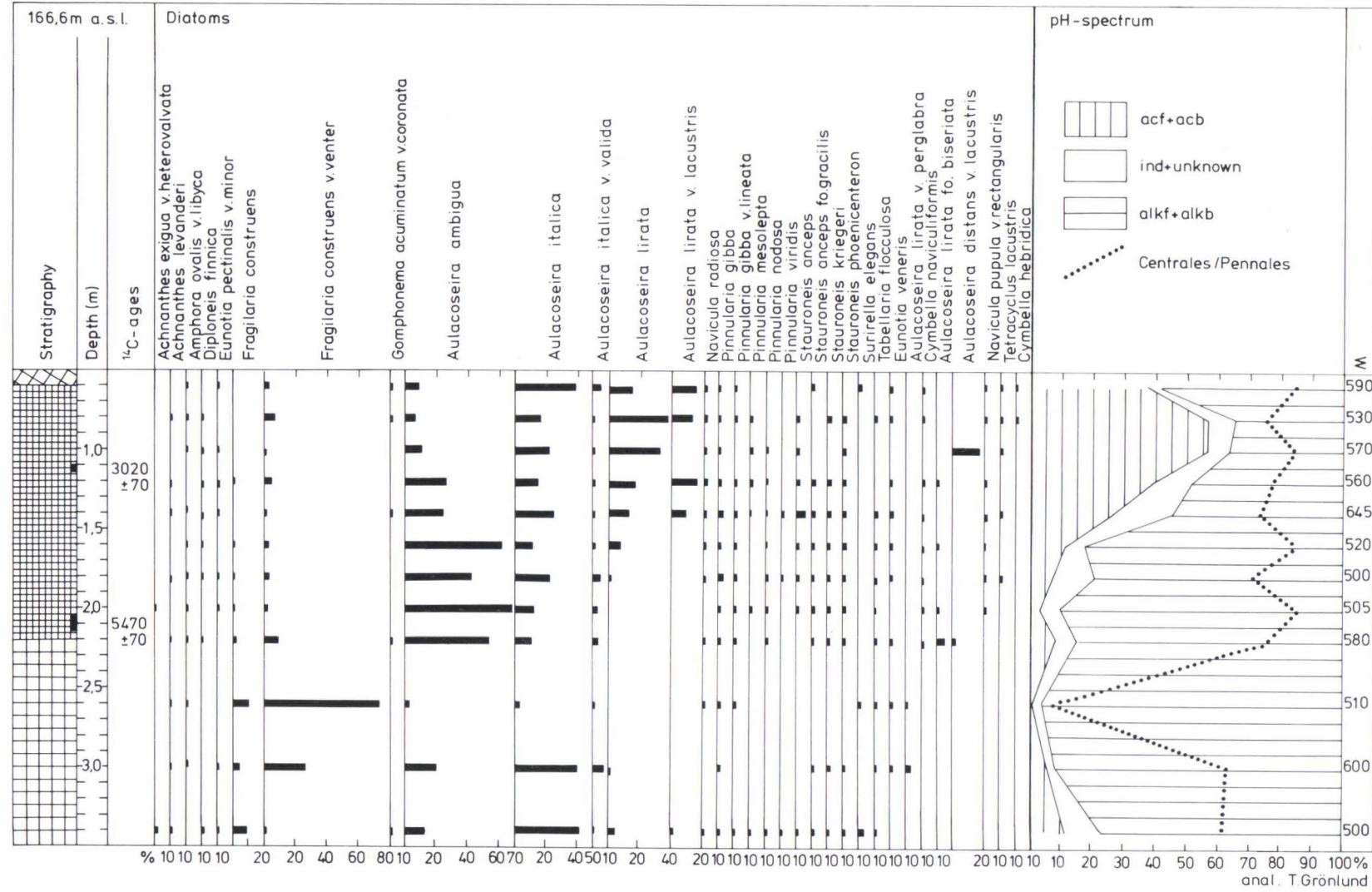


Fig. 10. Diatom diagram of Hinkkasuo mire. Selected species and pH spectrum. Radiocarbon ages are  $5470 \pm 70$  yr BP (Su-1740) and  $3020 \pm 70$  yr BP (1739). Symbols as in Fig. 14.

## 8) Hinkkasuo mire

The diatom succession of diatom gyttja/diatomite at Hinkkasuo is shown in Fig. 10. The diatom gyttja and the lower part of the diatomite in this mire deposited during the dominance of alkaliphilous diatoms. The main species are thus *Fragilaria construens*, *F. construens* var. *venter*, *Aulacoseira ambigua* and *A. italica*. The abundance of *A. ambigua* is highest in the basal part of the diatomite deposit, at a depth of about 2 m. The diatomite succession continues with alkaliphilous diatoms as prevailing species until half way up the layer when they start to decline and the acidophilous diatoms, *A. lirata* and *A. lirata* var. *lacustris* in particular, gain ground. In the very uppermost part of the diatomite the abundance of alkaliphilous diatoms increases slightly once more. The whole deposit studied at Hinkkasuo contained 117 taxa and 90 species from 22 diatom genera. The diatomite had 103 taxa, 80 species and 22 genera. Calculated from the formula of Renberg and Hellberg (1982), the pH was 6.1 at a depth of 100 cm, 7.4 at a depth of 200 cm (diatomite) and 7.3 at a depth of 300 cm (diatom gyttja). The  $^{14}\text{C}$  age of bottom part of the diatom deposit at a depth of 205 to 215 cm is  $5470 \pm 70$  years BP (Su-1740). The corresponding age at a depth of 110 to 115 cm is  $3020 \pm 70$  years BP (Su-1739). The sediment thickness between the dated layers is 105 cm, indicating a sedimentation rate of 0.4 mm per year.

## 9) Ukonmurronsuo mire

The diatom succession at Ukonmurronsuo is shown in Fig. 11. Examined under the microscope the material seems to contain abundant diatoms. However, chemical analyses reveal that the  $\text{SiO}_2$  concentration (53.5%) of the deposit overlying silt at Ukonmurronsuo is clearly less than 60% and thus sufficient to warrant the term diatom gyttja for the sediment. The basal part of the deposit is dominated by an alkaliphilous diatom flora, with *Aulacoseira italica* as the dominant species. In the upper portion of the deposit, at a depth of about 2 m, the diatom population changes radically and acidophilous species become dominant. *A. lirata* var. *lacustris*, *A. lirata*, *Eunotia veneris* and *E. robusta* prevail. A total of 108 taxa and 84 species from 22 genera were encountered in the diatom gyttja deposit at Ukonmurronsuo. Calculated from the formula of Renberg and Hellberg (1982), the pH that prevailed during deposition was 5.4 at a depth of 170 cm and 7.3 at a depth of 270 cm.

## 10) Housujärvensuo mire

The diatom succession at Housujärvensuo is shown in Fig. 12. The diatomite exhibits a diatom flora that is trophically almost constant. Acidophilous diatoms prevail throughout the succession, with *Aulacoseira distans* var. *alpigena* and *A. lirata* as dominant species. Other species are *A. lirata* var. *lacustris*, *A. italica*, *A. italica* ssp. *subarctica* and, in the upper part of the deposit, *Tetracyclus lacustris* and *Eunotia bidentula*. The diatomite at Housujärvensuo contained 135 taxa and 101 species from 26 genera. Calculated from the formula of Renberg and Hellberg the pH at deposition was 5.5 at a depth of 240 cm and 5.6 at a depth of 340 cm.

The  $^{14}\text{C}$  age of the diatom deposit is  $7620 \pm 90$  years BP (Su-1793) at a depth of 370 to 380 cm,  $6620 \pm 80$  years BP (Su-1742) at a depth of 320 to 325 cm and  $2910 \pm 70$  years BP (Su-1741) at a depth of 200 to 210 cm. The sediment thickness between the oldest and the youngest dated layers is 180 cm, indicating a sedimentation rate of 0.4 mm per year.

## 11) Kuljunsuo mire

The stratigraphy of the diatomite/diatom gyttja at Kuljunsuo is shown in Fig. 13. The basal and middle parts of the diatom gyttja layer are dominated by alkaliphilous diatoms, with *Aulacoseira ambigua*, whose abundance in places reaches 90%, as the prevailing species. At the very bottom of the layer, *A. granulata* also occurs. In the upper part of the layer, at a depth of about 250 cm where the diatomite begins, the diatom flora changes rapidly, and acidophilous species become dominant. The transition zone is dominated by *Fragilaria construens* var. *venter*, which is still an alkaliphilous species. In the surficial part of the deposit there are diatoms that are already distinctly acidophilous, for example, *Aulacoseira lirata*, *A. distans* var. *alpigena* and *A. lirata* var. *perglabra*. A total of 113 taxa and 89 species from 27 genera were encountered in the diatomite/diatom gyttja deposit at Kuljunsuo. Calculated from the Formula of Renberg and Hellberg (1982), the pH at deposition was 6.2 at a depth of 230 cm (diatomite) and 6.8 at a depth of 310 cm (diatom gyttja).

## UKONMURRONSUO, Keuruu

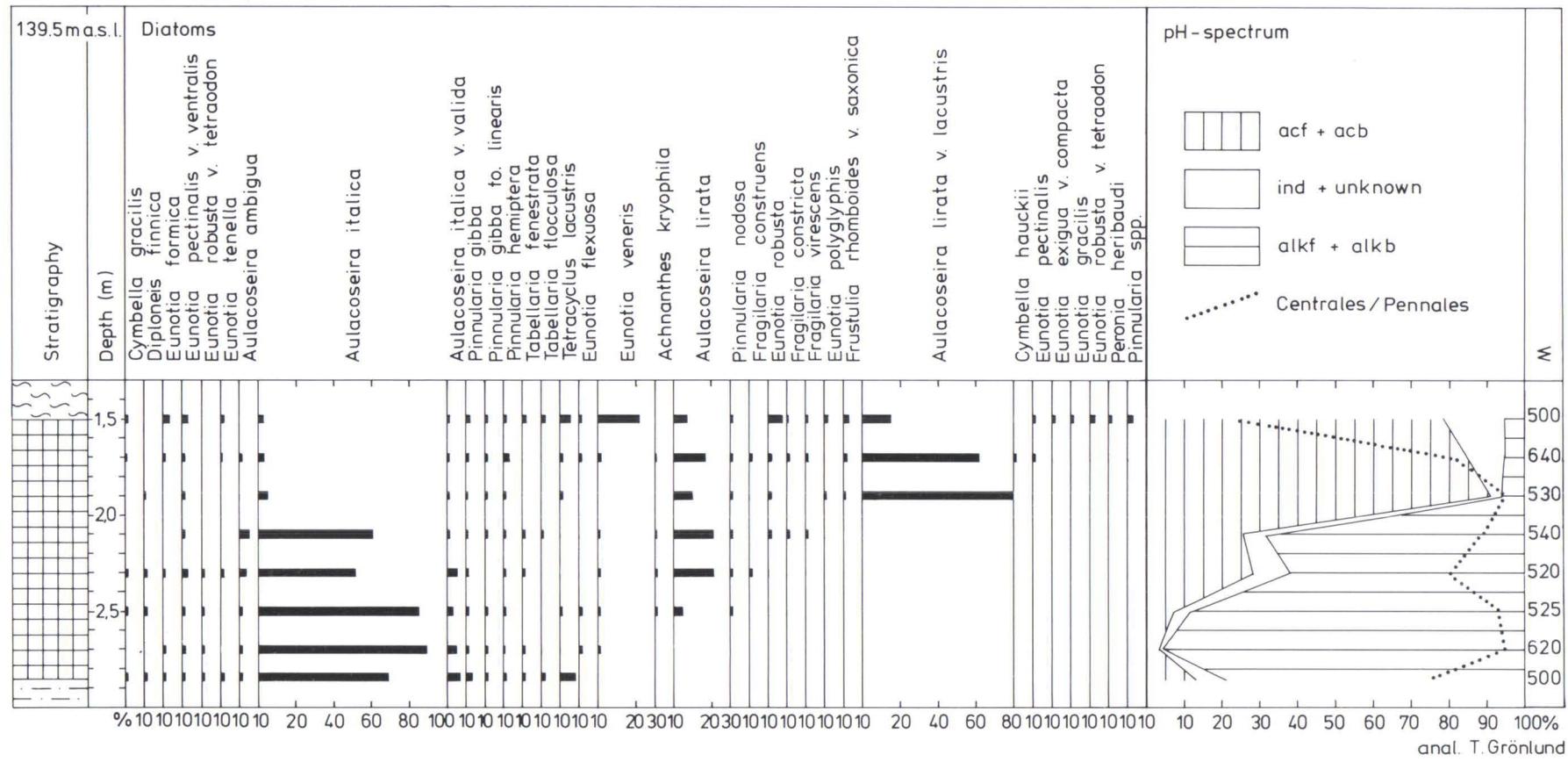


Fig. 11. Diatom diagram of Ukomurronsu mire. Selected species and pH spectrum. Symbols as in Fig. 14.

## HOUSUJÄRVENSUO, Kuorevesi

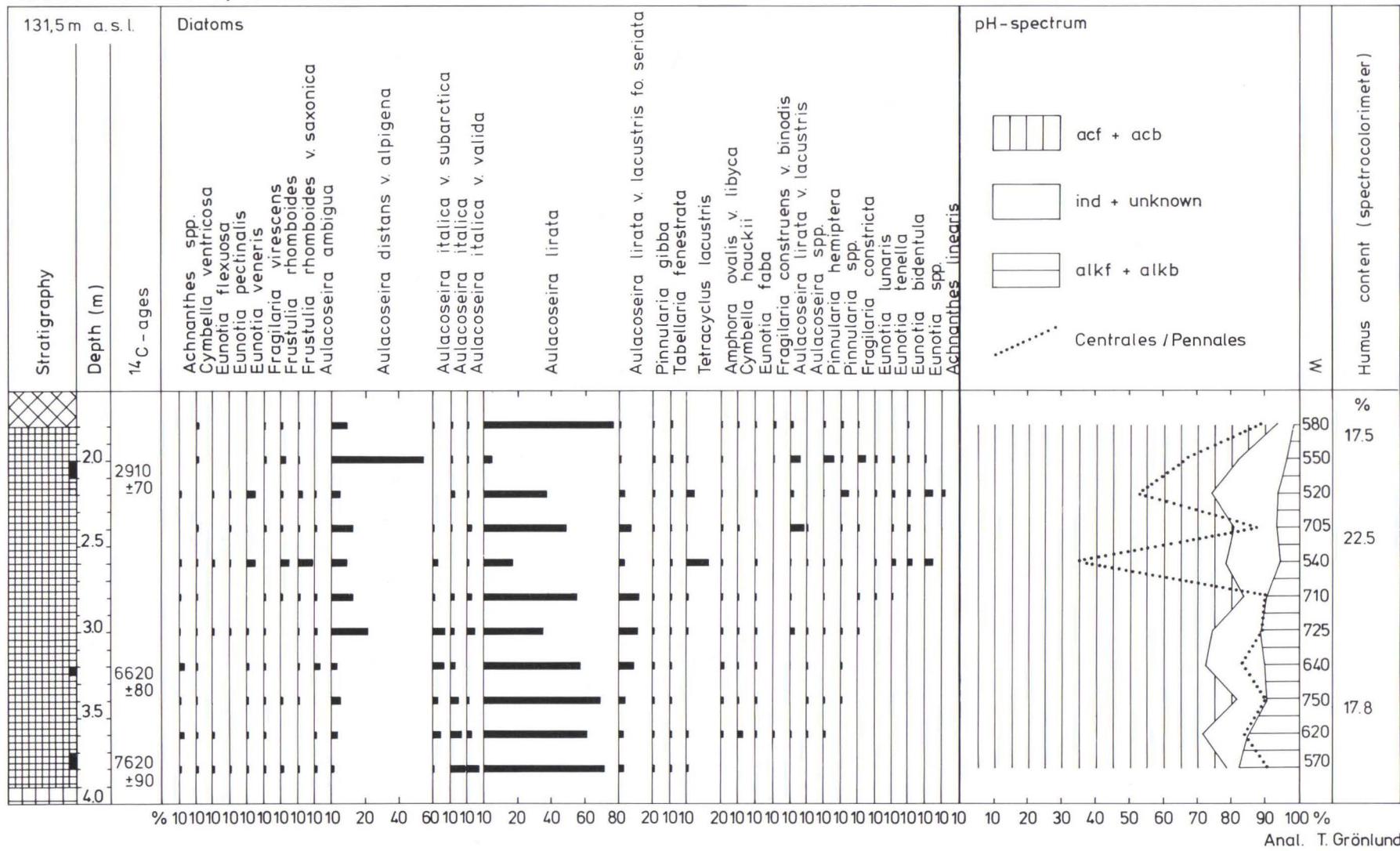


Fig. 12. Diatom diagram of Housujärvensuo mire. Selected species, pH spectrum and humus concentration. Symbols as in Fig. 14. Radiocarbon ages are  $7620 \pm 90$  yr BP (Su-1793),  $6620 \pm 80$  yr BP (Su-1742) and  $2910 \pm 70$  yr BP (Su-1741).

## KULJUNSUO, Kuorevesi

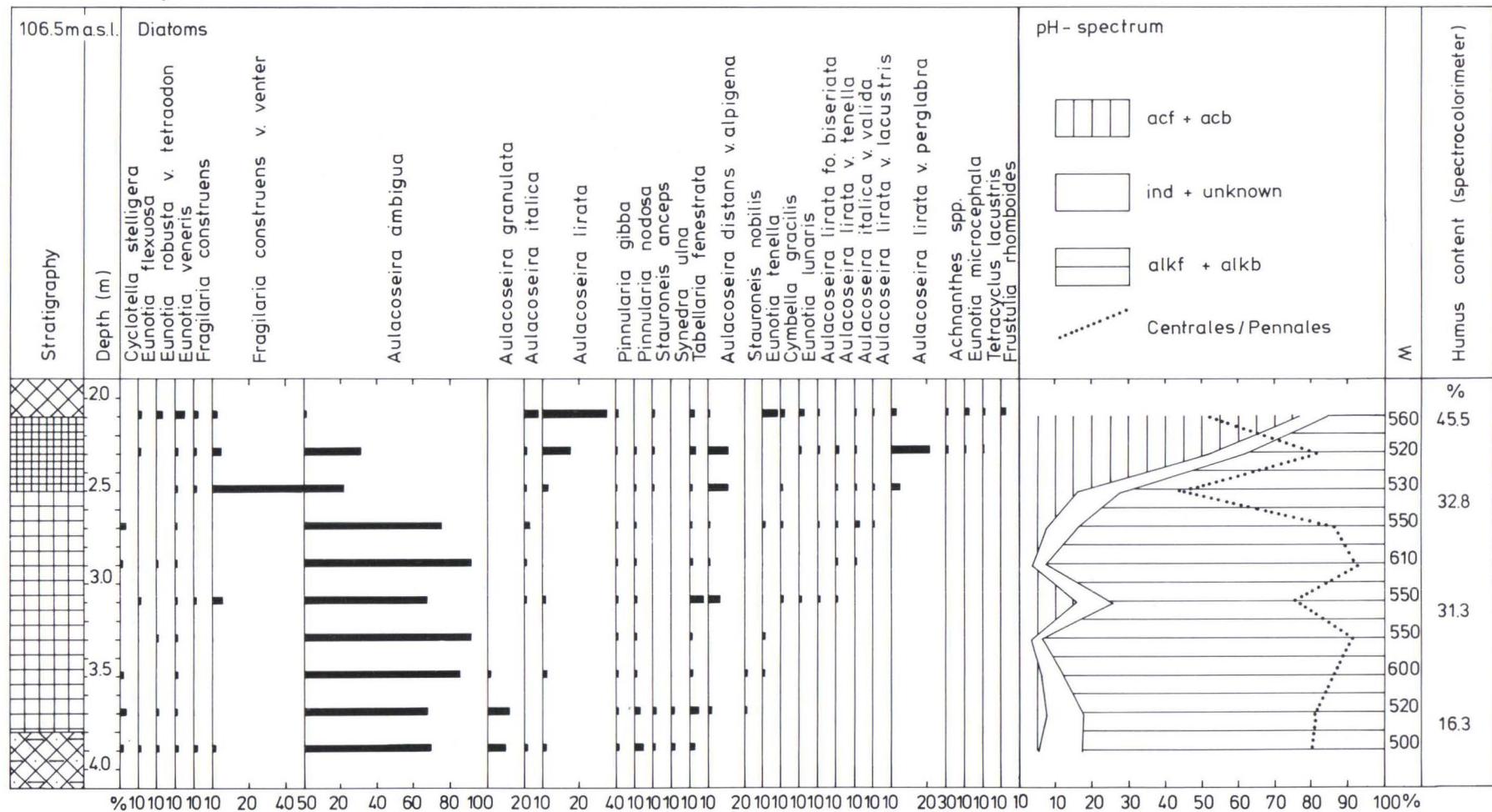


Fig. 13. Diatom diagram of Kuljunsuo mire. Selected species, pH spectrum and humus concentration. Symbols as in Fig. 14.

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## KELAOJANSUO, Jämsä

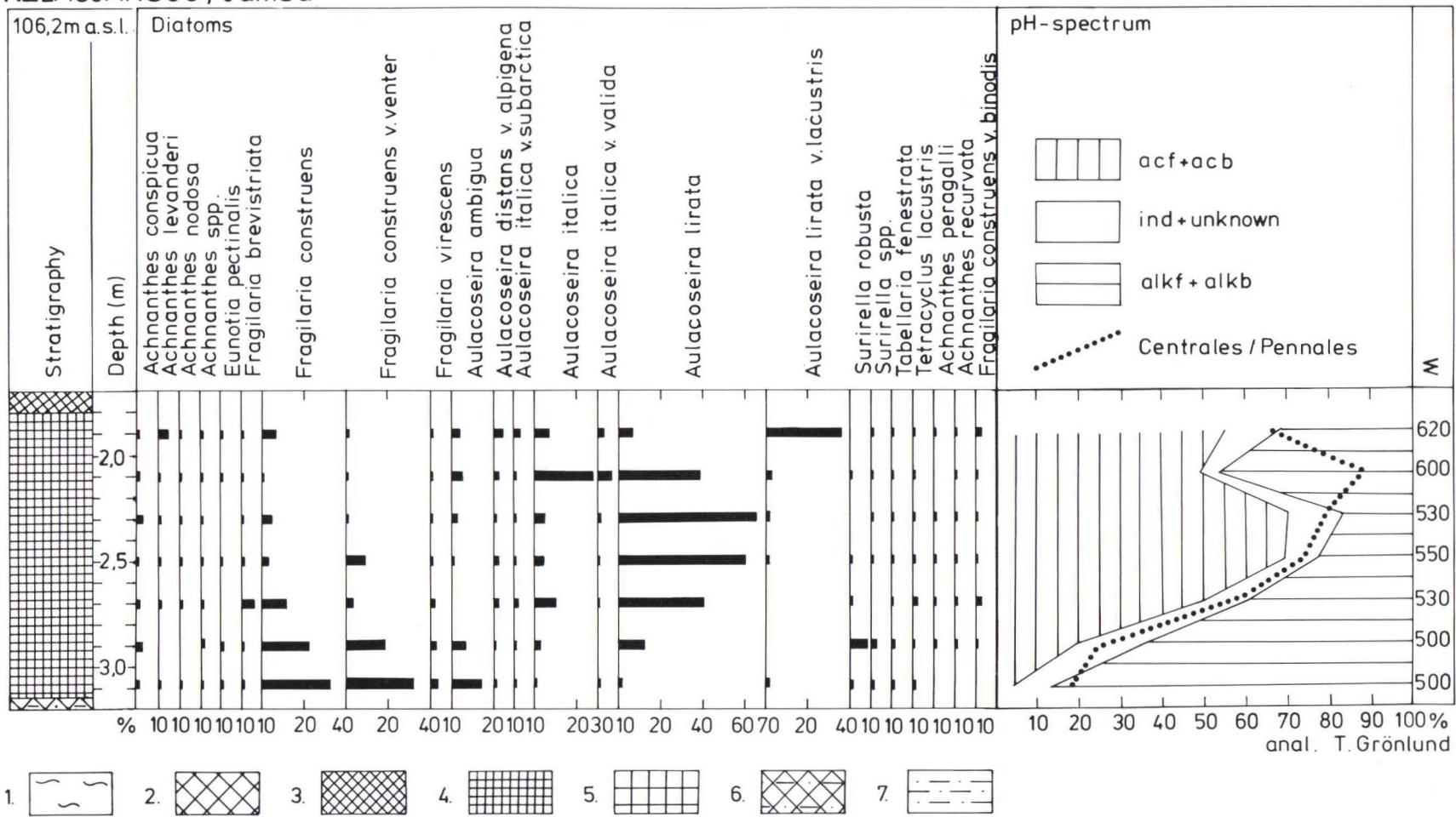


Fig. 14. Diatom diagram of Kelaojansuo mire. Selected species and pH spectrum. Symbols: 1 = peat, 2 = coarse detritus gyttja, 3 = fine detritus gyttja, 4 = diatomite, 5 = diatom gyttja, 6 = silty gyttja, 7 = silt.

## 12) Kelaojansuo mire

The diatom succession at Kelaojansuo is shown in Fig. 14. The succession begins with alkaliphilous diatoms as dominant species. These include *Fragilaria construens*, *F. construens* var. *venter* and *Aulacoseira ambigua*. Alkaliphilous diatoms prevail only for a short distance, as at a depth of 300 cm the proportion of acidophilous diatoms already begins to increase. The middle part of the deposit is dominated by *Aulacoseira lirata*, with an abundance of nearly 70%. It is accompanied by *A. italica*, *A. italica* var. *subarctica* and *A. italica* var. *valida*, of which the latter two are alkaliphilous. The very uppermost part of the diatomite layer is dominated by the acidophilous *A. lirata* var. *lacustris*. A total of 102 taxa and 84 species from 23 genera were encountered in the diatomite. Calculated from the formula of Renberg and Hellberg (1982), the pH that prevailed during deposition was 6.3 at a depth of 200—220 cm and 6.4 at a depth of 280—300 cm.

### SUMMARY OF DIATOM STRATIGRAPHY WITH SPECIAL REFERENCE TO *AULACOSEIRA (MELOSIRA)* ASSEMBLAGES

The following diatoms of the genus *Aulacoseira* were named from the diatomite or diatom gyttja occurrences described:

*Aulacoseira* Thwaites 1848

(*Melosira* Agardh 1824)

*Aulacoseira ambigua* (Grun. in Van Heurck) Simonsen 1979

Syn.: *Melosira ambigua* (Grun.) O. Müller, Hustedt 1930, p. 256, Fig. 108

- a common plankton species in eutrophic lakes
- alkaliphilous (Foged 1980)
- occurs as dominant species in diatomite or diatom gyttja deposit at sites 1, 5, 6, 7, 8, 11
- encountered in the assemblages at sites 2, 3, 4, 9, 10, 12
- Pl. IX, Figs. 1 and 2
- Pl. XII, Figs. 7, 8 and 9.

*Aulacoseira distans* var. *alpigena* (Grun. in Van Heurck) Simonsen

Syn.: *Melosira distans* var. *alpigena* Grun., Hustedt 1930, p. 263, Fig. 110

- acidophilous
- dominant species in a diatomite or diatom gyttja deposit at sites 3, 11
- in the assemblages at sites 1, 2, 3, 4, 5, 6, 7, 8, 11
- Pl. X, Fig. 3

*Aulacoseira distans* var. *tenella* (Nygaard) R. Ross

Syn.: *Melosira distans* var. *tenella* (Nygaard) Florin

Florin 1981, Pl. 2, Figs. 8—18

- acidophilous
- encountered in the assemblages at sites 2, 3, 5, 7, 8, 11
- Pl. XII, Figs. 12 and 13

*Aulacoseira granulata* (Ehrenb.) Simonsen

Syn.: *Melosira granulata* (Ehrenb.) Ralfs., Hustedt 1930, p. 248, Fig. 104

- occurs in Finland in plankton of the bigger lakes (Mölder & Tynni 1967)
- thrives in eutrophic to oligotrophic waters (Mölder & Tynni 1967)
- alkaliphilous (Foged 1980)
- occurs in the assemblages at sites 1, 4, 11
- Pl. XII, Figs. 1, 2 and 4

*Aulacoseira italica* (Ehrenb.) Simonsen

Syn.: *Melosira italica* (Ehrenb.) Kütz., Hustedt 1930, p. 259, Fig. 109

- alkaliphilous (indifferent) (Foged 1958, 1964)
- dominant species in diatomite or diatom gyttja deposit at sites 8, 9
- found in the assemblages at sites 1, 2, 3, 4, 5, 6, 7, 10, 11, 12
- Pl. XIII, Figs. 1 and 2

*Aulacoseira italica* ssp. *subarctica* (O. Müll.) Simonsen

- Syn.: *Melosira italica* ssp. *subarctica* O. Müller, Hustedt 1930, p. 259, Fig. 109  
 — encountered in the assemblages at sites 4, 6, 7, 10, 12  
 — Pl. XI, Figs. 3, 4 and 5

*Aulacoseira italica* var. *valida* (Grun. in Van Heurck) Simonsen

- Syn.: *Melosira italica* var. *valida* Grun., Hustedt 1930, p. 259, Fig. 109  
 — alkaliphilous (Lowe 1974)  
 — occurs in the assemblages at sites 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12  
 — Pl. X, Figs. 2  
 — Pl. XIII, Figs. 3 and 7

*Aulacoseira lirata* Ehrenb.) R. Ross.

- Syn.: *Melosira lirata* (Ehrenb.) Kütz., Florin 1981, Pl. 3, Fig. 19

- A. distans* var. *lirata* (Ehrenb.) Bethge  
 — acidophilous (Foged 1972)  
 — a dominant species in diatomite deposits at sites 1, 2, 3, 4, 5, 7, 8, 10, 12  
 — found in the assemblages at sites 6, 9, 11  
 — Pl. X, Fig. 1  
 — Pl. XI, Figs. 1 and 2

*Aulacoseira lirata* fo. *biseriata* (Grun.) Haworth

- Syn.: *Melosira lirata* fo. *biseriata* (Grun.) Camburn, Camburn & Kingston 1986 p. 25. PL. 3, Figs. 45 and 46  
 — acidophilous?, indifferent?  
 — occurs in the assemblages at sites 1, 2, 3, 4, 5, 6, 7, 8, 11  
 — Pl. XII, Figs. 6, 11, 14 and 15

*Aulacoseira lirata* var. *lacustris* (Grun. in Van Heurck) R. Ross.

- Syn.: *Melosira lirata* var. *lacustris* Grun.  
 Florin 1981, Pl. 3, Figs. 20—25, Pl. 4, Figs. 26—32  
*A. distans* var. *lirata* fo. *lacustris* (Grun.) Hustedt 1930  
*M. mikkelsenii* Nygaard 1956  
 — acidophilous (Nygaard 1956)  
 — occurs as dominant species in diatomites and diatom gyttja deposits at sites 2, 9, 12  
 — found in the assemblages at sites 1, 3, 5, 7, 8, 10, 11  
 — Pl. IX, Figs. 3 and 4  
 — Pl. XI, Fig. 3

*Aulacoseira lirata* var. *perglabra* (Östrup.) R. Ross

- Syn.: *Melosira lirata* var. *perglabra* (Östrup.), Florin Florin 1981, Pl. 5, Figs. 32—45  
 — acidophilous  
 — dominant in diatom gyttja at site 11  
 — occurs in the assemblages at sites 1, 2, 3, 4, 5, 6, 7, 8  
 — Pl. XIII, Figs. 3 and 5

The diatomites studied on the basis of diatom assemblages can be divided into three groups. In the first group, deposition started with the alkaliphilous diatoms as the prevailing species. In the course of deposition the diatom assemblage changed entirely, and the upper portion of the deposit is dominated by the acidophilous diatoms. *Aulacoseira granulata* and *A. ambigua* are clearly dominant among the alkaliphilous diatoms. *A. italica*, *A. italica* ssp. *subarctica* and *Fragilaria construens* are also common in the basal parts of the deposits. The pH values of this part calculated from the formula of Renberg and Hellberg (1982) vary between 6.4 and 7.4. *A. lirata* var. *lacustris* and *A. distans* var. *alpigena* prevail in the upper portion, where the pH values fluctuate between 5.4 and 6.3. This group includes the majority of the diatomite sites studied: Ihakkilammensuo, Kurkisuo, Maunusuo, Hinkkasuo and Kelaojansuo. In evolution the diatom gyttja deposit at Ukonmurronsuo also belongs to this group. If the whole deposit studied is considered, this group also includes the diatomite/diatom mire deposits at Hetonsuo and Kuljunsuo.

The second group consists of diatomites in which the acidophilous diatoms prevailed throughout the deposition period. *Aulacoseira lirata*, *A. lirata* var. *lacustris* and *A. distans* var. *alpigena* are the dominant species. Deposition took place at pH 5.5—5.7. This group includes the diatomites at Iso Rautasuo, Joutavanmäensuo and Housujärvensuo.

The third group comprises only one site, i.e. the diatom gyttja deposit at Pengerjoensuo, wholly dominated by the alkaliphilous diatoms. *Aulacoseira ambigua* and *Fragilaria construens* are the prevailing species. pH values of 6.8 and 7.8 have been calculated for the deposit.

Of deposits studied earlier the diatomite at Soijärvi (Grönlund 1986) can be included in the first group. The basal part of the diatomite in that deposit contains alkaliphilous diatoms and the bulk of the deposit is characterized by acidophilous *Melosira* (*Aulacoseira*) *lirata* and *M. (A.) distans*. In contrast, alkaliphilous diatoms prevail in the Rätäksuo diatomite at Hollola (Grönlund 1982), where *Fragilaria construens* and *F. construens* var. *venter* of the order *Pennales* are dominant. Therefore the Rätäksuo diatomite belongs to the same group as that at Pengerjoensuo.

As shown by the radiocarbon ages the deposition of diatomites in the mires of Ihakkilammensuo in Petäjävesi and Housujärvensuo in Kuorevesi started at about 8000 BP. The deposition of diatomite in Hinkkasuo was preceded by that of diatom gyttja. Before the present study, the only sites where the onset of diatomite deposition had been dated with the radiocarbon method in Finland were Vähä-Komujärvi and Rätäksuo (Grönlund 1982). The basal part of the diatomite at Vähä-Komujärvi yielded a  $^{14}\text{C}$  age of  $9440 \pm 100$  years BP (Su-761), and the diatomite at Rätäksuo  $10050 \pm 180$  years BP (Su-912) and  $9830 \pm 160$  years BP (Su-911). These ages are clearly too high, probably owing to the hard water, and thus cannot be compared with the  $^{14}\text{C}$  ages reported here.

## SUMMARY

The areas of Petäjävesi, Keuruu, Kuorevesi and Jämsä favoured the growth of diatoms and the deposition of diatomites. Silica was abundant and the oxygen content was high in the basins. Sediments classified as diatomite or diatom gyttja deposited on the basal parts of the mires in the area. Of the twelve sites studied, nine contain diatomite and three diatom gyttja. At most sites, deposition started with the diatom gyttja, which, as deposition proceeded, passed into diatomite. The greatest resources of diatomite,  $411\,600\,\text{m}^3$ , were assessed at Kurkisuo, Petäjävesi.

The number of taxa identified in the investigated diatomites varied between 102 and 199 and the number of diatom genera between 22 and 31. The richest in species was the deposit at Hetonsuo, Keuruu, 199 taxa being named from its 31 genera. *Centrales* diatoms, mainly species of the genus *Aulacoseira*, prevail at every site, and in terms of species, the deposits can be divided into those dominated by either alkaliphilous or acidophilous *Aulacoseira* species. *Aulacoseira ambigua* and *A. granulata* are the prevailing alkaliphilous species and *A. lirata* var. *lacustris* and *A. distans* var. *alpigena* the dominant acidophilous ones. At most of the sites the deposition of diatomite or diatom gyttja started with predominantly alkaliphilous diatoms. In the course of deposition the diatom assemblage passed into acidophilous. At some sites, for example at Joutavanmäensuo and Kurkisuo, Petäjävesi, the change was abrupt. The evolution from an alkaliphilous to an acidophilous diatom assemblage is characteristic of paludified lakes and ponds surrounded by mires in Finland.

The diatomites encountered are of fairly high quality in terms of chemical composition and physical properties. The  $\text{SiO}_2$  concentration is high (60.2—75.7%) and the abundance of accessories is low, excluding that of organic compounds, which is considerable high. The specific surface area varies between 10 300 and 33 100  $\text{m}^2/\text{kg}$ .

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## REFERENCES

- Aario, L., 1943.** Über die Wald- und Klimaentwicklung an der Lappländischen Eismeerküste in Petsamo mit einem Beitrag zur Nord- und Mitteleuropäische Klimageschichte. Ann. Bot. 'Vanamo' (1) 1—158.
- Aario, R., 1966.** Kieselgur in fluvioglazialen Ablagerungen in Haapajärvi in Ostbottnien. C. R. Soc. géol. Finlande 38, 3—30.
- Behre, K.-E., 1962.** Pollen- und diatomeenanalytische Untersuchungen an letzterglazialen Kieselgurlagern der Luneburger Heide (Schwindebeck und Grevenhof im oberen Luhetal). Flora 152, 325—370.
- Benda, L., 1963.** Die Diatomeen der Kieselgur von Hutzels im Luhetal (Eem-Interglazial). Ber. Nat. hist. Ges. 107, 31—47.
- Benda, L., 1974.** Die Diatomeen der niedersächsischen Kieselgur-Vorkommen palökologische Befunde und Nachweis einer Jahresschichtung. Geol. Jahrb. Reihe A, 21, 171—197.
- Benda, L. & Brandes, H., 1974.** Die Kieselgur-Lagerstätten Niedersachsens. Geol. Jahrb., Reihe A, 21, 3—85.
- Camburn, K.E. & Kingston, J.C., 1986.** The genus *Melosira* from soft-water lakes with special reference to northern Michigan, Wisconsin and Minnesota. In J.P. Smol, R.W. Batterbee, R.B. Davis & J. Meriläinen (eds.) Diatoms and Lake Acidity, 17—34.
- Cleve, P.T., 1891.** The Diatoms of Finland. Acta Soc. Fauna Flora Fennica 8 (2), 70 p.
- Cleve-Euler, A., 1951—1955.** Die Diatomeen von Schweden und Finnland. I—V. Kungliga Svenska Vetensk. Handl. 4. Ser., 2:1 (1951) 163 p. 3:3 (1952) 154 p. 4:1 (1953) 158 p. 4:5 (1953) 255 p. 5:4 (1955) 232 p.
- Grawford, R.M., 1975.** The frustule of the initial cells of some species of the diatom genus *Melosira* C. Agardh. Beih. Nova Hedwigia 53, 37—50.
- Donner, J., 1957.** The Post-Glacial Shore-Line Displacement in the Kuopio District. Ann. Acad. Scient. Fenniae, Ser. A III. Geol.-Geogr. 49, 33 p.
- Durham, D.L., 1973.** Diatomite Ch. in United States Mineral Resources. U.S. Geol. Surv. Prof. Pap. 820, 191—195.
- Ehrenberg, C.G., 1838.** Further notices of fossil infusoria. Ann. Phys. Chem. 38 (6), 455 p.
- Ehrenberg, C.G., 1940.** Characteristik von 274 neuen Arten von Infusorien (the title given by VanLangingham 1975) Bericht über die zur Bekanntmachung geeigneten Verhandlungen der königlichen, preuss. Akademie der Wissenschaften zur Berlin, 197—219.
- Florin, M-B., 1981.** The taxonomy of some *Melosira* species a comparative morphological study, II. Proc. Budapest Symp. Diatoms 1980. Koenigstein, Koeltz. 43—73.
- Foged, N., 1958.** The diatoms in the basalt area and adjoining areas of Archean rock in West Greenland. Medd. Grönland 156 (4), 1—146.
- Foged, N., 1960.** Diatomefloraen i en interglacial kiéselguraflerjring ved Rands fjord i Østjylland, Medd. Dansk. Geol. Fören. 14, 197—205.
- Foged, N., 1964.** Freshwater diatoms from Spitzbergen. Tromsö Mus. Skr. 11. 205 p.
- Foged, N., 1970.** The Diatomaceous Flora in a Postglacial Kieselguhr Deposit in Southwestern Norway. Beih. Nova Hedwigia 31, 169—201.
- Foged, N., 1972.** The Diatoms in four Postglacial Deposits in Greenland. Medd. Grönland 194 (4), 1—66.
- Foged, N., 1980.** Diatoms in Öland, Sweden. Bibl. Phycol. 49, 193 p.
- Forsström, L., 1982.** The Oulainen Interglacial in Ostrobothnia, western Finland. Acta Univ. Ouluensis A 136, Geologica 4, 116 p.
- Forsström, L., 1988.** The northern limit of pine forest in Finland during the Weichselian interstadials. Ann. Acad. Sci. Fenniae A. III. 147, 24 p.
- Grönlund, T., 1982.** On Finnish diatomites. In Håkansson H. (ed.), Rapport från diatomésymposium i Lund, maj 1981. Univ. Lund, Dep. Quat. Geol., 22, 23—52.
- Grönlund, T., 1986a.** Piimaista, Geologi 38 (3), 57—60.
- Grönlund, 1986b.** Diatomite deposit in the basin Lake Soijärvi, central Finland. Bull. Geol. Soc. Finland 58 (2), 35—45.
- Hajós, M., 1970.** Kieselgurvorkommen im Tertiärbecken von Aflenzen. (Steiermark.) Mitt. Geol. Ges. Wien. 63, 149—159.
- Hajós, M., 1977a.** A correlation study of diatoms of Carpathian age recovered from the borehole DJ-8 of Diósgyőr (N Hungary). M. All. Földtani Intézet Évi Jelentése Az 1977. Évröl. 46 p.
- Hajós, M., 1977b.** Miocene diatomaceous sediments of the Szokolya region, northern Hungary. Hung., Foeldt. Intez., Evi Jel., 1975, 39—82.
- Hartley, B., 1966.** A check-list of the freshwater, brackish and marine diatoms of the British isles and adjoining coastal waters. J. mar. biol. Ass. U.K. 66, 531—610.

- Haworth, E.Y., 1988.** Distribution of Diatom Taxa of the Old Genus *Melosira* (now mainly *Aulacoseira*) in Cumbrian waters. In Round, F.E. (ed.), Algal and the Aquatic Environment. Biopress, 138—167.
- Hirvas, H., Alfthan, A., Pulkkinen, E., Puranen, R. & Tynni, R., 1977.** Raportti malmintintsintää palvelevasta maaperätutkimuksesta Pohjois-Suomessa vuosina 1972—1976. Summary: A report on glacial drift investigations for ore prospecting purposes in northern Finland 1972 — 1976. Geol. Surv. Finland, Rep. Invest. 19, 54 p.
- Hustedt, F., 1930.** Bacillariophyta (Diatomeae). In Pascher, A. (ed.), Süsswasser—Flora Mitteleuropas. Gustav Fischer, Jena, 466 p.
- Hustedt, F., 1937—39.** Systematische und ökologische Untersuchungen über die Diatomeen-Flora von Java, Bali und Sumatra. Arch. Hydrobiol. Suppl. Bd XV, XVI, "Tropische Binnengewässer" Bd. VII—VIII. Stuttgart (Java). 131—177.
- Hustedt, F., 1954.** Die Diatomeenflora des Interglazials von Oberrohe in der Lüneburger Heide. Abh. naturw. Verein 33, 431—455.
- Ilvonen, E., 1973.** Eem-kerrostuma Savukosken Soklilla. Summary: An Eem-Interglacial deposit at Sokli in Savukoski, Finnish Lapland. Geologi 25, 81—83.
- Kadey, F.L., 1975.** Diatomite. In Lefond, S. (ed.) Industr. Minerals and Rocks. Am. Inst. Min. Metal. Pet. Eng. Inc. 605—635.
- Kanerva, R., 1956.** Pollenanalytische Studien über die Spätquartäre Wald- und Klimgeschichte von Hyrynsalmi in NO-Finnland. Ann. Acad. Sci. Fenn. Ser. A: III, 46, 1—108.
- Korhonen, R., 1986.** Jämsässä ja Jämsänkoskella tutkitut suot ja niiden turvevarat. Abstract: Mires of the municipalities of Jämsä and Jämsänkoski and their peat resources. Geologian tutkimuskeskus. Maaperäosasto. Turveraportti 181. 160 p.
- Korhonen, R., 1988.** Keuruulla tutkitut suot ja niiden turvevarat. Osa I. Abstract: The mires and their peat resources in Keuruu. Geologian tutkimuskeskus. Maaperäosasto. Turveraportti 221. 175 p.
- Korpilaakko, K., 1981.** Uusi kairatyyppi tilavuustarkkojen turve- näytteiden ottamiseen. Summary: A piston sampler for undisturbed peat samples. Suo 32 (I), 7—8.
- Krammer, K. & Lange-Bertalot, H., 1986.** Bacillariophyceae. Teil. 1: Naviculaceae. Gustav Fischer Verlag, Stuttgart. 876 p. Krasske, G., 1933. Über Kieselgur-Geschiebe von Oderberg-Bralitz. Z. Geschiebeforschung 9 (2), 84—95.
- Krasske, G., 1937.** Spät- und postglaziale Süßwasser-Ablagerungen auf Rügen. II. Diatomeen aus den postglazialen Seen auf Rügen. Arch. Hydrol. 31. 38—53.
- Lappalainen, V., 1962.** The Shore-line displacement on southern Lake Saimaa. Acta Bot. Fenn. 64, 1—125.
- Lowe, R.L., 1974.** Environmental requirements and pollution tolerance of freshwater diatoms. U.S. Department of Commerce. National Technical Information Service. PB-239 490. 333 p.
- Müller, H., 1974a.** Pollenanalytische Untersuchungen und Jahresschichten-zählungen an der eem-zeitlichen Kieselgur von Bispingen/Luhe. Geol. Jahrb. A 21, 149—169.
- Müller, H., 1974b.** Pollenanalytische Untersuchungen und Jahresschichten-zählungen an der holstein-zeitlichen Kieselgur von Munster-Breloh. Geol. Jahrb. A 21, 107—140.
- Mölder, K., 1960.** Piimaan käyttö teollisuudessa. In Virkkala, K. (ed.), Sovellettua maaperägeologian. Geologinen tutkimuslaitos. Geoteknillisä julkaisuja 65, 41—46.
- Mölder, K. & Tynni, R., 1967.** Über Finnlands rezente und subfossile Diatomeen. I. C. R. géol. Soc. Finlande 39, 199—217.
- Nieminen, K., 1976.** Diatomite deposits in Finnish bogs. Proceedings of the 5th International Peat Congress. New Recognitions of Peatlands and Peat 2. Poznan, Poland. 123—128.
- Nieminen, P., 1982.** Ominaispinta-ala ja sen käyttö maalajien luokituksessa. Partikkelipäivät 1982, luentomiste. Oy Tamro Ab, Helsinki, 15 p.
- Nygaard, G., 1956.** Ancient and recent flora of diatoms and Chrysophyceae in Lake Gribsoø. Folia limnol. scand. 8, 32—94.
- Nylander, W., 1861.** Diatomaceis Fenniae Fossilibus. Additamentum. Not. Sällsk. Fauna Flora Fennica Förh., sjette häftet, Ny serie, tredje häftet, 145—159.
- Patrick, R. & Reimer, C.W., 1966.** The Diatoms of the United States. I. Acad. Nat. Sci. Philadelphia. 688 p.
- Ramsay, W., 1909.** Geologian perusteet. Helsinki. 518 p.
- Renberg, I., 1976.** Palaeolimnological investigations in Lake Prästjön. Early Norrland 9, 113—159.
- Renberg, I. & Hellberg, T., 1982.** The pH History of Lakes in Soutwestern Sweden, as calculated from Subfossil Diatom Flora of the Sediments. Ambio 11, 30—33.
- Ristaniemi, O., 1984.** Petäjäveden kunnan länsiosan turvevarat. Geologian tutkimuskeskus. Maaperäosasto. Raportti P 13.4/84/146. 108 p.
- Ristaniemi, O. & Stén, C-G., 1984.** Petäjäveden kunnassa suoritetut turvetutkimukset. Geologian tutkimuskeskus. Maaperäosasto. Raportti P 13.4/84/147. 12 p.
- Sauramo, M., 1939.** Luvian muinaisruuhi. Satakunta XI, 15—24. Sauramo, M., 1949. Das dritte Scharnier der fennoskandischen Landheburg. Soc. Sci. Fenn. XXVII B, 4, 26 p.
- Sauramo, M., 1951.** Antrean verkkolöydön uusittu paleontologinen ajoitus. Referat: Eine erneuerte pollentalytische Datierung des mesolithischen Netzfundes von Antrea auf der Karelischen Landenge. Suomen museo L. VIII, 87—98.
- Sauramo, M., 1958.** Die Geschichte der Ostsee. Ann. Acad. Sci. Fenn. A III, 51, 1—522.
- Schmidt, A., 1874 — 1959.** Atlas der Diatomaceenkunde. Leipzig.
- Simonsen, R., 1979.** The diatom system: ideas on phylogeny. Bacillaria 2, 9—71.
- Stén, C-G., Korhonen, R. & Svahnback, L., 1982.** Petäjäveden karttalehdet (2234) itäosan suot. Väliraportti Petäjävedellä, Korpilahdella, Jyväskylän mlk:ssa ja Jämsänkoskella tehdystä turvetutkimuksista. Geologian tutkimuskeskus. Maaperäosasto. Raportti P 13.4/82/110. 119 p.
- Tynni, R., 1982.** The reflection of geological evolution in Tertiary and interglacial diatoms and silico-flagellates in Finnish Lapland. Geol. Surv. Finland, Bulletin 320. 40 p.

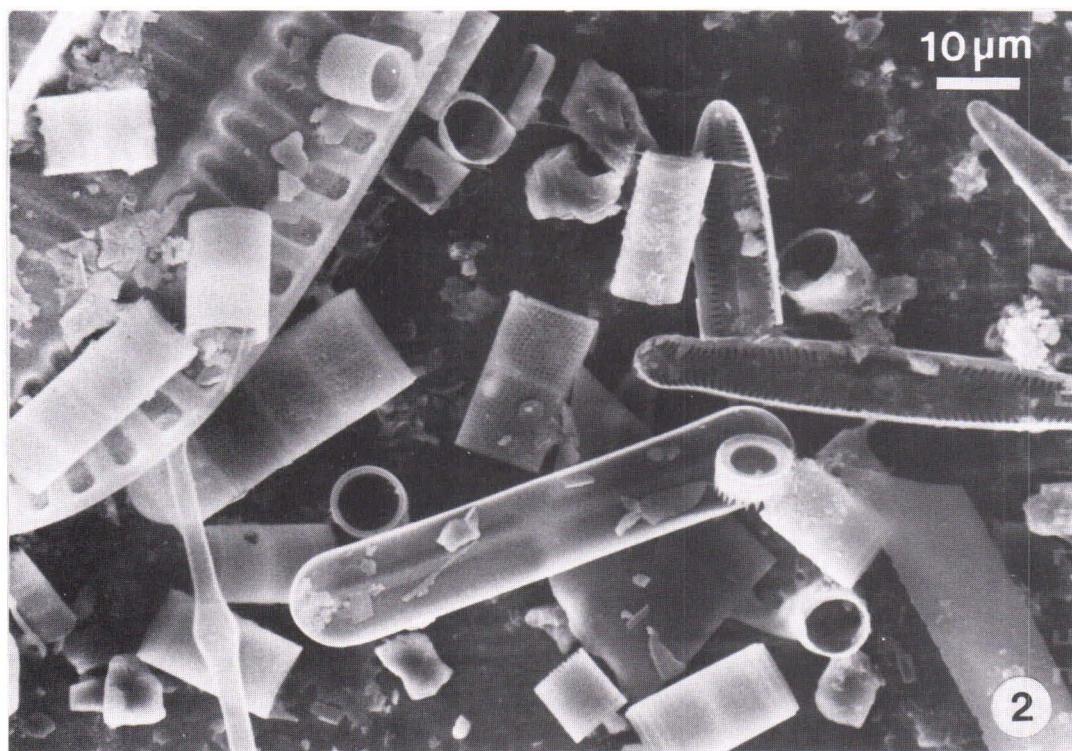
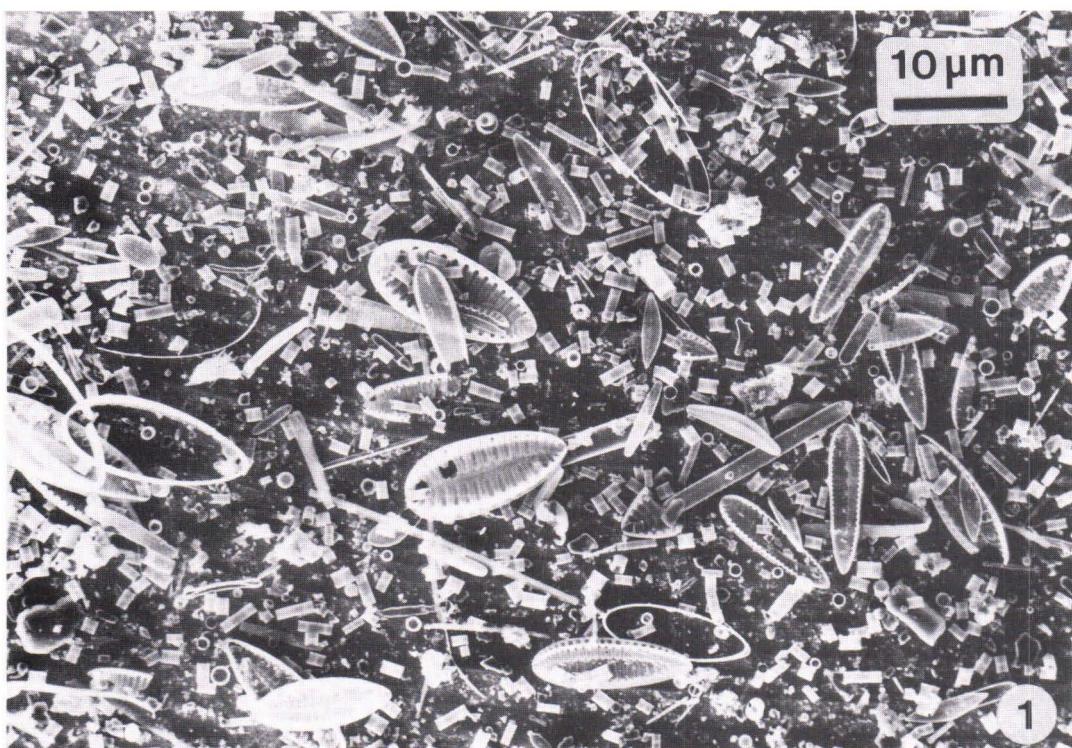


Plate I

Fig. 1. Scanning electron micrograph of diatomite from Ihakkilammensuo mire (depth 250 cm). Fig. 2. Scanning electron micrograph of diatomite from Ihakkilammensuo mire (depth 250 cm).

**Plate II**

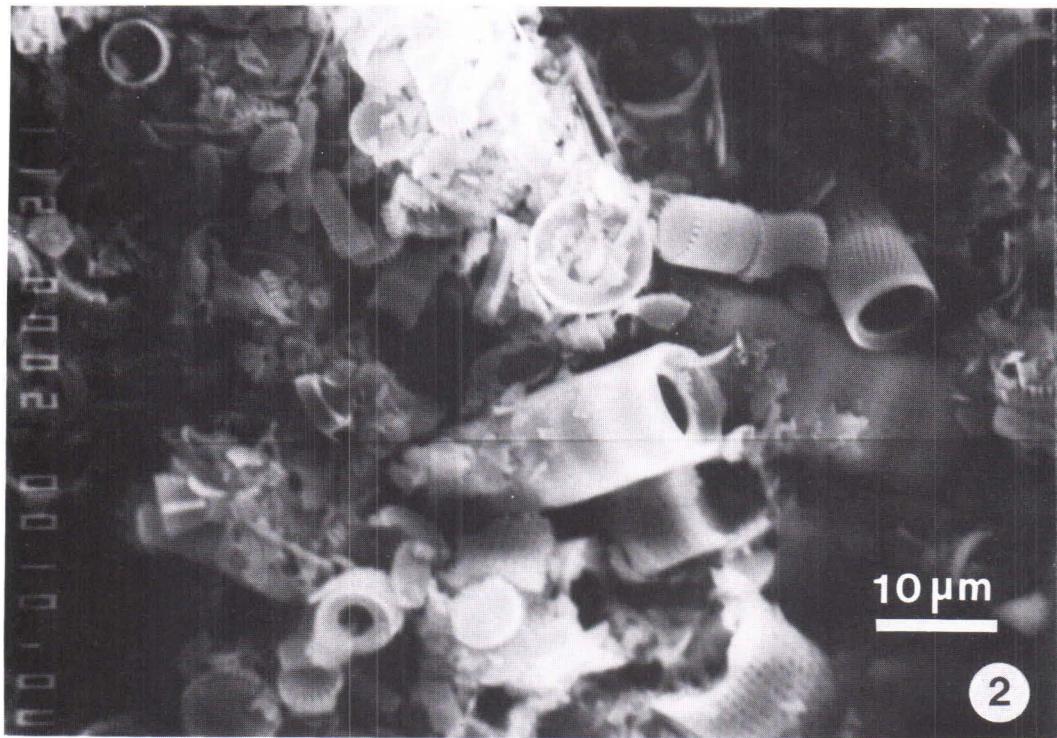
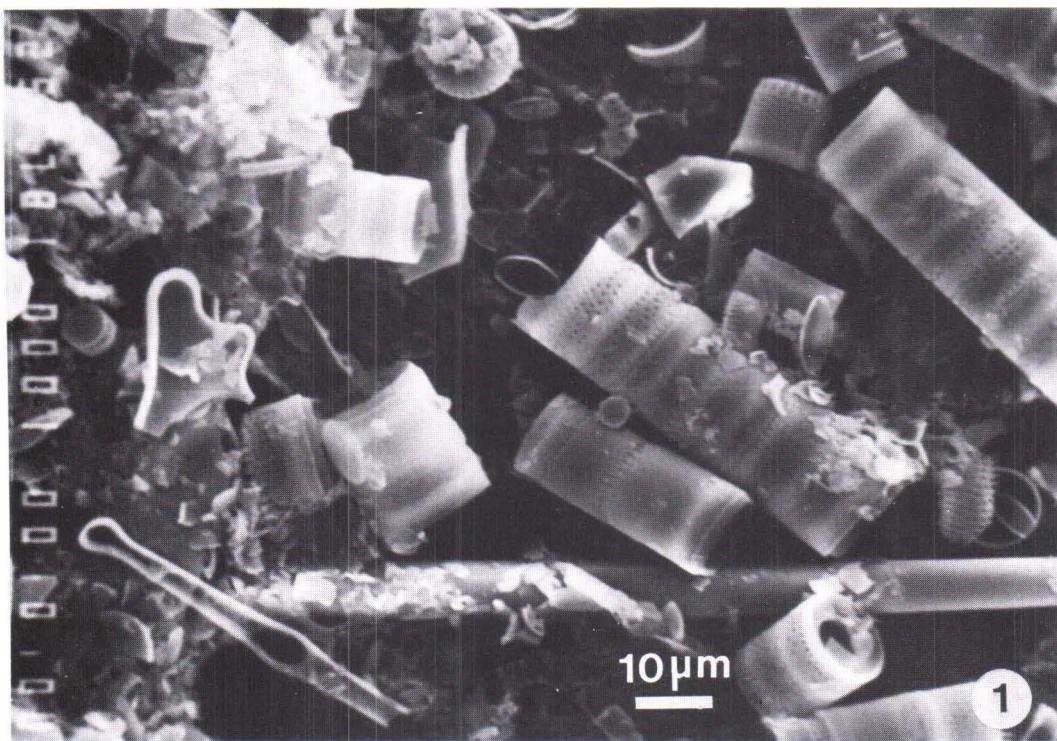


Plate II

Fig. 1. Scanning electron micrograph of diatomite from Iso Rautasuo mire (depth 170 cm). Fig. 2. Scanning electron micrograph of diatomite from Joutavanmäensuo mire (depth 250 cm).

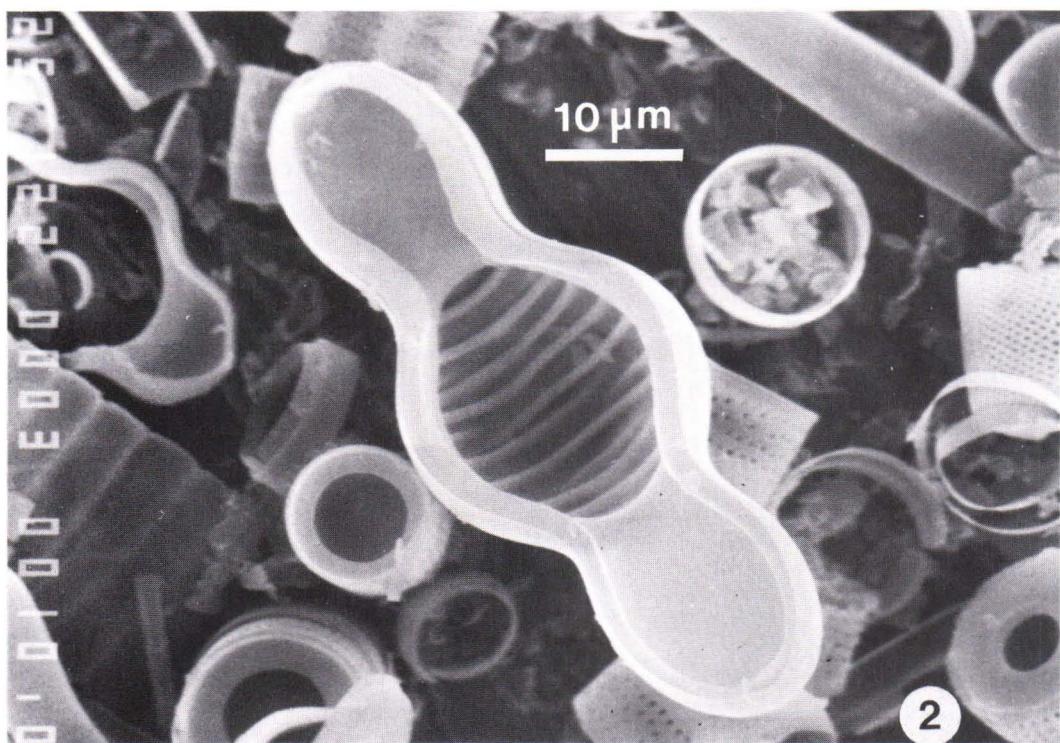
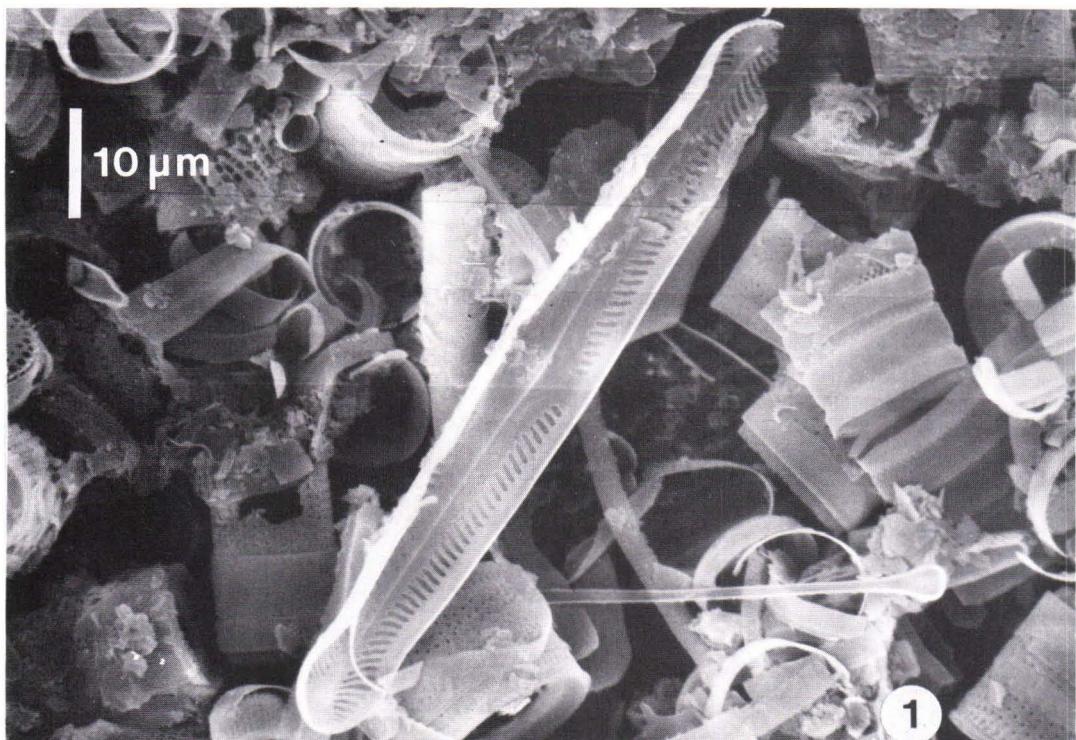


Plate III

Fig. 1. Scanning electron micrograph of diatomite from Kurkisuo mire (depth 260 cm). Fig. 2. Scanning electron micrograph of diatomite from Kurkisuo mire (depth 260 cm). *Tetracyclus lacustris* var. *capitata* Hust. in the middle.

Plate IV

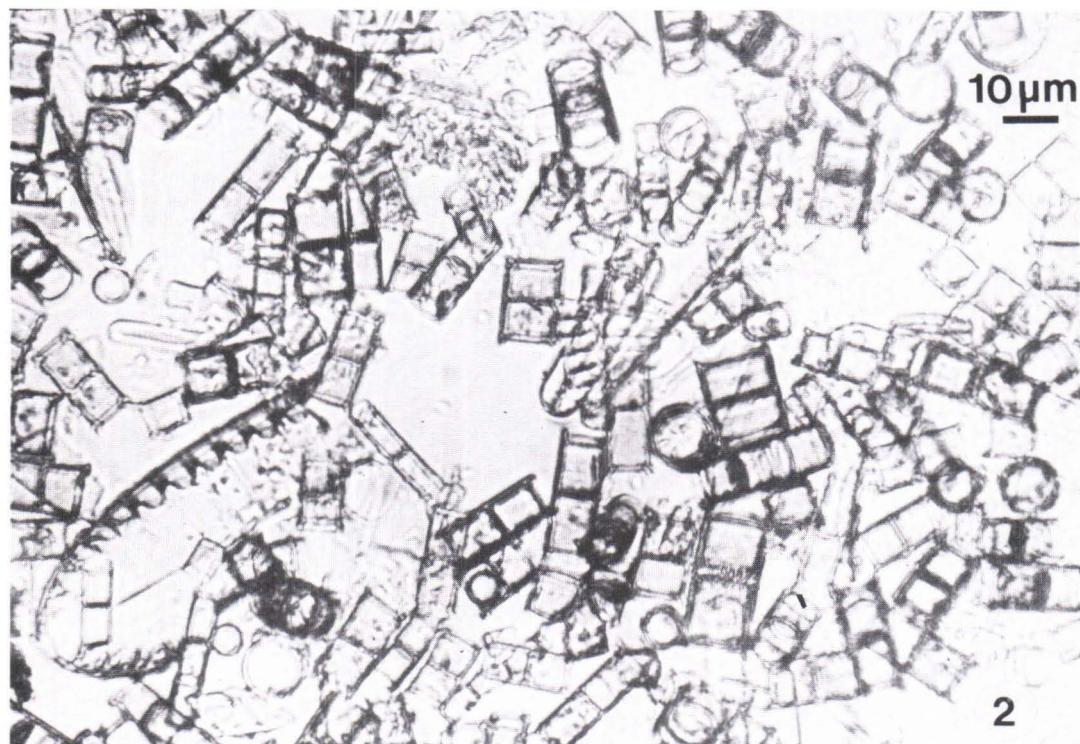
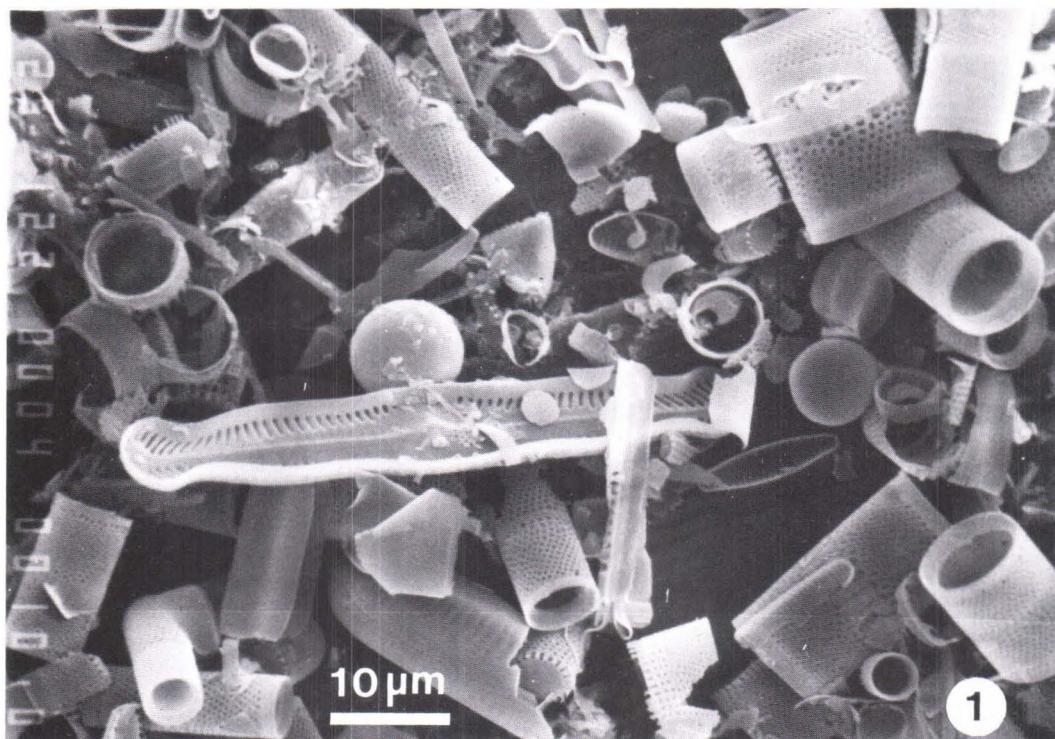


Plate IV

Fig. 1. Scanning electron micrograph of diatomite from Maunusuo mire (depth 230 cm). Fig. 2. Picture of diatomite from Pengerjoensuo mire (depth 360 cm).

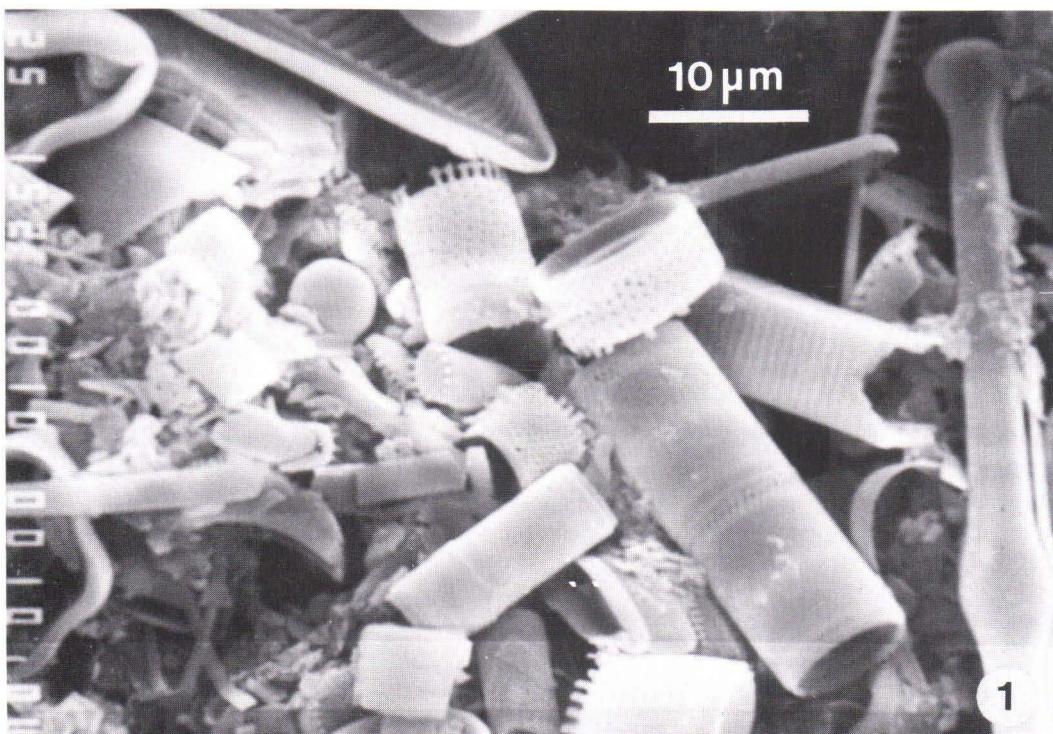


Plate V

Fig. 1. Scanning electron micrograph of diatomite from Hetonsuo mire (depth 160 cm). Fig. 2. Scanning electron micrograph of diatomite from Hinkkasuo mire (depth 160 cm).

Plate VI

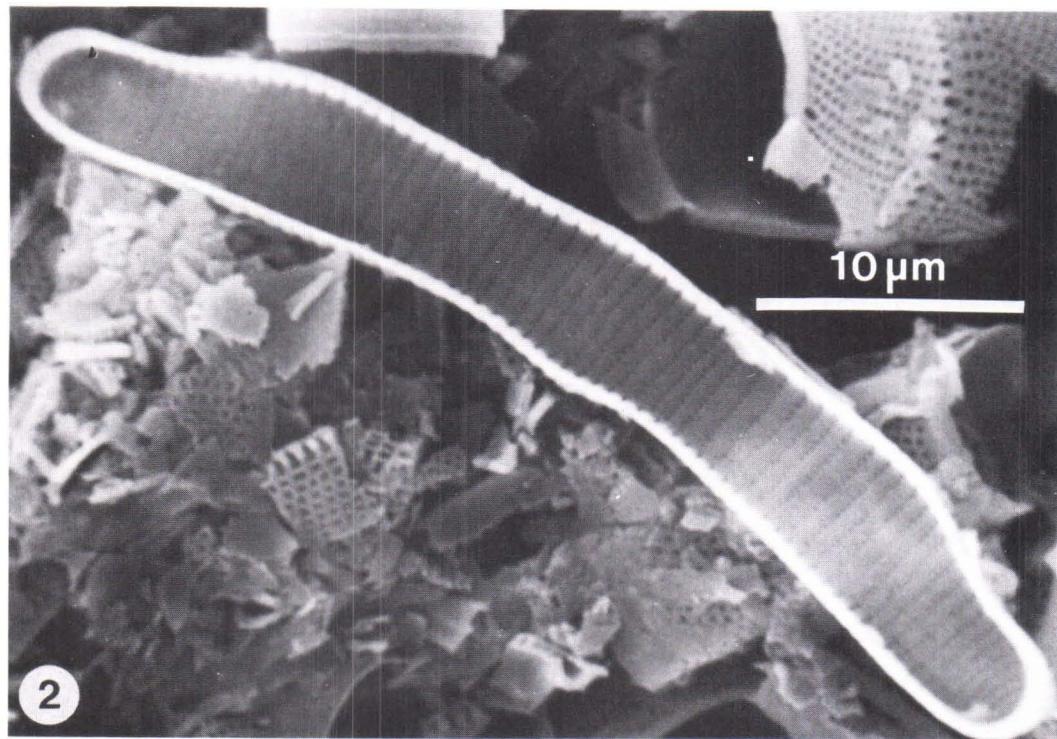
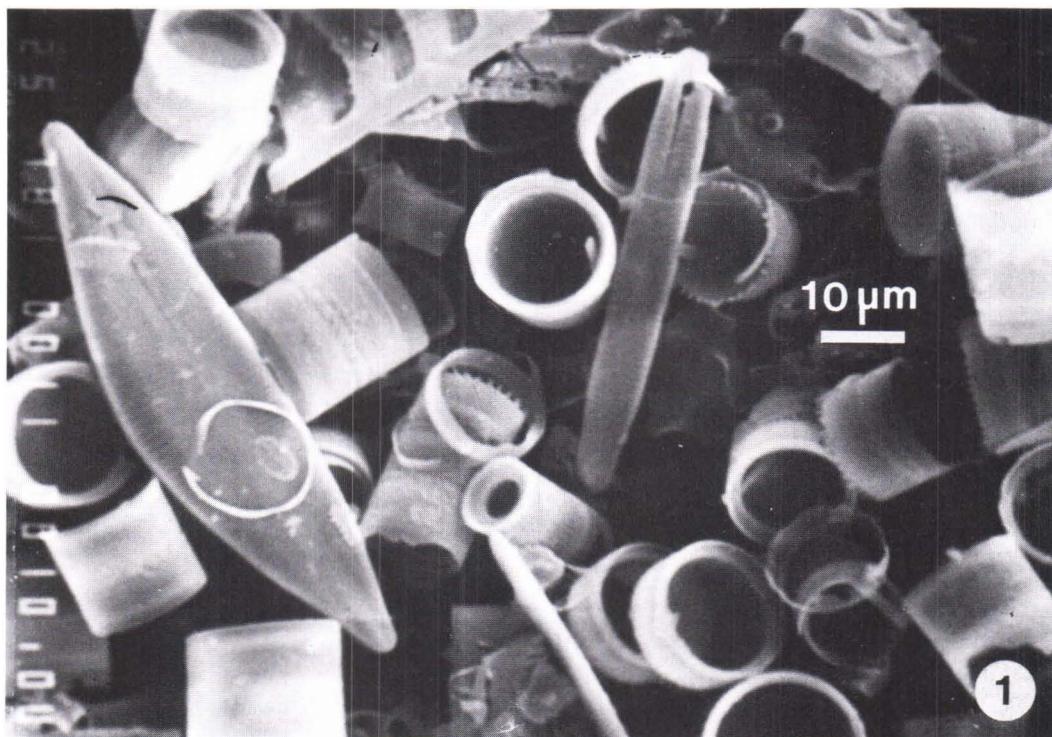


Plate VI

Fig. 1. Scanning electron micrograph of diatomite from Ukonmurronsuo mire (depth 190 cm). Fig. 2. Scanning electron micrograph of diatomite from Kuljunsuo mire (depth 270 cm). *Eunotia pectinalis* var. *ventricosa* (Ehr.) Hust. in the middle.

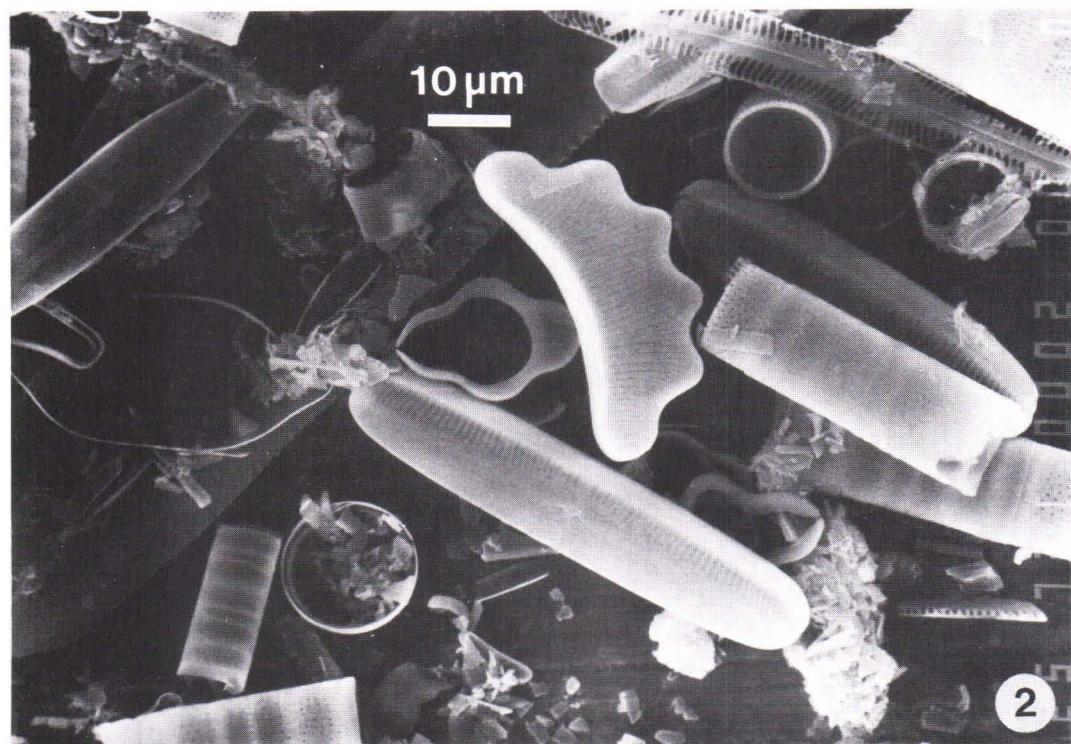
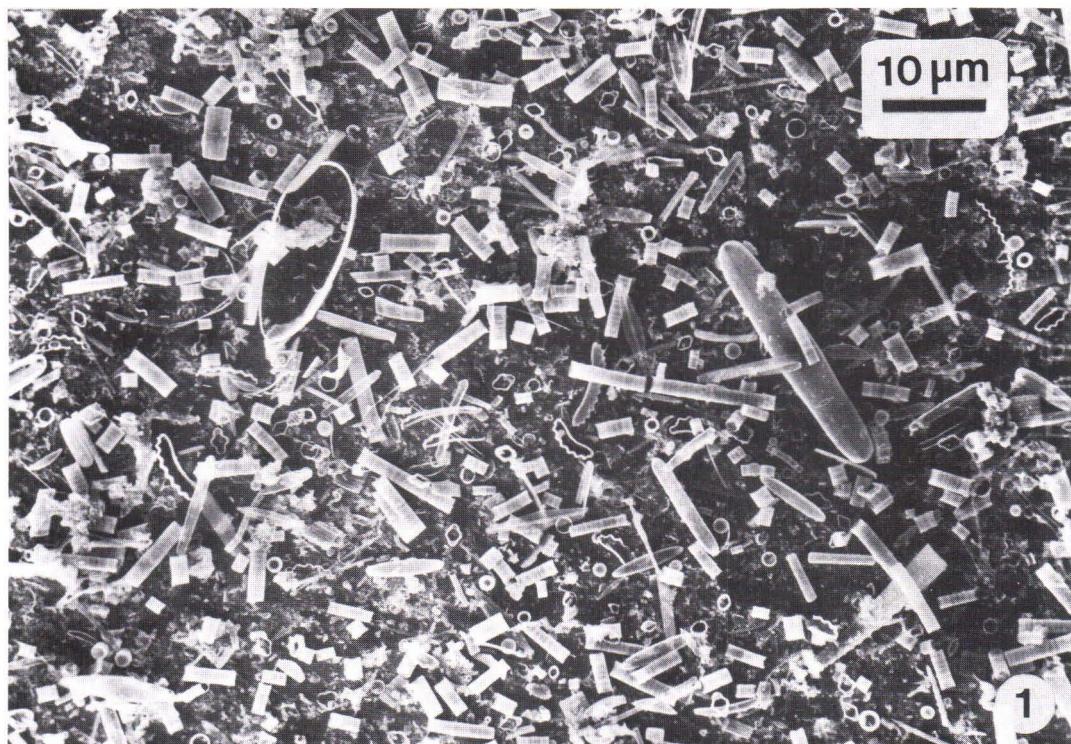
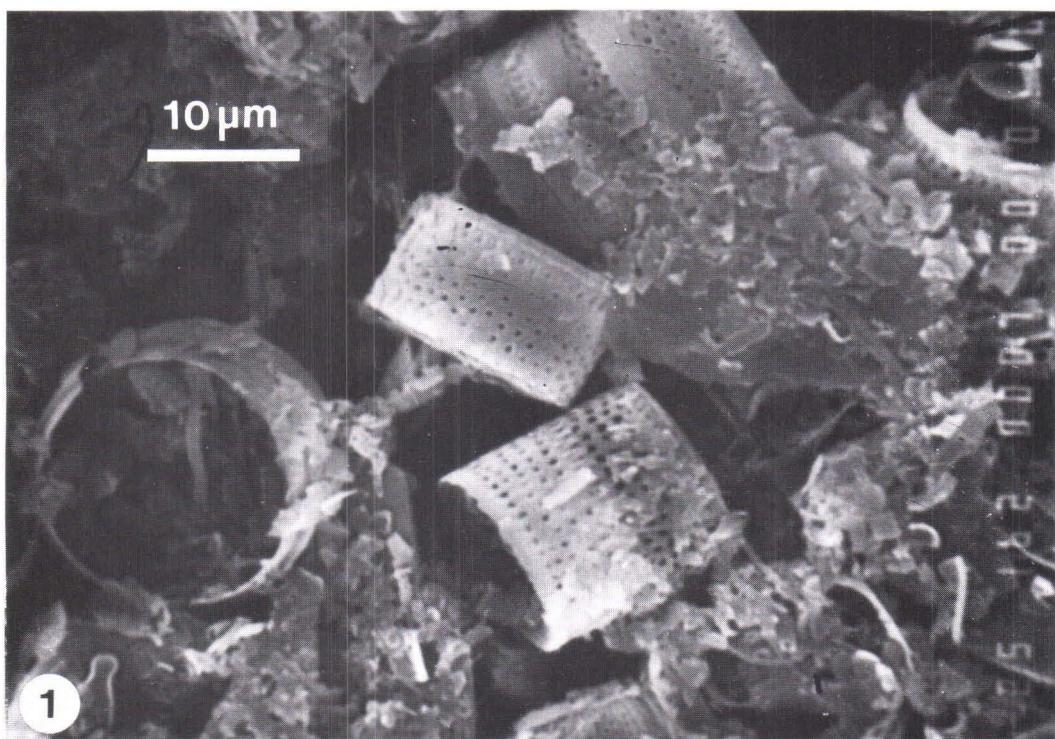


Plate VII

Fig. 1. Scanning electron micrograph of diatomite from Housujärvensuo mire (depth 250 cm). Fig. 2. Scanning electron micrograph of diatomite from Housujärvensuo mire (depth 250 cm). *Eunotie robusta* var. *tetraodon* (Ehr.) Ralfs in the middle.

**Plate VIII**



**Plate VIII**

Fig. 1. Scanning electron micrograph of diatomite from Kelaojansuo mire (depth 250 cm). Fig. 2. Picture of diatomite from Kelaojansuo mire (depth 270 m).

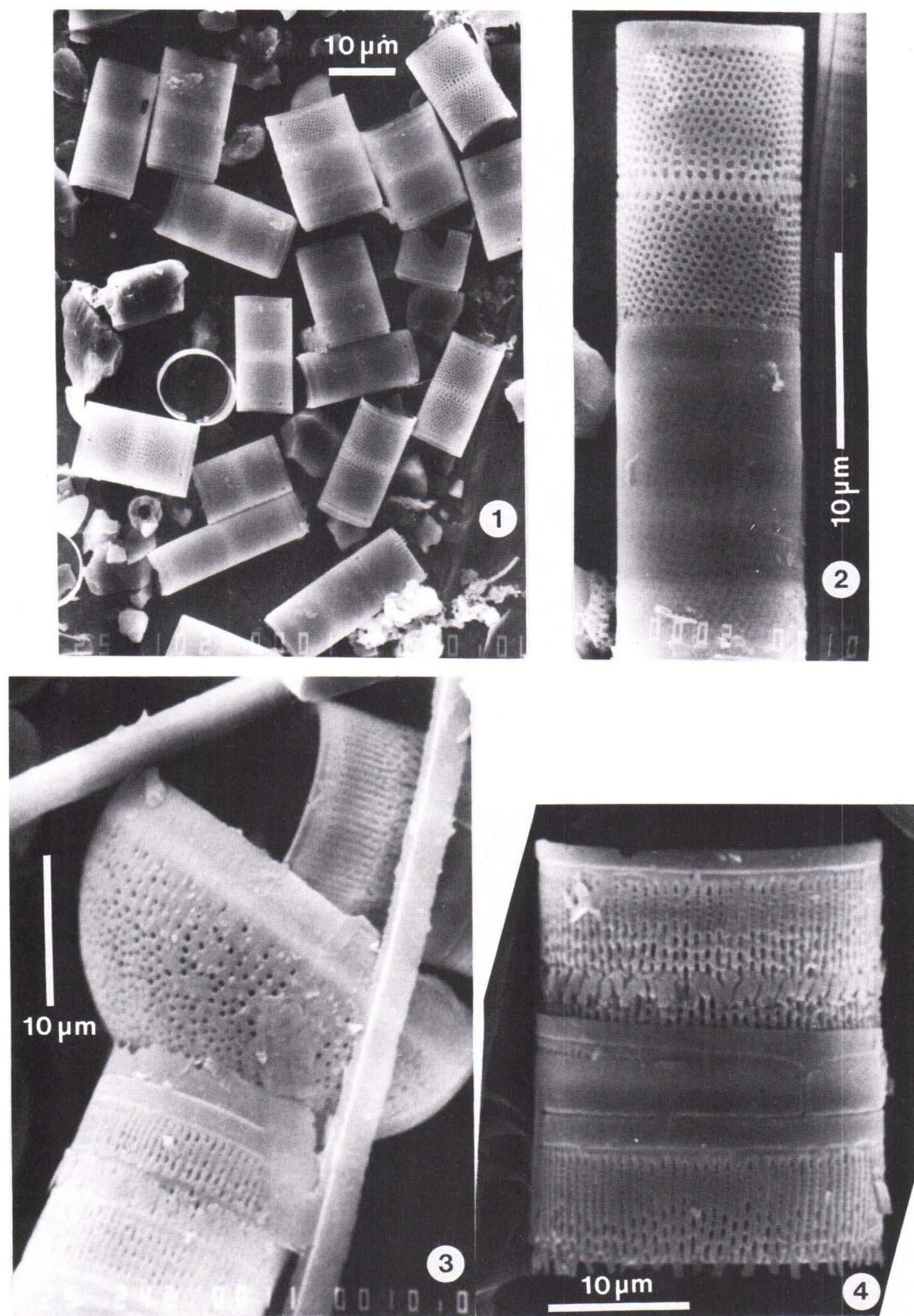


Plate IX

Fig. 1. *Aulacoseira ambigua* (Grun. in Van Heurck) Simonsen. Fig. 2. *Aulacoseira ambigua* (Grun. in Van Heurck) Simonsen. Fig. 3. *Aulacoseira lirata* var. *lacustris* (Grun. in Van Heurck) R. Ross. Fig. 4. *Aulacoseira lirata* var. *lacustris* (Grun. in Van Heurck) R. Ross.

Plate X

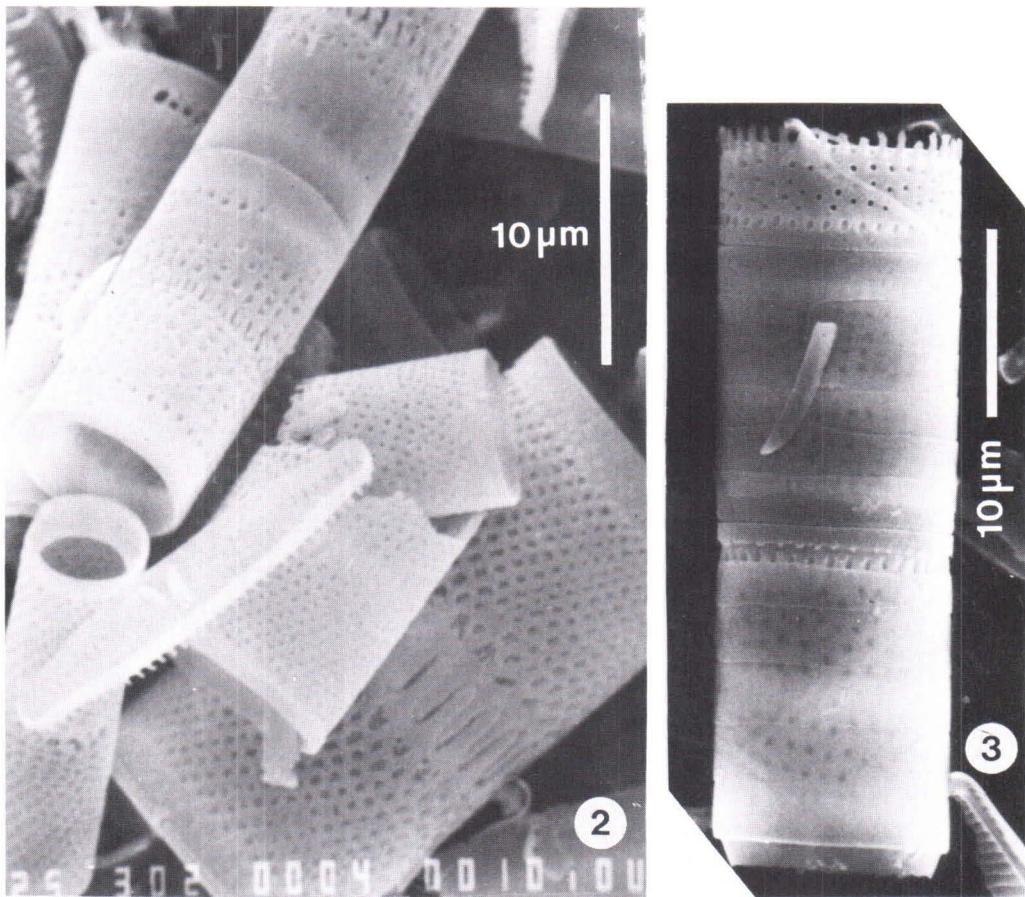
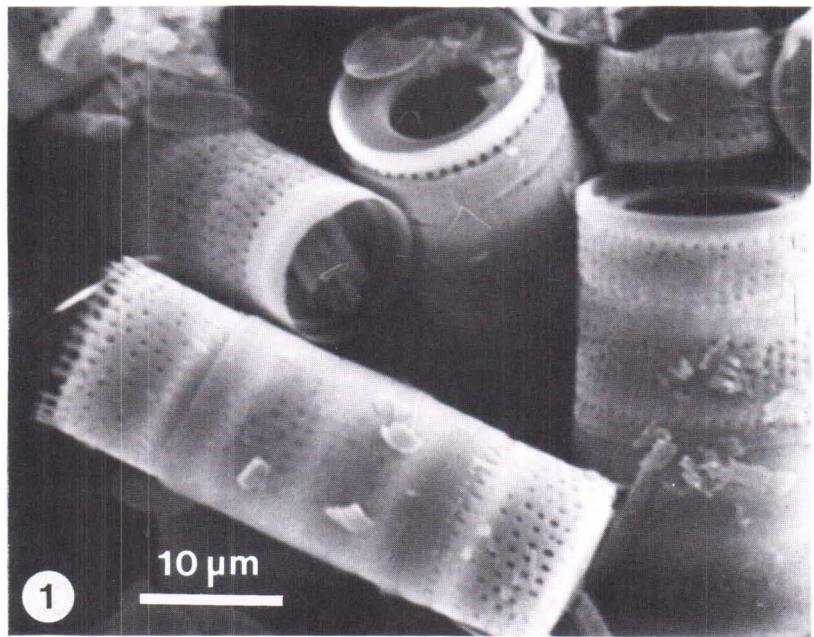


Plate X

Fig. 1. *Aulacoseira lirata* (Ehrenb.) R. Ross Scanning electron micrograph. Fig. 2. *Aulacoseira italicica* (Ehrenb.) Simonsen Scanning electron micrograph. Fig. 3. *Aulacoseira distans* var. *alpigena* (Grun. in Van Heurck) Simonsen Scanning electron micrograph.

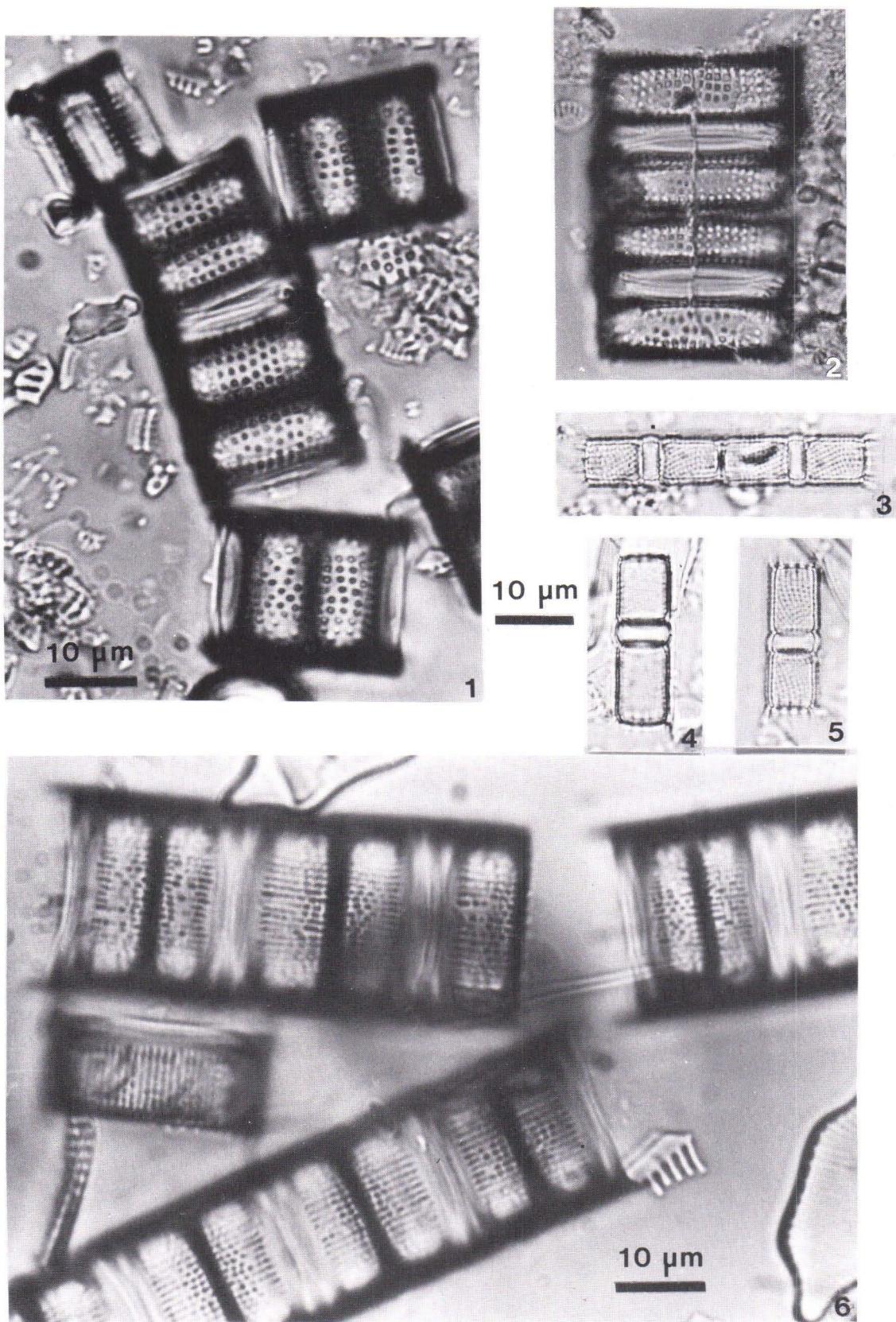


Plate XI

Fig. 1. *Aulacoseira lirata* var. *perglabra* (Östrup.) Florin, *Aulacoseira lirata* (Ehrenb.) R. Ross. Fig. 2. *Aulacoseira lirata* (Ehrenb.) R. Ross. Fig. 3. *Aulacoseira italicica* ssp. *subarctica* (O. Müll.) Simonsen. Fig. 4. *Aulacoseira italicica* ssp. *subarctica* (O. Müll.) Simonsen. Fig. 5. *Aulacoseira italicica* ssp. *subarctica* (O. Müll.) Simonsen. Fig. 6. *Aulacoseira lirata* var. *lacustris* (Grun. in Van Heurck) R. Ross.

Plate XII

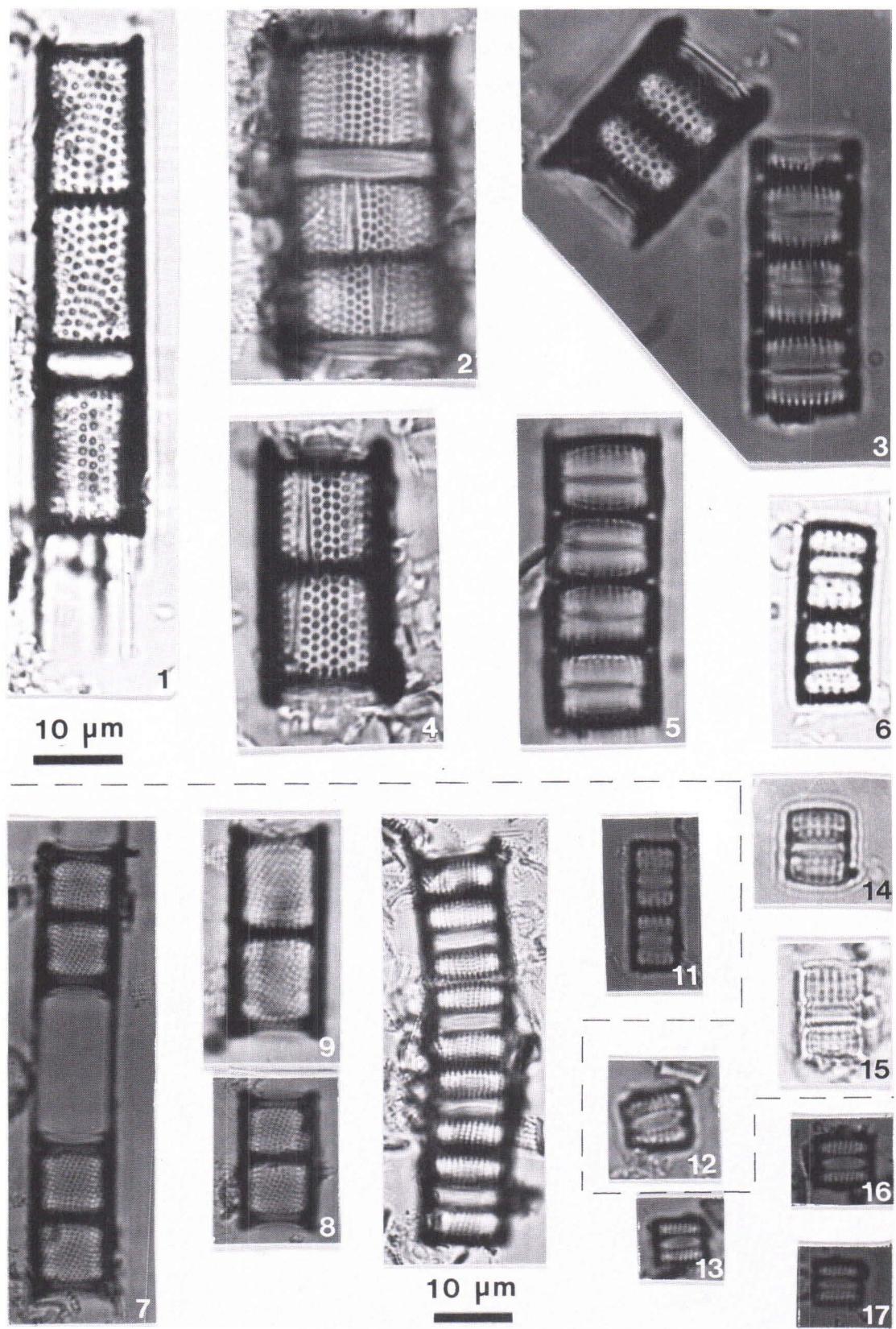


Plate XII

Fig. 1. *Aulacoseira granulata* (Ehrenb.) Simonsen. Fig. 2. *Aulacoseira granulata* (Ehrenb.) Simonsen. Fig. 3. *Aulacoseira lirata* (Ehrenb.) R. Ross, *Aulacoseira lirata* var. *perglabra* (Östrup.) R. Ross. Fig. 4. *Aulacoseira granulata* (Ehrenb.) Simonsen. Fig. 5. *Aulacoseira lirata* var. *perglabra* (Östrup.) R. Ross. Fig. 6. *Aulacoseira lirata* fo. *biseriata* (Grun.) Haworth. Figs. 7—9. *Aulacoseira ambigua* (Grun. in Van Heurck) Simonsen. Fig. 10. *Aulacoseira distans* var. *alpigena* (Grun. in Van Heurck) Simonsen. Fig. 11. *Aulacoseira lirata* fo. *biseriata* (Grun.) Haworth. Fig. 12. *Aulacoseira distans* var. *tenella* (Nygaard) R. Ross. Fig. 13. *Aulacoseira distans* var. *tenella* (Nygaard) R. Ross. Fig. 14. *Aulacoseira lirata* fo. *biseriata* (Grun.) Haworth. Fig. 15. *Aulacoseira lirata* fo. *biseriata* (Grun.) Haworth. Fig. 16. *Aulacoseira distans* var. *tenella* (Nygaard) R. Ross. Fig. 17. *Aulacoseira distans* var. *tenella* (Nygaard) R. Ross.

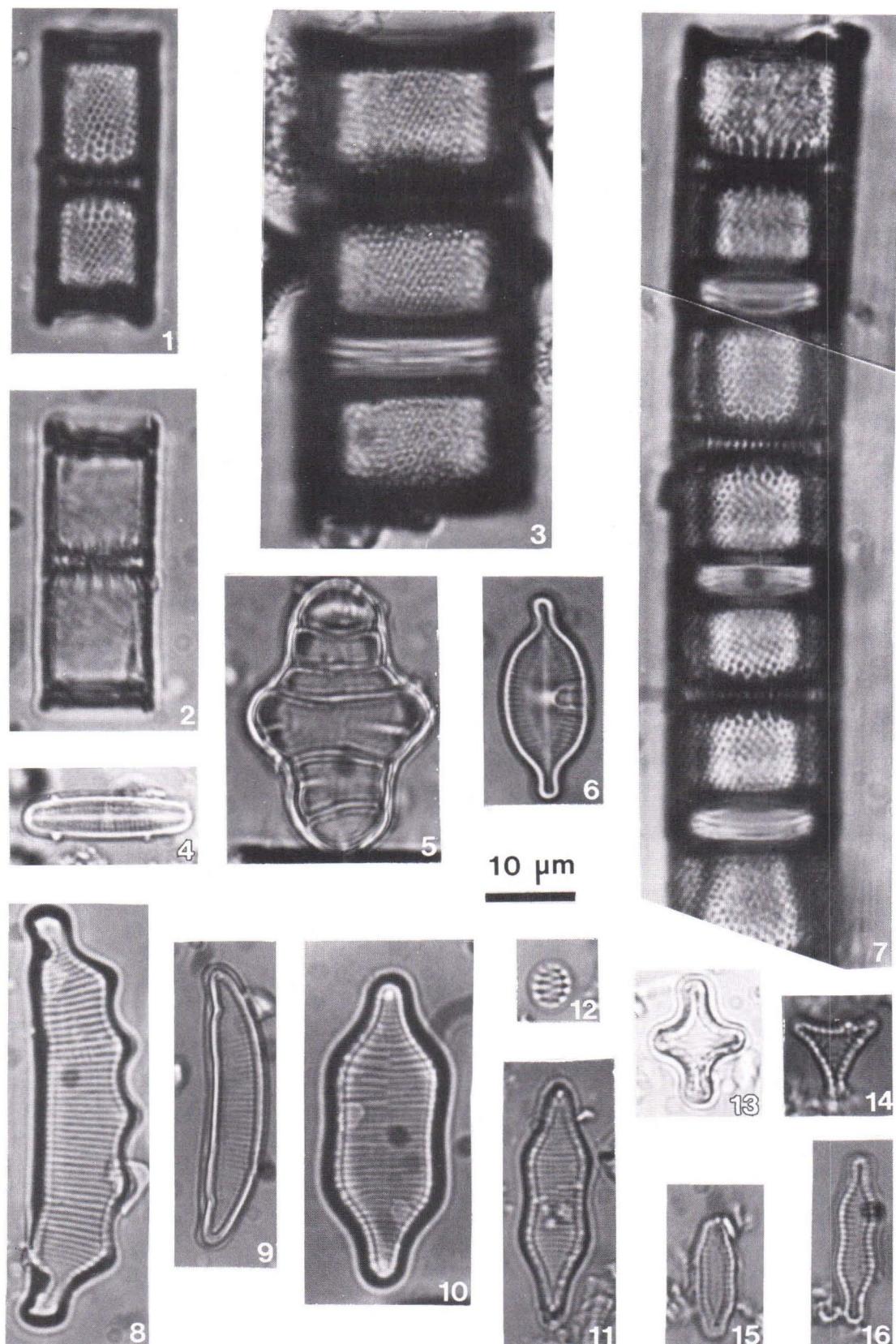


Plate XIII

Fig. 1. *Aulacoseira italica* (Ehrenb.) Simonsen. Fig. 2. *Aulacoseira italica* (Ehrenb.) Simonsen. Fig. 3. *Aulacoseira italica* var. *valida* (Grun. in Van Heurck) Simonsen. Fig. 4. *Achnanthes linearis* (W. Sm.) Grun. Fig. 5. *Tetracyclus lacustris* Ralfs. Fig. 6. *Achnanthes peragalli* Brun & Héribaud. Fig. 7. *Aulacoseira italica* var. *valida* (Grun. in Van Heurck) Simonsen. Fig. 8. *Eunotia polyglyphis* Grun. Fig. 9. *Eunotia veneris* (Kütz.) O. Müll. Fig. 10. *Fragilaria constricta* Ehr. Fig. 11. *Fragilaria constricta* Ehr. Fig. 12. *Fragilaria construens* var. *venter* (Ehr.) Grun. Fig. 13. *Fragilaria construens* (Ehr.) Grun. Fig. 14. *Fragilaria construens* var. *exigua* (W. Sm.) Schulz. Fig. 15. *Fragilaria construens* var. *binodis* (Ehr.) Grun. Fig. 16. *Fragilaria construens* var. *binodis* (Ehr.) Grun.

Plate XIV

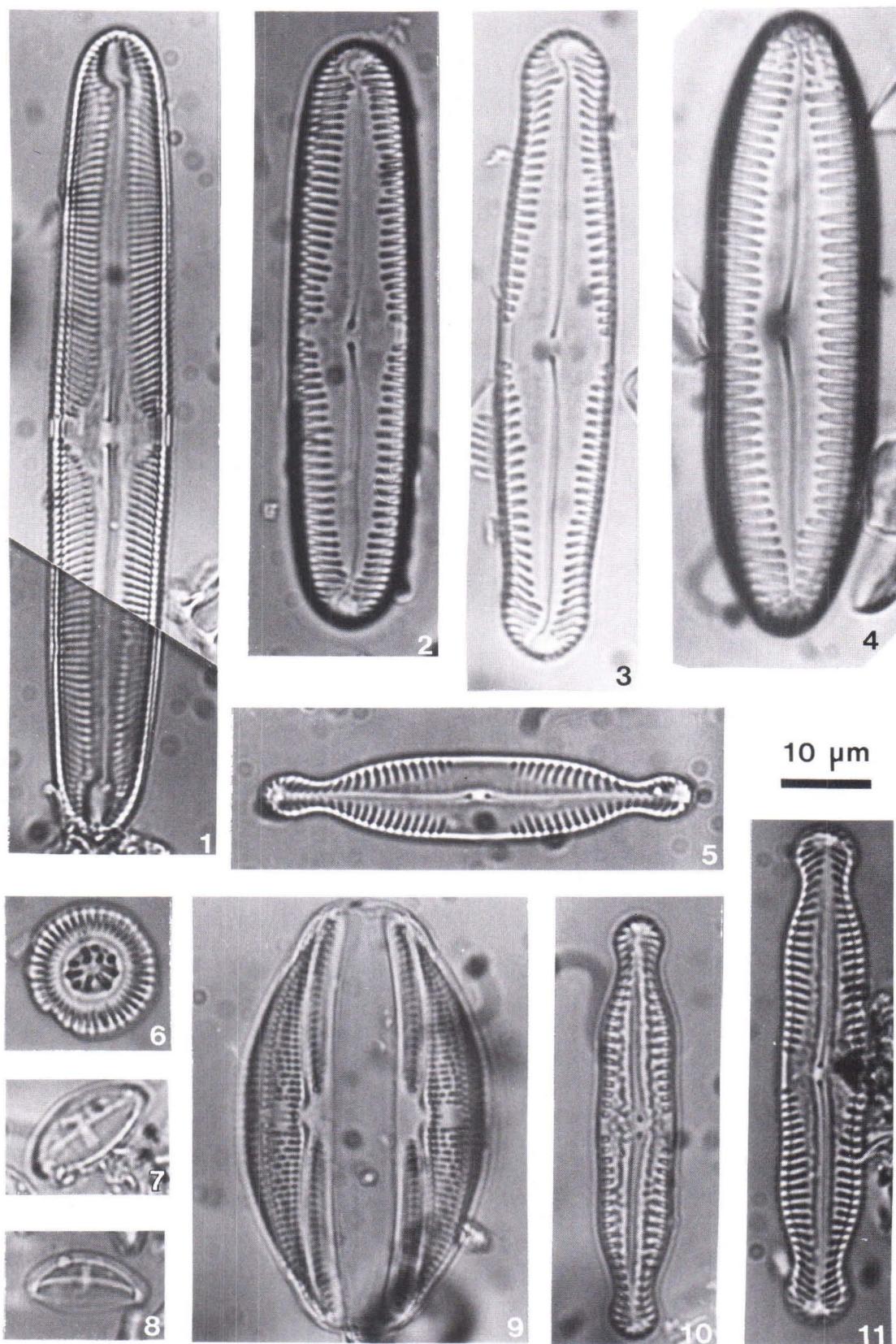


Plate XIV

Fig. 1. *Pinnularia stomatophora* Mayer. Fig. 2. *Pinnularia brevicostata* Cl. Fig. 3. *Pinnularia gibba* Ehr. Fig. 4. *Pinnularia hemiptera* (Kütz.) Cl. Fig. 5. *Pinnularia braunii* (Grun.) Cl. Fig. 6. *Cyclotella stelligera* Cl. & Grun. Fig. 7. *Achnanthes recurvata* Hust. Fig. 8. *Achnanthes recurvata* Hust. Fig. 9. *Amphora ovalis* var. *libyca* (Ehr.) Cl. Fig. 10. *Pinnularia nodosa* Ehr. Fig. 11. *Pinnularia nodosa* Ehr.

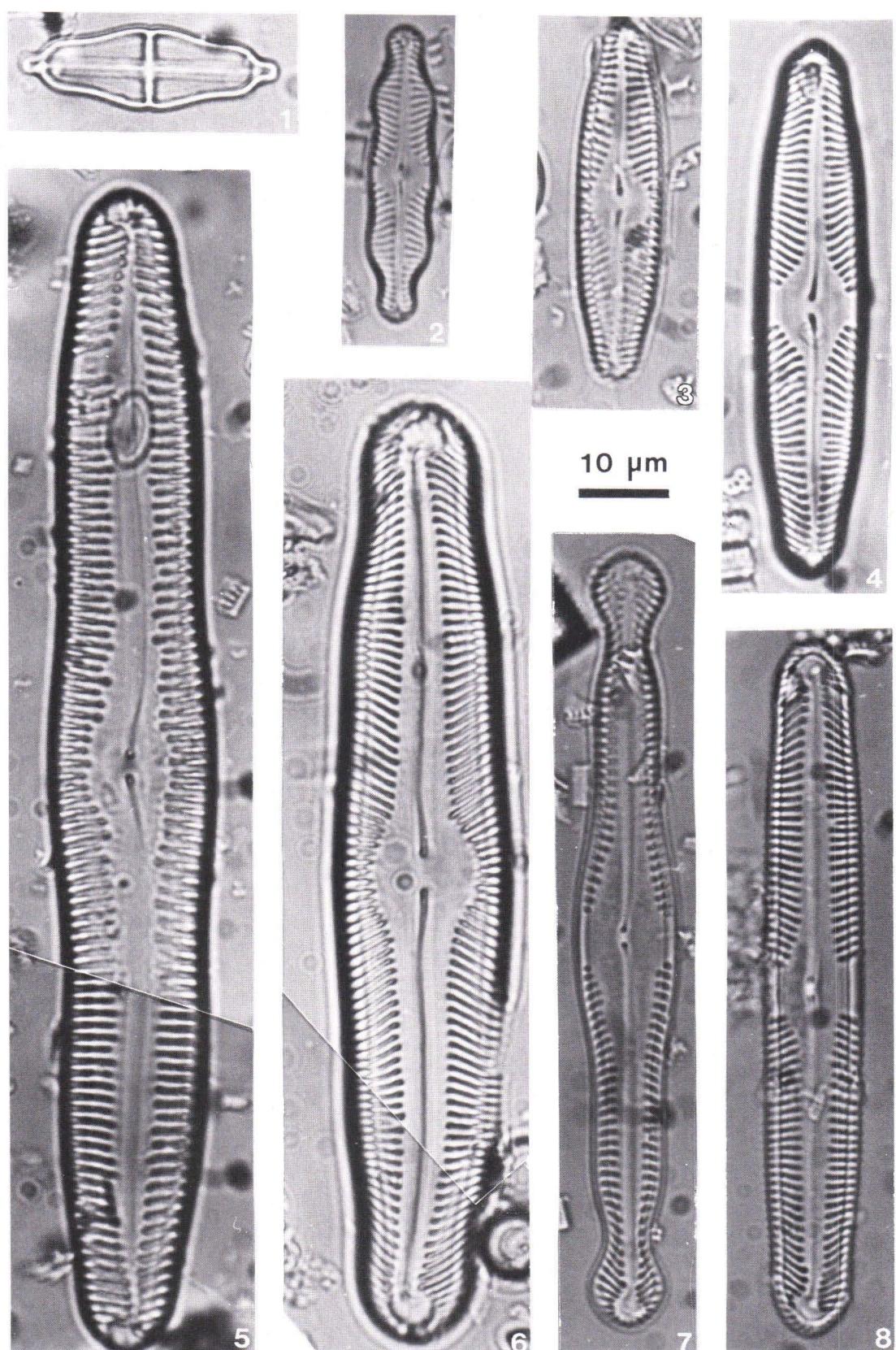


Plate XV

Fig. 1. *Stauroneis smithii* Grun. Fig. 2. *Pinnularia mesolepta* (Ehr.) W. Sm. Fig. 3. *Pinnularia microstauron* (Ehr.) Cl.  
Fig. 4. *Pinnularia microstauron* (Ehr.) Cl. Fig. 5. *Pinnularia esox* Ehr. Fig. 6. *Pinnularia subsolaris* (Grun.) Cl. Fig.  
7. *Pinnularia polyonca* (Breb.) O. Müll. Fig. 8. *Pinnularia gibba* fo. *subundulata* Mayer, Hustedt



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