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Diatom (Bacillariophyceae) flora of early Holocene freshwater sediments from Skalafjord, Faeroe Islands

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ABSTRACT – Relative abundance data of diatom (Bacillariophyceae) species were generated for sediment core SKPC-01B from the Skalafjord, Faeroe Islands. The record shows distinct temporal changes in species composition. In the lowermost 65 cm of the 230 cm long core a species-rich freshwater diatom assemblage was found. Most of the taxa observed in this section are typical of oligotrophic to dystrophic lakes in northern Europe (Scandinavia, Iceland and Spitsbergen). Above this interval the diatom flora is dominated by marine taxa. The change from a freshwater to a marine flora is inferred to be caused by rising sea-level that took place about 7700–6400 years BP. Drastic changes in the diatom species composition within the transitional core section show that environmental change in the Skalafjord took place in several pulses. The first stage included strong inflow (possibly catastrophic) of marine waters. As a possible trigger of this phenomenon the tsunami released by the Storegga Slide is proposed. Before the final flooding by marine waters, freshwater conditions were re-established within the Skalafjord. These results have important implications for the interpretation of the palaeogeographical development of the Eysturoy area. Hence, it is suggested that the Storegga Slide led to inflow of marine waters at a distinctly lower water level in the area of the Skalafjord than proposed in recent publications and that the inundation of the threshold in the fjord happened after the tsunami. *J. Micropalaeontol*. **22**(2): 183–208, November 2003.

INTRODUCTION

Fossil diatom floras of freshwater and marine origin may be used for reconstructing environmental changes. Freshwater diatom floras from limnic sediments are useful for reconstructions of the climate changes that took place at high latitudes in the Northern Hemisphere since the last deglaciation. Recently, studies of lacustrine sediments from the land areas surrounding the North Sea and Norwegian Sea have been shown to contain a record of past catastrophic events that took place in the area. One such record is a tsunami caused by the Storegga Slide dated at *c.* 7500 ^{14}C years BP (Dawson & Smith, 2000). Diatoms represent one of the best indicators of the impact of this tsunami on the sedimentary record. This phenomenon has been shown to occur in sediment cores from lakes from the Faeroe Islands (Grauert *et al*., 2001). Abrupt changes in diatom species composition were interpreted as indicators of this catastrophic event. However, the altitude of the sediment section analysed here and its significance for the ocean level at which the Storegga Slide took part is not in agreement with palaeogeographical interpretations given by Bennike *et al*. (1998) and Grauert *et al*. (2001).

Although the first publications on freshwater diatoms from the northern part of the North Atlantic are from the nineteenth and twentieth centuries, knowledge of the freshwater diatom flora of the Faeroe Islands is rather poor. Early publications (Lyngbye, 1819; Cleve, 1873, 1896, 1898, 1900; Lagerstedt, 1873; Cleve & Grunow, 1880; Østrup, 1897; Brun, 1901) dealt with the high latitude North Atlantic in general and usually concerned both marine and freshwater floras. Later, Hustedt (1937), Krasske (1938) and Foged (1964, 1974) published results on their studies of the freshwater diatom flora from some North Atlantic islands (for example, the Faeroe Islands and Spitsbergen). Only Hustedt (1937) dealt with diatoms from Iceland, the Faeroe Islands and Spitsbergen. The first report focusing on freshwater diatoms from the Faeroe Islands was by Lyngbye (1819). The next study specifically dealing with the freshwater diatom flora from the Faeroe Islands was published by Østrup (1901). Somewhat later, Østrup (1903) published a report on marine diatoms from this area. Since then, no papers on freshwater diatoms from the Faeroes have been published, to the best of our knowledge.

Recently, an effort was directed towards studies of the marine diatom flora of the North Atlantic and the results were used for studies of climate change following the last deglaciation. The major objective of these studies was to decipher palaeoceanographical changes (Koc & Schrader, 1990; Koc & Jansen, 1992; Schrader *et al*., 1993a, b; Kohly, 1998; Wachnicka, 1999; Jozkow, 2000; Jiang *et al*., 2001; Witak *et al*., 2004).

Core SKPC-01B from the Skalafjord, Faeroe Islands has been analysed for diatoms. The Skalafjord penetrates into Eysturoy, the biggest of the Faeroe Islands (Fig. 1). Diatoms are well preserved and dominated by freshwater forms in the lowermost part and marine forms in the upper part. The focus is on the freshwater diatom flora from the lower part of the core. The sediments are of early Holocene age, and the flora is typical of high latitude nutrient-poor (oligotrophic to dystrophic) lakes (e.g. Cleve-Euler, 1951–1955; Lange-Bertalot & Metzeltin, 1996). The position of the freshwater deposits within the section and the weak representation of marine elements suggest that deposition took place before the threshold in the Skalafjord was inundated.

Geological setting

The Faeroe Islands consist of a group of islands in the North Atlantic situated between 61°20′N and 62°24′N and between 6°15′W and 7°41′W (Fig. 1). Geologically, they belong to

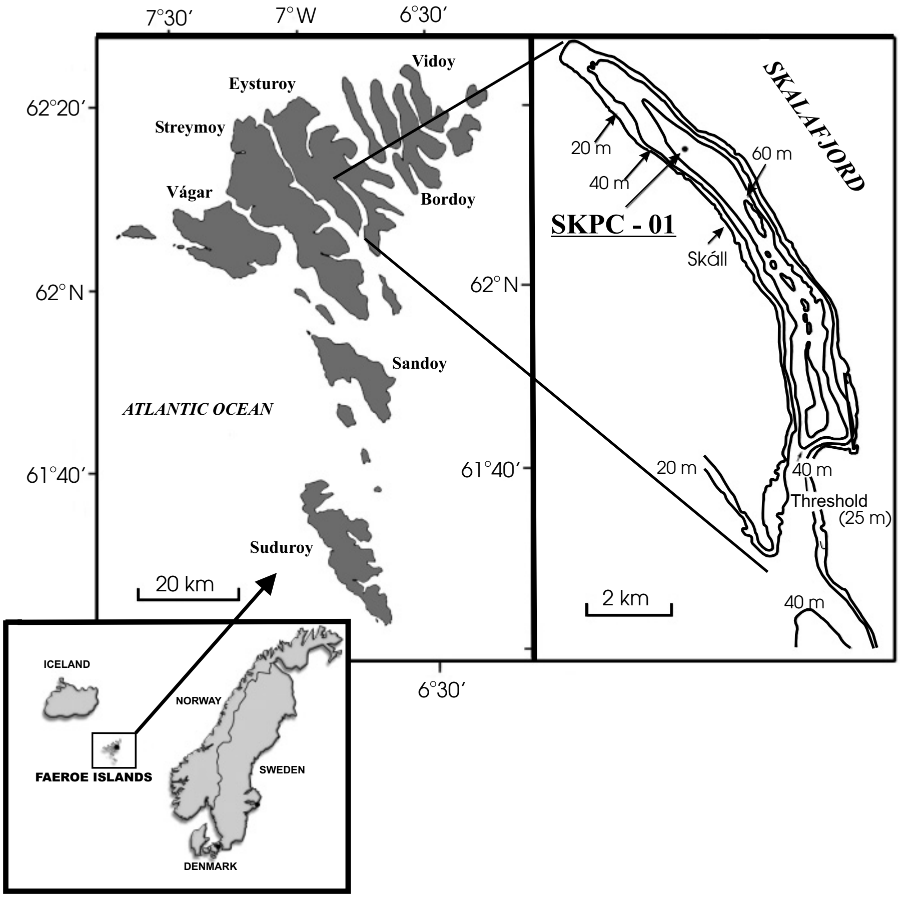

Fig. 1. Location of the core sampled in the Skalafjord, Faeroe Island.

the North Atlantic basalt province, and the whole area was influenced by Tertiary volcanism (Boldreel & Andersen, 1995; van Weering *et al*., 1998). During glacial periods, part of the North Faeroe shelf was exposed subaerially and may have been glaciated (Jørgensen & Rasmussen, 1986). Lakes and bogs are common throughout the islands, and the deposits within them provide Holocene palaeoenvironmental records (Grauert *et al*., 2001). Skalafjord is 13 km long with a greatest depth of around 70 m. At the entrance of the fjord a sill with a water depth of 25 m is present. The fjord is surrounded by 500–600 m high mountains. Post-glacial sediments in the fjord were deposited in two separate basins and have a maximum thickness of about 20 m (Juul, 1992).

MATERIAL AND METHODS

Core SKPC-01B was one of nine sediment cores retrieved from the Faeroe Islands during the September–October 1995 *R/V Skagerak* cruise organized by Göteborg University in collaboration with the Geological Survey of Denmark and Greenland (Fig. 1). The coring site was situated in the central part of the Skalafjord (62°10′70″N and 6°47′87″W) in a water depth of 50 m.

Samples were prepared in the manner of Håkansson & Ross (1984). Samples for diatom analyses were collected at 5 cm intervals. One gram of sediment was dried at 60° for 24 hours. The sediment was treated with 10% HCl to dissolve carbonates and then washed several times with distilled water. The siliceous material was gently boiled in concentrated (37%) H_2O_2 and washed several times with distilled water. The supernatant was decanted off after 20 hours. An aliquot of the shaken suspension was transferred by pipette to an 18 × 18 mm square coverslip. The coverslips were left to dry at room temperature. After evaporation, the coverslips were placed onto labelled slides. Permanent diatom preparations were mounted with Naphrax® (refractive index=1.78) and briefly heated to 200°C. Diatom analyses were performed with a LEICA DMLB light microscope, using × 100/1.25 planapochromatic oil-immersion objective. Scanning electron microscope analysis was performed by means of a Zeiss DSM 940 at 25 kV. In each sample more than 300 valves were counted. Diatoms were counted by the Schrader & Gersonde (1978) method.

Diatom identifications were based on the works of Podzorski (1985), Krammer & Lange-Bertalot (1986, 1991a, b, 1997, 2000), Sala e*t al*. (1993), Lange-Bertalot & Moser (1994), Lange-Bertalot & Metzeltin (1996), Metzeltin & Witkowski (1996), Witkowski e*t al*. (1996), Metzeltin & Lange-Bertalot (1998), Lange-Bertalot & Genkal (1999), Reichardt (1999), Lange-Bertalot (2001), Krammer (1992, 1997, 2000, 2002) and Håkansson (1990, 2002) for freshwater taxa and Witkowski *et al*. (2000) for marine forms. Diatoms were divided into groups according to their ecological requirements after Denys (1992), Hoffman (1994) and Van Dam *et al*. (1994).

Depth (cm)	Lab. no.	^{14}C age (bp)	Reservoir-corrected ^{14}C age (bp)	Calibrated age ±1d (bc)
50	AAR-6940	3380 ± 55	2980 ± 55	1370–1130
150	AAR-6941	6235 ± 60	5835 ± 60	4780–4620
183	AAR-6942	7465 ± 55	7065 ± 55	5990–5840

The calibrated ages in calendar years have been obtained from the calibration tables in Stuiver *et al.* (1998) by means of the 1998 version (4.0) of the Seattle CALIB program (Stuiver & Reimer, 1993).

Table 1. Results of AMS ^{14}C datings for the piston core SKPC-01B retreived from the Skalafjord, Faeroe Islands

The chronology of core SKPC-01B is based on three radiocarbon AMS ^{14}C analyses (Table 1) from macrofossil shells. The dating was performed at the University of Aarhus, Denmark. Calibrated ages in calendar years were obtained from Stuiver *et al.* (1998) by means of the Seattle calibration program CALIB version 4.0 (Stuiver & Reimer, 1993). Ages of certain levels in SKPC-01B were estimated through linear interpolation between the AMS ^{14}C dated levels assuming a constant sedimentation rate.

DISTRIBUTION OF FRESHWATER DIATOMS

Abundance and concentration

The core length studied is 230 cm, and it is characterized by predominantly homogeneous olive-grey clayey mud (Fig. 2). More or less corroded shell fragments were observed along the whole profile. Their quantity distinctly increased at 120–130 cm depth. At 108–118 cm the sediment was distinctly laminated and somewhat darker.

Within the whole sediment profile the diatoms represent two completely different environments. At a depth of 230–165 cm, taxa typical of limnic environments predominated (Fig. 3). Above 165 cm the flora is almost exclusively marine. The sediments representing these two different environments are connected by an apparently transitional section between 180–165 cm. In this part of the sediment profile a transition from limnic to marine conditions is recorded. First, in the section from 180–170 cm, a strong peak in marine diatoms occurs followed by a dominance of freshwater taxa in the sediment interval from 170–165 cm. These abrupt environmental changes took place during the period 7700–6400 years BP.

A total of 166 diatom taxa have been identified. In general, the preservation state was satisfactory but, at some levels, the valves were fragmented. Freshwater diatoms were represented by 121 taxa, brackish-water forms by 16 taxa and marine forms by 28 taxa. The freshwater flora was dominated by benthic species (126 species), while the planktonic flora consisted of 39 species.

In this paper the freshwater diatoms that occurred in the lowermost part of the core are described. Two diatom assemblage zones (DAZ) and several subzones are distinguished (Fig. 3). The first zone (DAZ-1) corresponds to the lower part of the core (230–165 cm). Two subzones were distinguished, DAZ-1a (depth interval 230–195 cm) and DAZ-1b (depth interval 195–165 cm) (Fig. 4). The following criteria were applied to distinguish the diatom assemblage zones:

- changes in the ratio between marine and freshwater taxa;
- habitat characteristics, i.e. planktonic versus benthic forms;
- diatom concentration in number of valves per 1 g of sediment.

DAZ-1a. The age of the boundary between subzone DAZ-1a and DAZ-1b sediments was estimated to be about 7700 ^{14}C years BP. Diatom zone DAZ-1 is characterized by abundant freshwater taxa and less abundant marine ones (Fig. 3). Diatom valves are usually very well preserved.

In diatom subzone DAZ-1a the proportion of marine taxa was very low. Planktonic forms showed a distinct upward

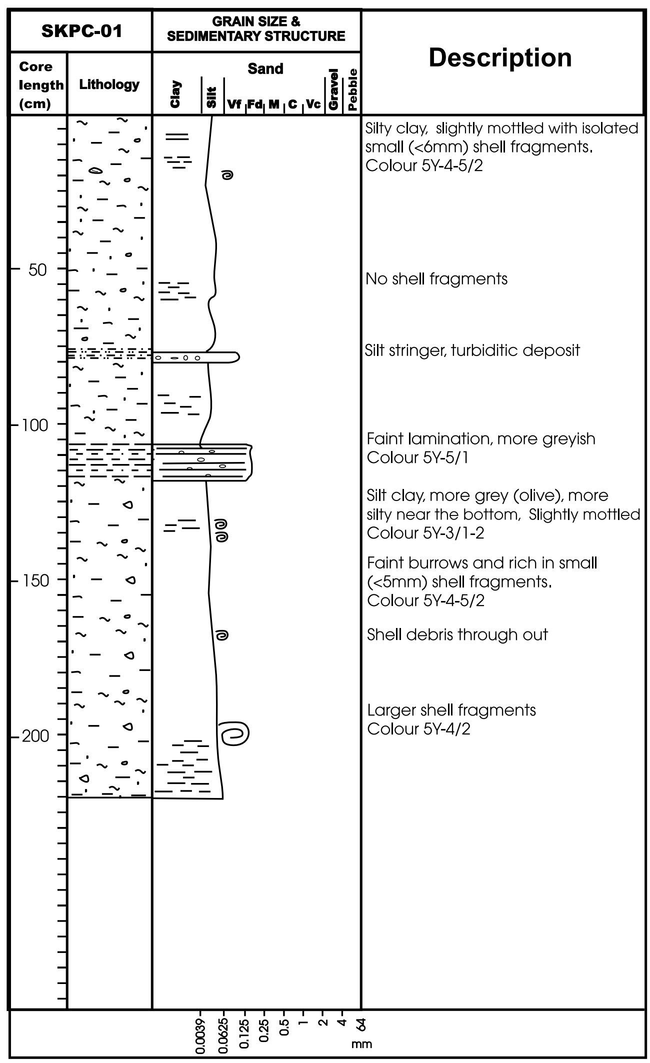

Fig. 2. Lithology of the core SKPC-01B.

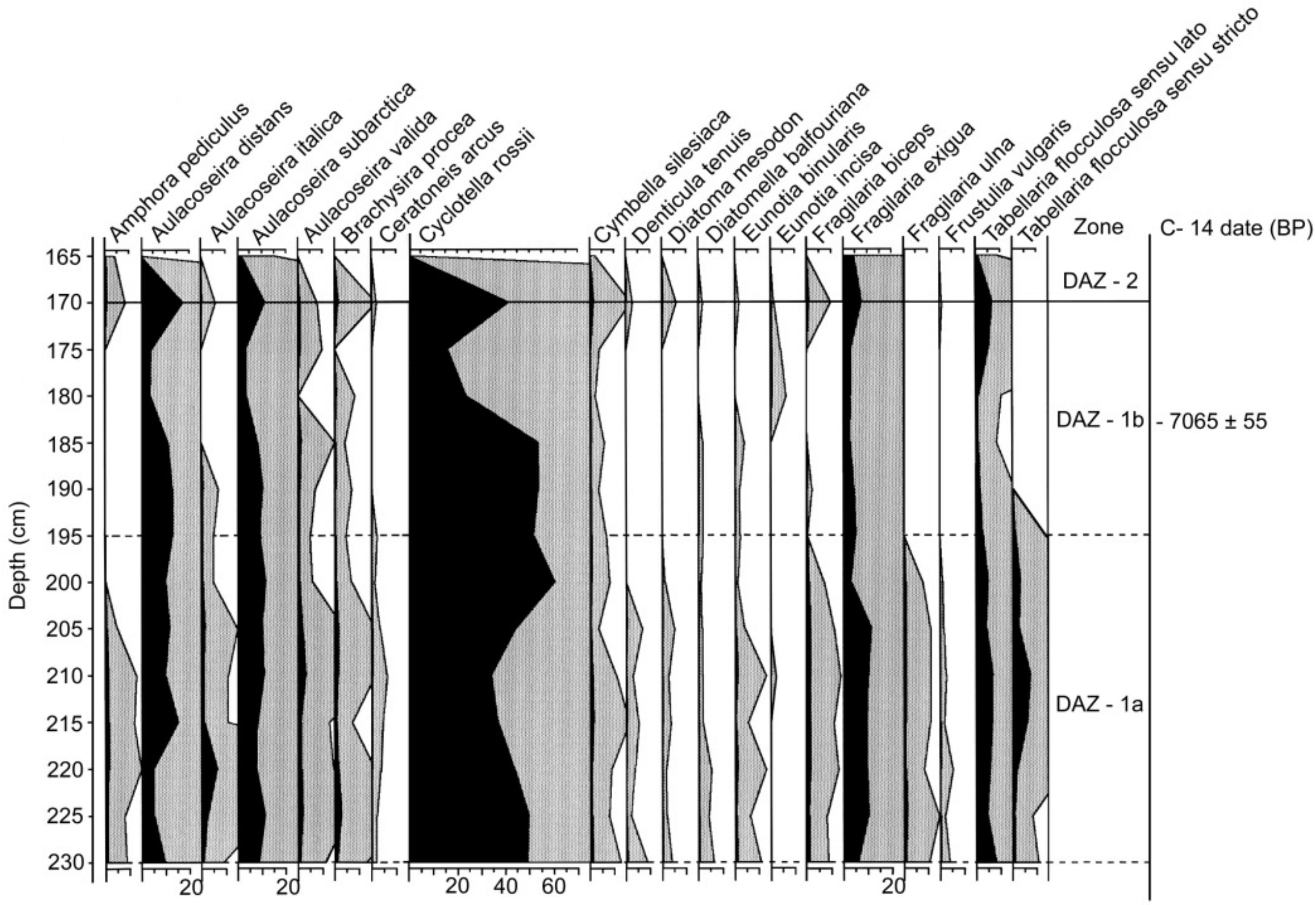

Fig. 3. Distribution and relative abundance the most common freshwater diatom taxa from core SKPC-01B from interval 165–230 cm. Solid area stands for % contents of ecological groups. dotted areas express contents of ecological groups with very low abundance in ‰.

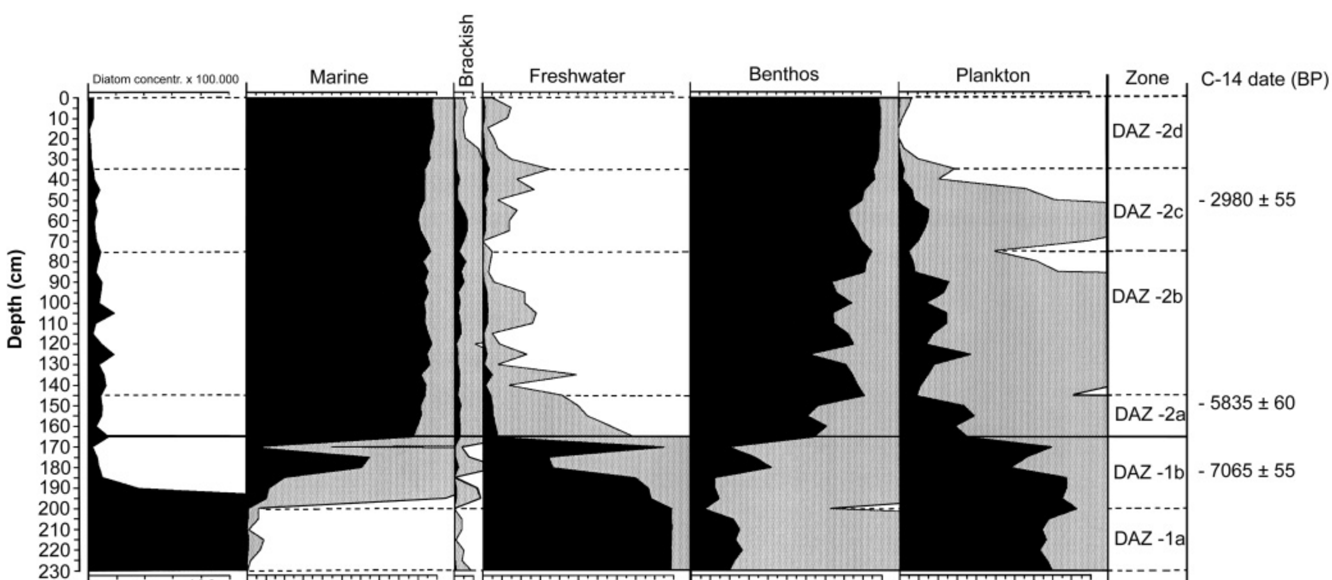

Fig. 4. Percentage diagram of diatom ecological groups core in SKPC-01B. Solid area stands for % contents of particular taxa. dotted areas express contents of taxa with very low abundance in ‰.

increase within this subzone. The concentration of diatom valves fell from 435×10^6 to 3.5×10^6 per 1 g of sediment. The most abundant taxa include *Cyclotella rossii* Håkansson (up to 60%), *Aulacoseira distans* (Ehrenberg) Simonsen (16%), *Fragilaria exigua* Grunow (12%), *Aulacoseira subarctica* (O. Müller) Haworth (12%) and *Tabellaria flocculosa* (Roth) Kützing (7%).

DAZ-1b. Diatom assemblage subzone DAZ-1b encompasses the sediment interval 195–165 cm. The age of the transition from subzone DAZ-1b to DAZ-2 was estimated to be about 6400 years BP. The bottom of the zone is marked by a drastic decrease in diatom valve concentration to *c.* 50×10^5 valves/g (Fig. 3). Freshwater taxa dominate, but in the interval 180–170 cm a peak of marine taxa is recorded. Amongst the predominant species are: *Paralia sulcata* (up to 30%), *Thalassiosira nordenskioeldii* (up to 17%), *Thalassiosira hyalina* (up to 9%) and *Odontella aurita* (up to 5%). Among the freshwater forms the following taxa were the most abundant: *C. rossii* (up to 53%), *A. distans* (up to 15%), *A. subarctica* (up. to 10%), *Fragilaria ulna* (up to 10%) and *T. flocculosa* (up to 10%). With respect to habitat, planktonic forms dominate with 50–80% (Fig. 4). Only in the section rich in marine forms is a peak in benthic forms (up to 40%) seen.

DISCUSSION

The development of the Skalafjord since the last deglaciation was studied by Bennike *et al*. (1998; macrofossils in core SKPC-18), Jozkow (2000; diatoms in core SKPC-18) and Wachnicka (1999; diatoms in core DAPC-01).

The diatom record in core SKPC-01B provides excellent documentation of the Holocene development of the Faeroe Islands area – the best record of Early Holocene changes known so far. Well-preserved lacustrine deposits at a similar altitude within the Skalafjord were also studied by Jozkow (2000). However, the upper part of core SKPC-18 studied by Jozkow (2000) apparently did not contain the complete record of the diatom flora.

The sediments of core SKPC-01B show two distinct developmental stages. The first one recorded in the lowermost part of the core, subzone DAZ-1a, encompasses lacustrine sediments with a very low content of marine- and brackish-water diatoms. As the proportion between fully marine taxa and brackish-water ones is similar, it is assumed that no permanent connection existed between the central part of the fjord and the ocean. Apparently, diatoms of a marine origin were transported into the Skalafjord during storms. It appears that relative sea-level was below the threshold.

The species composition recorded in subzone DAZ-1b indicates the existence of a lake with abundant planktonic diatoms dominated by *C. rossii* and *F. ulna* (Fig. 4). Their vertical distributions do not show any dramatic changes, implying rather stable conditions. Sporadic inflow of marine waters did not cause any spectacular changes during this developmental stage. Environmental conditions of diatoms in subzone DAZ-1a indicate oligotrophic to mesotrophic waters (Krammer & Lange-Bertalot, 1986, 1997, 1991a, b, 2000; Håkansson, 1990; Denys, 1992; Hoffman, 1994; Van Dam *et al*., 1994). It is likely that the dominating taxon, *C. rossii*, formed blooms. Most of the taxa recorded in DAZ-1a are typical for oligotrophic to dystrophic waters (e.g. Lange-Bertalot & Metzeltin, 1996) accompanied by, for example, *A. distans*, *F. exigua* and the *T. flocculosa* complex (Fig. 4). Generally, within DAZ-1a, a continuous distribution of freshwater taxa is observed. Several of these taxa have been recently described (e.g. Lange-Bertalot & Metzeltin, 1996; Krammer, 2000, 2002) or are known only from very few localities. e.g. *Fragilaria opacolineata* Lange-Bertalot, *Stauroneis neohyalina* Lange-Bertalot, *Gomphonema subtile* Ehrenberg, *Pinnularia ovata* Krammer, *Pinnularia platycephala* Krammer and *Pinnularia turbulenta* Krammer.

The Skalafjord lake formed after the last deglaciation of the area at *c.* 10 000 years BP (core SKPC-18; Bennike *et al*., 1998). The diatom record of the early stages of lake development is recorded by Jozkow (2000). The chronology of core SKPC-18 was established from ^{14}C dating and tephra chronology based on the Saksunarvatn ash (Bennike *et al*., 1998). Diatom analysis of this core revealed a species composition very similar to that in core SKPC-01B, with *C. rossii* as the dominant species. As core SKPC-01B did not penetrate the Saksunarvatn ash and the uppermost part of the former core is disturbed, these two cores complement each other. Core SKPC-18 provides a record of the early stages of lake development, while core SKPC-01B records the later stage including the transition from lacustrine to marine conditions.

Bennike *et al*. (1998) determined the inundation of the threshold and the change from lacustrine to marine conditions in core SKPC-18 at *c.* 7800 ^{14}C years BP. They also determined the relative sea-level which at that time was *c.* 25 m below the present sea-level. However, in core SKPC-01B, the transition between lacustrine and marine conditions is dated between 7700 years BP and 6400 years BP. Previously, studies of the benthic foraminiferal fauna of the fjord (Juul, 1992) indicated that the marine transgression occurred around 7500 ^{14}C years BP. In addition the diatom species composition prior to the change from lacustrine to marine conditions shows a rise in marine diatoms at 185–180 cm. In the overlying section (180–165 cm) lacustrine taxa with *C. rossii* dominate again, with a distinct decrease in marine forms.

The effect of a tsunami, triggered by the Storegga Slide, has been documented in Norway and Britain (e.g. Dawson *et al*., 1988; Bondevik *et al*., 1997). Deposits resulting from this event were recognized by Grauert *et al*. (2001) in Lake Vagur on Suduroy Island, which is located south of Skalafjord. The lithology (redeposited organic material and marine microfossils) marks the tsunami section. The age of the tsunami event was estimated at *c.* 7200 years BP. In core SKPC–01B the rapid increase in marine taxa between 180 cm and 170 cm (Fig. 3) may signal an inflow of marine waters. As there is no simultaneous change in lithology it appears that this event did not significantly affect sedimentation processes in the lake. Therefore, this event may instead have been caused by a storm surge. The change in diatom flora at 180–170 cm in core SKPC-01B may be evidence of one of the first large-scale inflows of marine waters prior to the inundation of the threshold. It may be assumed that the relative sea-level at that time was a few metres lower than 25 m, as limnic conditions were re-established in the basin after termination of the marine inflow. The beginning of environmental change from lacustrine conditions, which resulted in the establishment of the marine environment, is dated between

7000 ^{14}C years BP and 6400 ^{14}C years BP, implying that environmental change took place rather rapidly.

Diatom analysis of subzone DAZ-1b shows that the lake in Skalafjord was affected by a strong inflow (possibly catastrophic) of marine waters. This phenomenon happened somewhat later than 7700 ^{14}C years BP. However, towards the top of this subzone lacustrine conditions were re-established. The development of the lake in the Skalafjord implies that the Storegga Slide led to inflow of marine waters at a distinctly lower water level in the area of Eysturoy and that the inundation of the threshold in the fjord happened after the tsunami. The lithology of this part of the core indicates that the tsunami impact in this area was relatively weak.

ACKNOWLEDGEMENTS

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APPENDIX A: TAXONOMIC NOTE

Either the dominating or interesting taxa are listed below and the sources of their identification are given. The identification was primarily based on the diatom flora of middle Europe by Krammer & Lange-Bertalot (1986, 1991a, b, 1997). The reason for choosing this was that all the taxa treated in these references are illustrated with relevant LM micrographs. For the complete list of taxa see Appendix B.

Achnanthes holstii Cleve
Lit.: Krammer & Lange-Bertalot (1991b, p. 33, fig. 18: 14–17)
Pl. 3, fig. 16

Achnanthes pusilla (Grunow) de Toni
Syn.: *Achnanthes* (*linearis* var.?) *pusilla* Grunow in Cleve & Grunow
Lit.: Krammer & Lange-Bertalot (1991b, p. 67, fig. 37: 9–18)
Pl. 3, figs 11–13

Amphora inariensis Krammer
Lit.: Krammer & Lange-Bertalot (1986, p. 310, fig. 96: 18–20)
Pl. 5, figs 10–12

Amphora veneta Kützing
Lit.: Krammer & Lange-Bertalot (1986, p. 348, fig. 151: 7–17)
Pl. 5, figs 8, 9

Aneumastus rostratus (Hustedt) Lange-Bertalot
Syn.: *Navicula tuscula* var. *rostrata* Hustedt; *Navicula tusculoides* Cleve-Euler
Lit.: Lange-Bertalot (2001, p. 156, fig. 118: 1–6)
Pl. 5, fig. 18

Aulacoseira distans (Ehrenberg) Simonsen
Syn.: *Gallionella distans* Ehrenberg; *Melosira distans* (Ehrenberg) Kützing
Lit.: Krammer & Lange-Bertalot (1991a, p. 32, fig. 29: 1–23, fig. 30: 1–11)
Pl. 1, figs 6–11

Aulacoseira italica (Ehrenberg) Simonsen
Syn.: *Gallionella italica* Ehrenberg; *Melosira italica* (Ehrenberg) Kützing
Lit.: Krammer & Lange-Bertalot (1991a, p. 29, fig. 24: 1, 3–6, fig. 25: 1–11)
Pl. 1, fig. 21

Aulacoseira subarctica (O. Müller) Haworth
Syn.: *Melosira italica* ssp. *subarctica* O. Müller; *Aulacoseira italica* ssp. *subarctica* (O. Müller) Simonsen
Lit.: Krammer & Lange-Bertalot (1991a, p. 28, fig. 23: 1–11, fig. 2: 1)
Pl. 1, figs 16, 17

Aulacoseira valida (Grunow) Krammer
Syn.: *Melosira crenulata* var. *valida* Grunow in Van Heurck. *Melosira italica* var. *valida* (Grunow) Hustedt. *Aulacoseira italica* var. *valida* (Grunow) Simonsen
Lit.: Krammer & Lange-Bertalot (1991a, p. 32, fig. 28: 1–11)
Pl. 1, figs 18–20

Brachysira brebissonii Ross
Bas.: *Navicula aponina* var. *brachysira* Brébisson ex Kützing
Syn.: *Anomoeoneis brachysira* (Brébisson ex. Rabenhorst) Grunow *in* Cleve
Lit.: Lange-Bertalot & Moser (1994, p. 20, fig. 12: 6, fig. 41: 1–18, fig. 44: 1–10)
Pl. 12, fig. 9

Brachysira zellensis (Grunow) Round & Mann
Bas.: *Navicula zellensis* Grunow
Syn.: *Anomoeoneis zellensis* (Grunow) Cleve; *Anomoeoneis brachysira* var. *zellensis* (Grunow) Krammer
Lit.: Lange-Bertalot & Moser (1994, p. 73, fig. 11: 24–28, fig. 12: 5)
Pl. 12, fig. 10

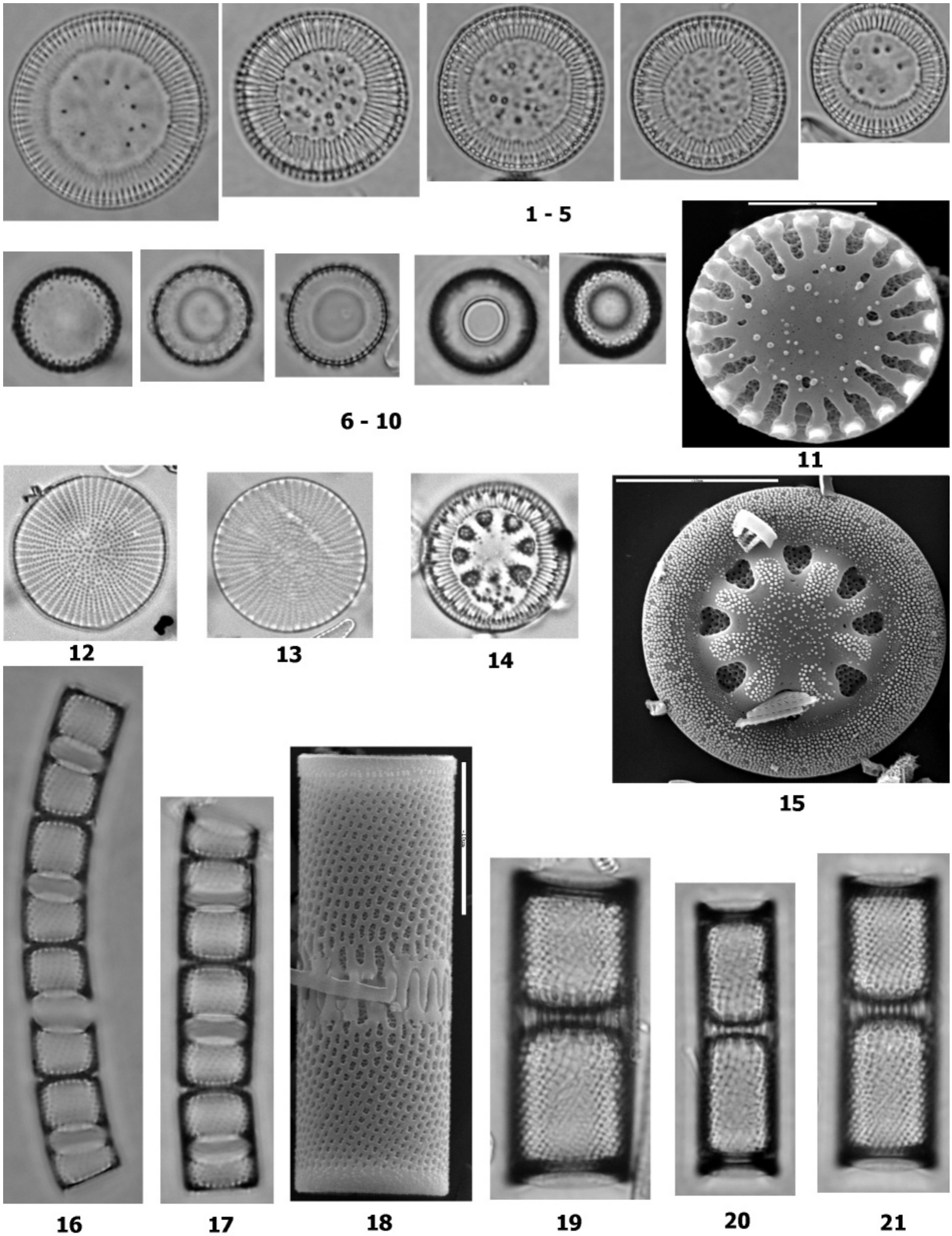
Caloneis cf. *bacillum* (Grunow) Cleve
Syn.: *Stauroneis bacillum* Grunow; *Navicula fasciata* Lagerstedt; *Caloneis fasciata* (Lagerstedt) Cleve; (?)*Caloneis bacillaris* (Gregory) Cleve
Lit.: Krammer & Lange-Bertalot (1986, p. 390, fig. 174: 9–20)
Pl. 10, figs 10, 11

Caloneis pulchra Messikommer
Lit.: Krammer & Lange-Bertalot (1986, p. 392, fig. 173: 1–4)
Pl. 10, fig. 14

Caloneis tenuis (Gregory) Krammer
Syn.: *Pinnularia tenuis* Gregory; *Pinnularia gracillima* Gregory
Lit.: Krammer & Lange-Bertalot (1986, p. 392, fig. 174: 5–10)
Pl. 10, fig. 13

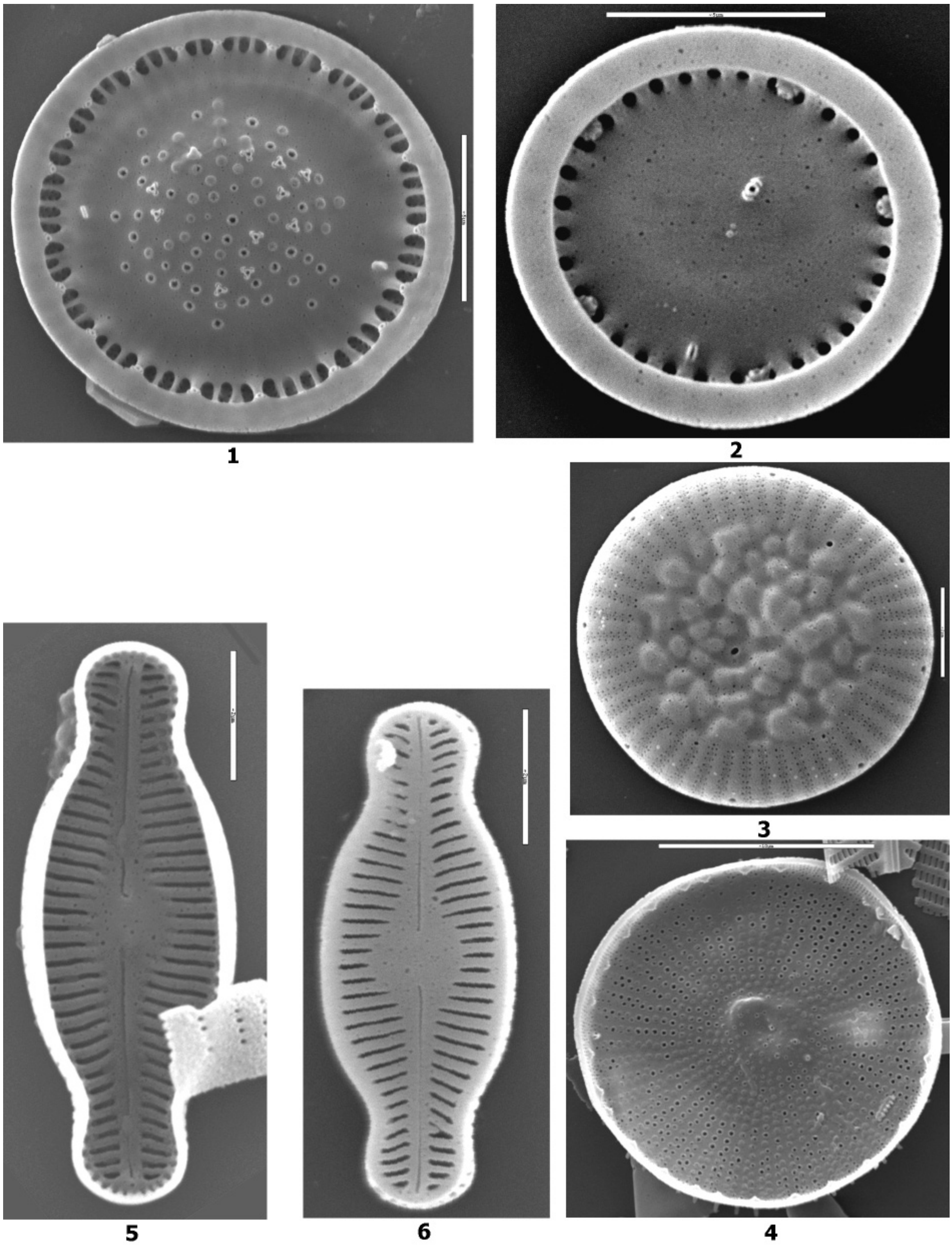
Caloneis undulata (Gregory) Krammer
Syn.: *Pinnularia undulata* Gregory
Lit.: Krammer & Lange-Bertalot (1986, p. 394, fig. 175: 1–6)
Pl. 10, fig. 12

Ceratoneis arcus (Ehrenberg) Kützing var. *arcus*
Syn.: *Fragilaria arcus* var. *arcus* (Ehrenberg) Cleve; *Ceratoneis amphioxys* Rabenhorst; *Ceratoneis arcus* var. *amphioxys* (Rabenhorst) Brun; *Ceratoneis arcus* var. *linearis*



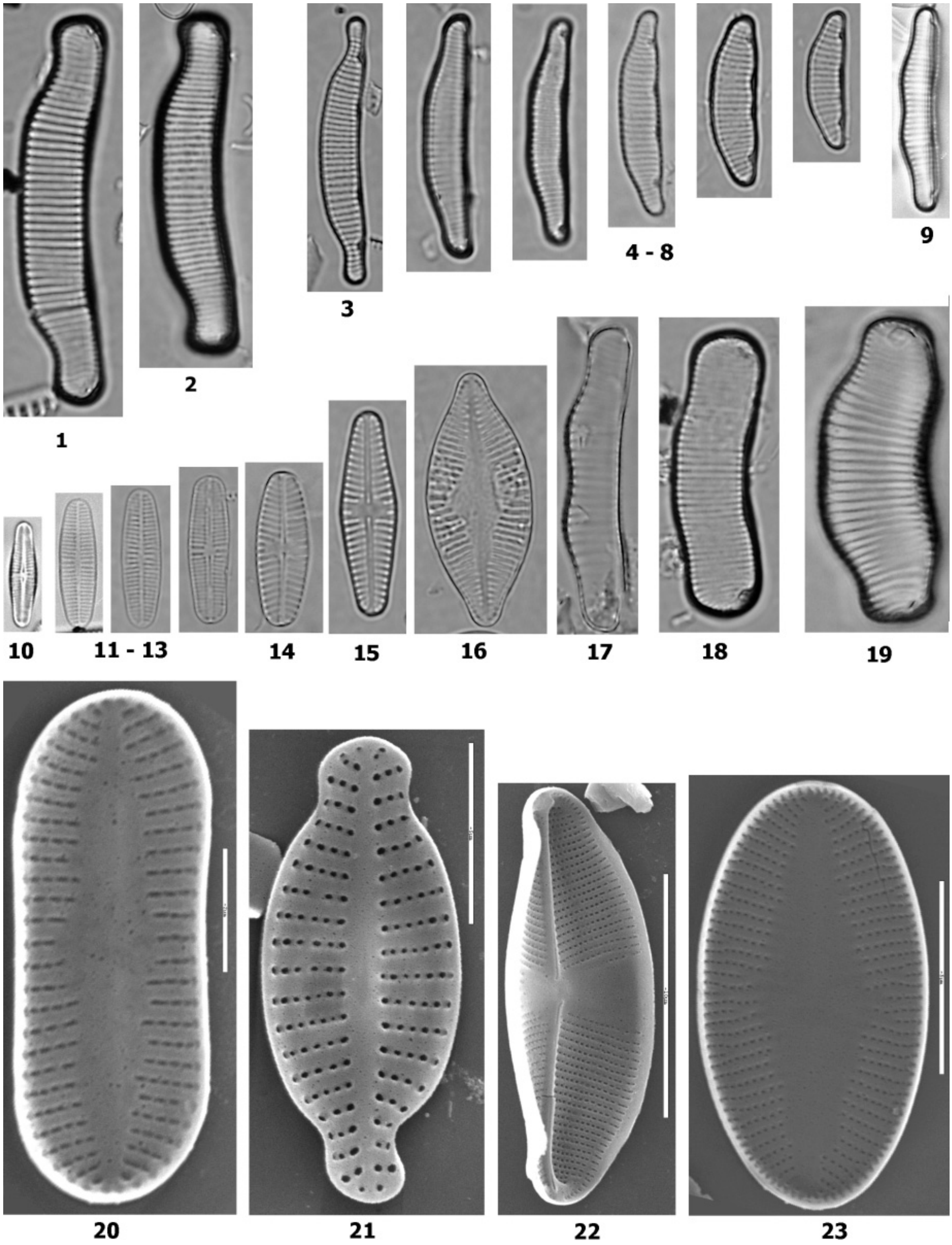
Explanation of Plate 1.

figs 1–5. *Cyclotella rossii* Håkansson. **figs 6–11.** *Aulacoseira distans* (Ehrenberg) Simonsen. **figs 12, 13.** *Cyclostephanus invisitatus* (Hohn & Hellerman) Theriot, Stoermer & Håkansson. **figs 14, 15.** *Cyclotella antiqua* W. Smith. **figs 16, 17.** *Aulacoseira subarctica* (O. Müller) Haworth. **figs 18–20.** *Aulacoseira valida* (Grunow) Krammer. **fig. 21.** *Aulacoseira italica* (Ehrenberg) Simonsen. figs 1–10, 12–14, 16–17, 19–21 LM micrographs (magnification ×1500); figs 11, 15, 18 SEM micrographs (scale bars: 11=5 µm; 15, 18=10 µm).



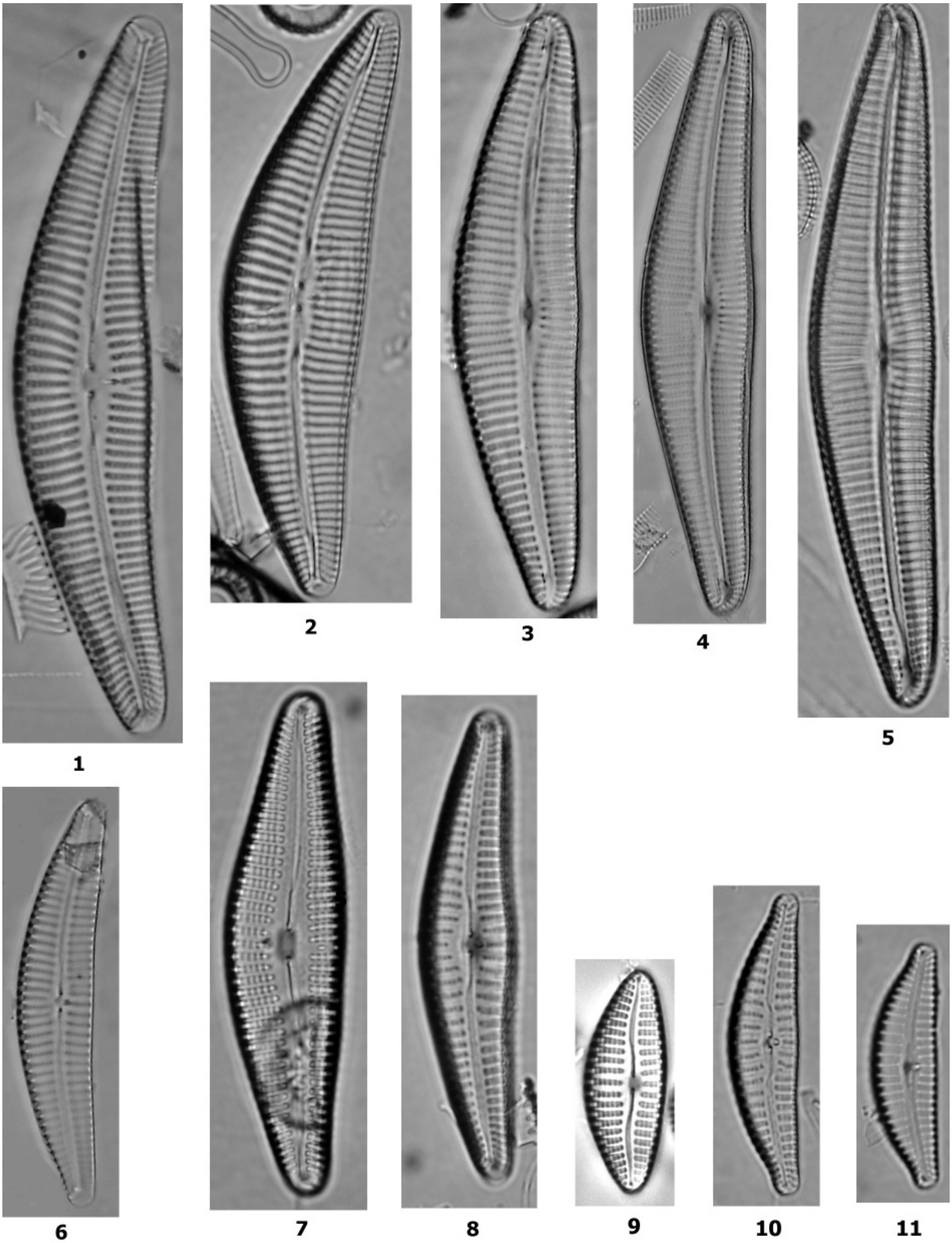
Explanation of Plate 2.

fig. 1. *Cyclotella radiosa* (Grunow) Lemmermann. **figs 2, 3.** *Cyclotella rossi* Håkansson. **fig. 4.** *Cyclostephanus invisitatus* (Hohn & Hellerman) Theriot, Stoermer & Håkansson. **figs 5, 6.** *Navicula schmasmannii* Hustedt. All SEM micrographs (scale bars: 1, 2=5 μm; 3, 5, 6=2 μm; 4=10 μm).



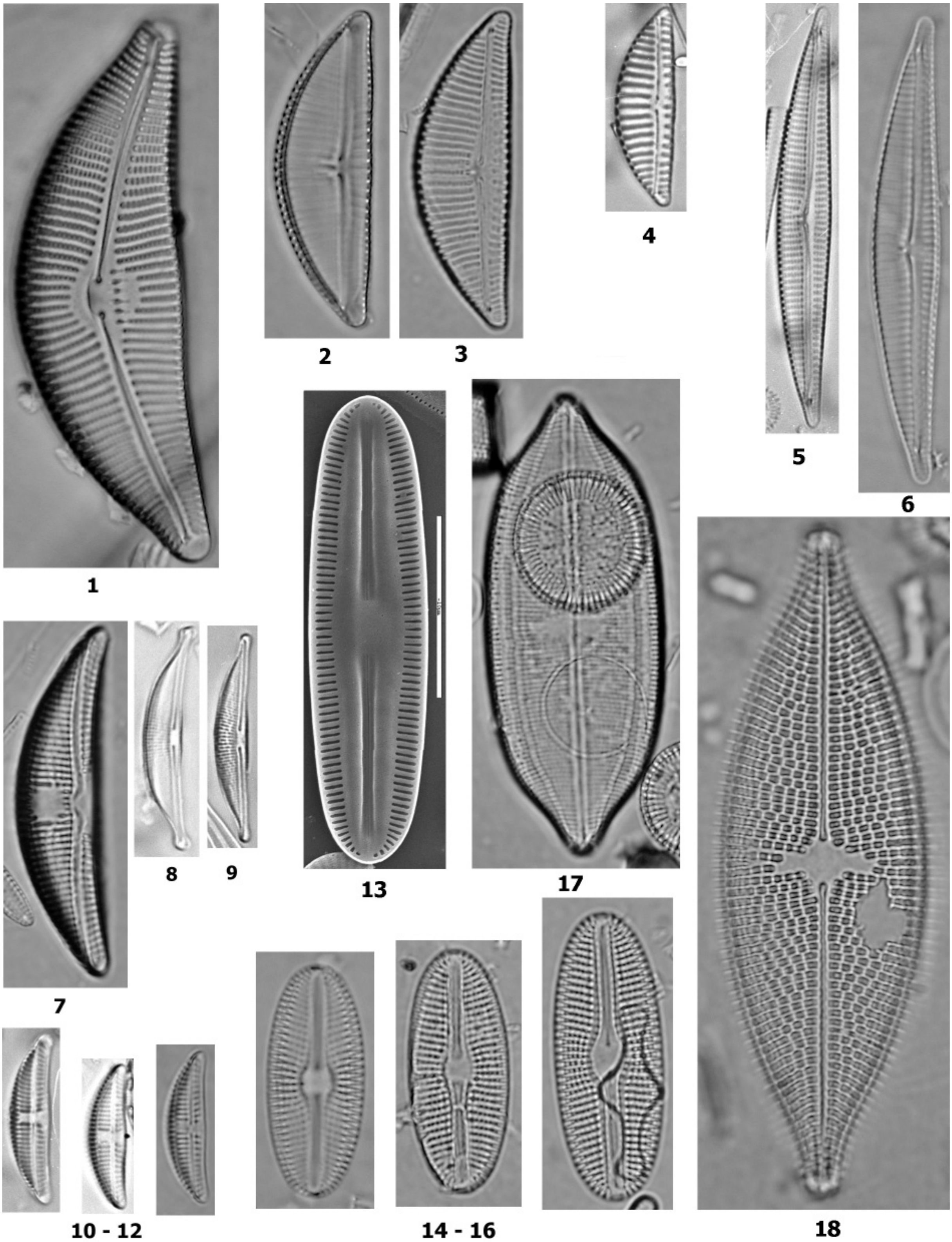
Explanation of Plate 3.

figs 1, 2. *Eunotia arcus* Ehrenberg. **fig. 3.** *Eunotia boreoalpina* Lange-Bertalot & Nörpel-Schempp. **figs 4–8.** *Eunotia incisa* Gregory. **fig. 9.** (?)*Eunotia implicata* Nörpel-Schempp, Lange-Bertalot & Alles. **fig. 10.** *Achnanthes minutissima sensu* auct. nonnull. **figs 11–13.** *Achnanthes pusilla* (Grunow) De Toni. **figs 14, 15.** *Achnanthes lanceolata* (Brébisson) Grunow. **fig. 16.** *Achnanthes holstii* Cleve. **fig. 17.** *Eunotia circumborealis* Nörpel-Schempp & Lange-Bertalot. **fig. 18.** *Eunotia media* A. Cleve. **fig. 19.** *Eunotia praerupta* Ehrenberg. **fig. 20.** *Achnanthes didyma* Hustedt. **fig. 21.** *Achnanthes laterostrata* Hustedt. **fig. 22.** *Eucocconeis laevis* (Østrup) Lange-Bertalot. **fig. 23.** (?)*Achnanthes daonensis* Lange-Bertalot. figs 1–19 LM micrographs (magnification $\times 1500$); figs 20–23 SEM micrographs (scale bars: 20=2 μm; 21, 23=5 μm; 22=10 μm).



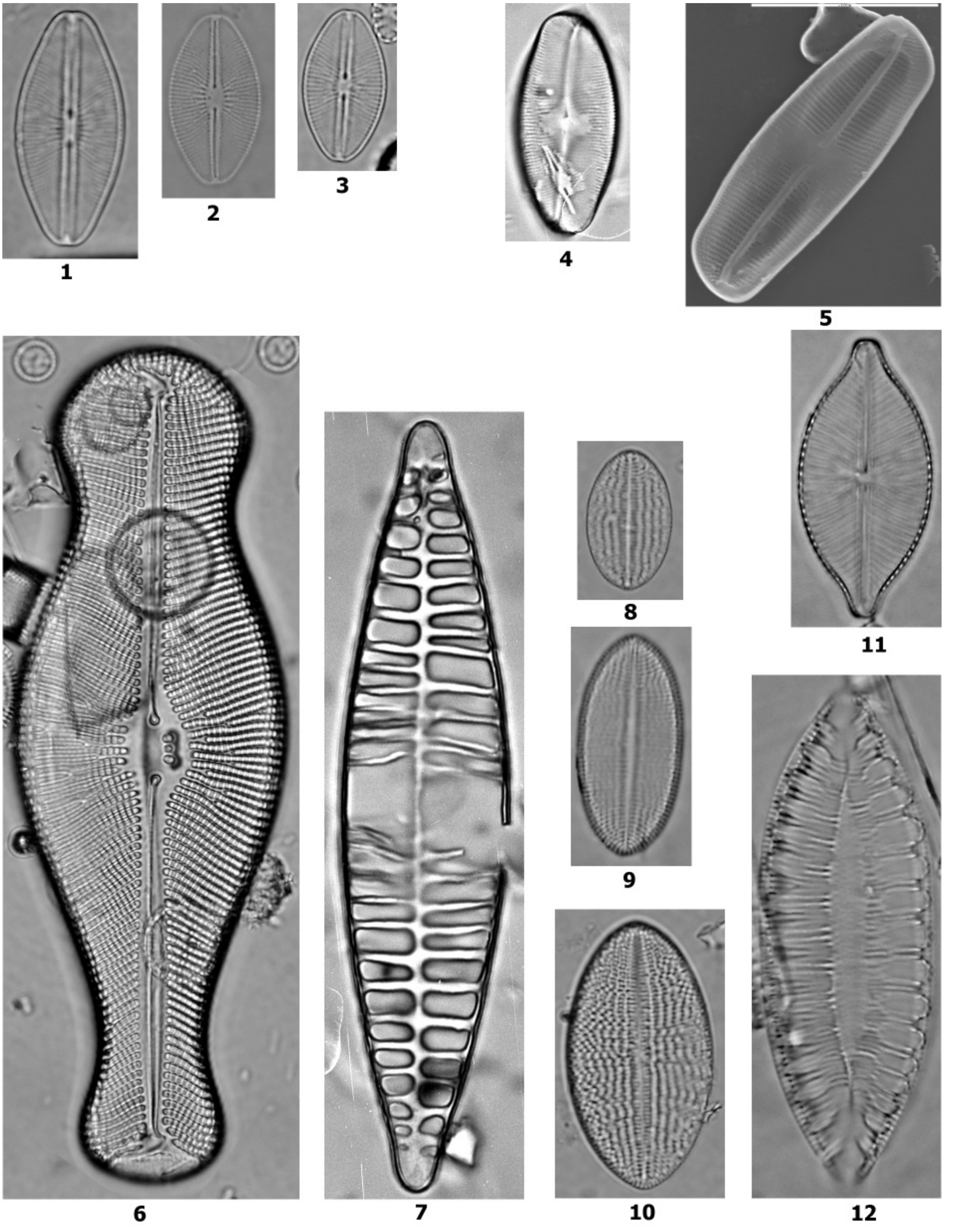
Explanation of Plate 4.

figs 1, 2. *Cymbella* spec. cf. *helvetica* Kützing. **figs 3–5.** *Cymbella lange-bertalotii* Krammer. **fig. 6.** *Cymbella vulgata* Krammer. **figs 7, 8.** *Cymbella neoleptoceros* var. *tenuistriata* Krammer. **fig. 9.** *Cymbella pervarians* Krammer. **figs 10, 11.** *Cymbella* cf. *subtruncata* Krammer. All LM micrographs (magnification ×1500).



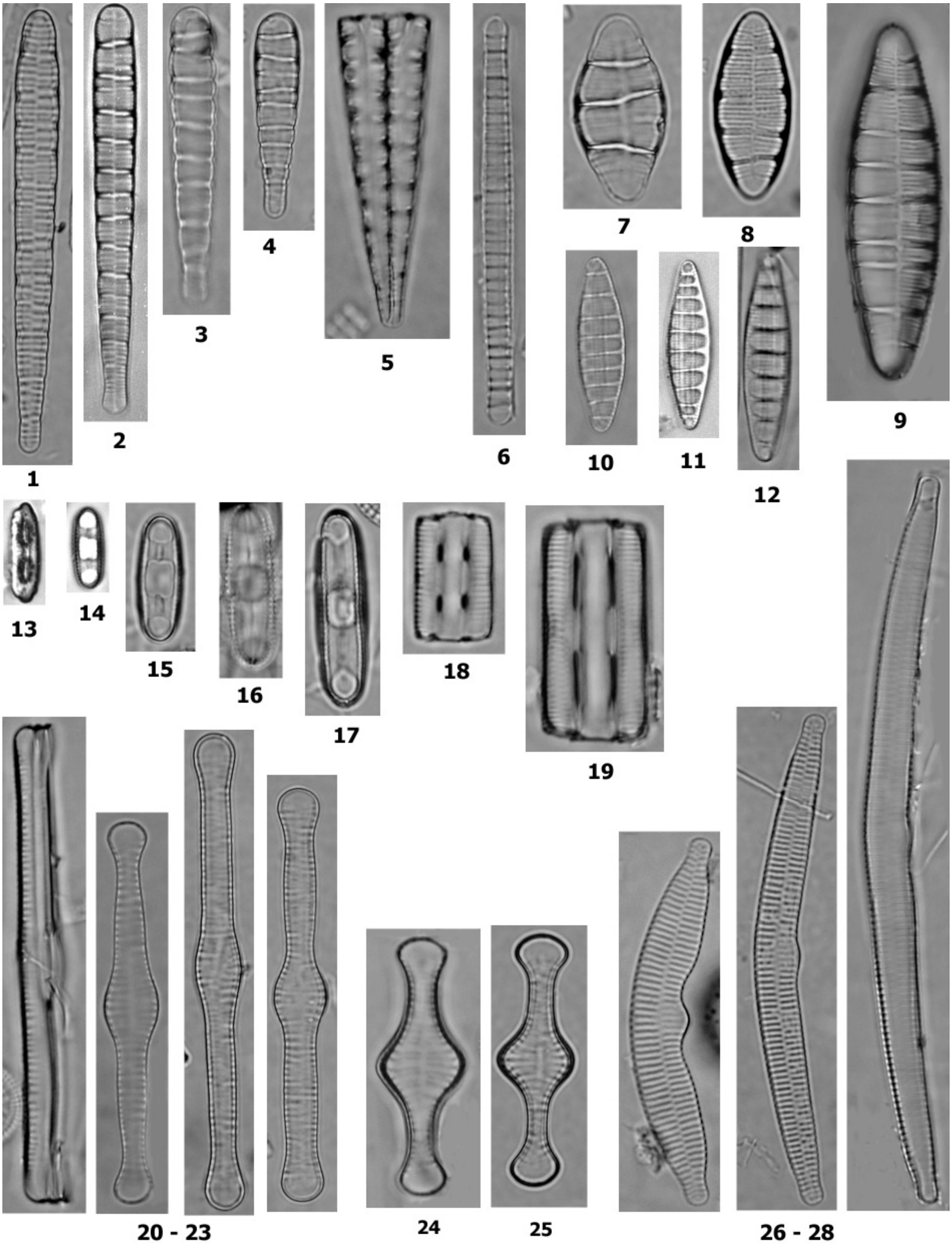
Explanation of Plate 5.

fig. 1. *Cymbella proxima* Reimer. **figs 2, 3.** *Encyonema silesiacum* (Bleisch) D.G. Mann. **fig. 4.** *Encyonema procerum* Krammer. **figs 5, 6.** *Encyonema neogracile* Krammer. **fig. 7.** *Amphora copulata* (Kützing) Schoeman & Archibald. **figs 8, 9.** *Amphora veneta* Kützing. **figs 10–12.** *Amphora inariensis* Krammer. **fig. 13.** *Diploneis petersenii* Hustedt. **figs 14–16.** *Diploneis pseudovalis* Hustedt. **fig. 17.** *Neidium apiculatum* Reimer. **fig. 18.** *Aneumastus rostratus* Lange-Bertalot. figs 1–12, 14–18 LM micrographs (magnification ×1500); fig. 13 SEM micrograph (scale bar: 10 μm).



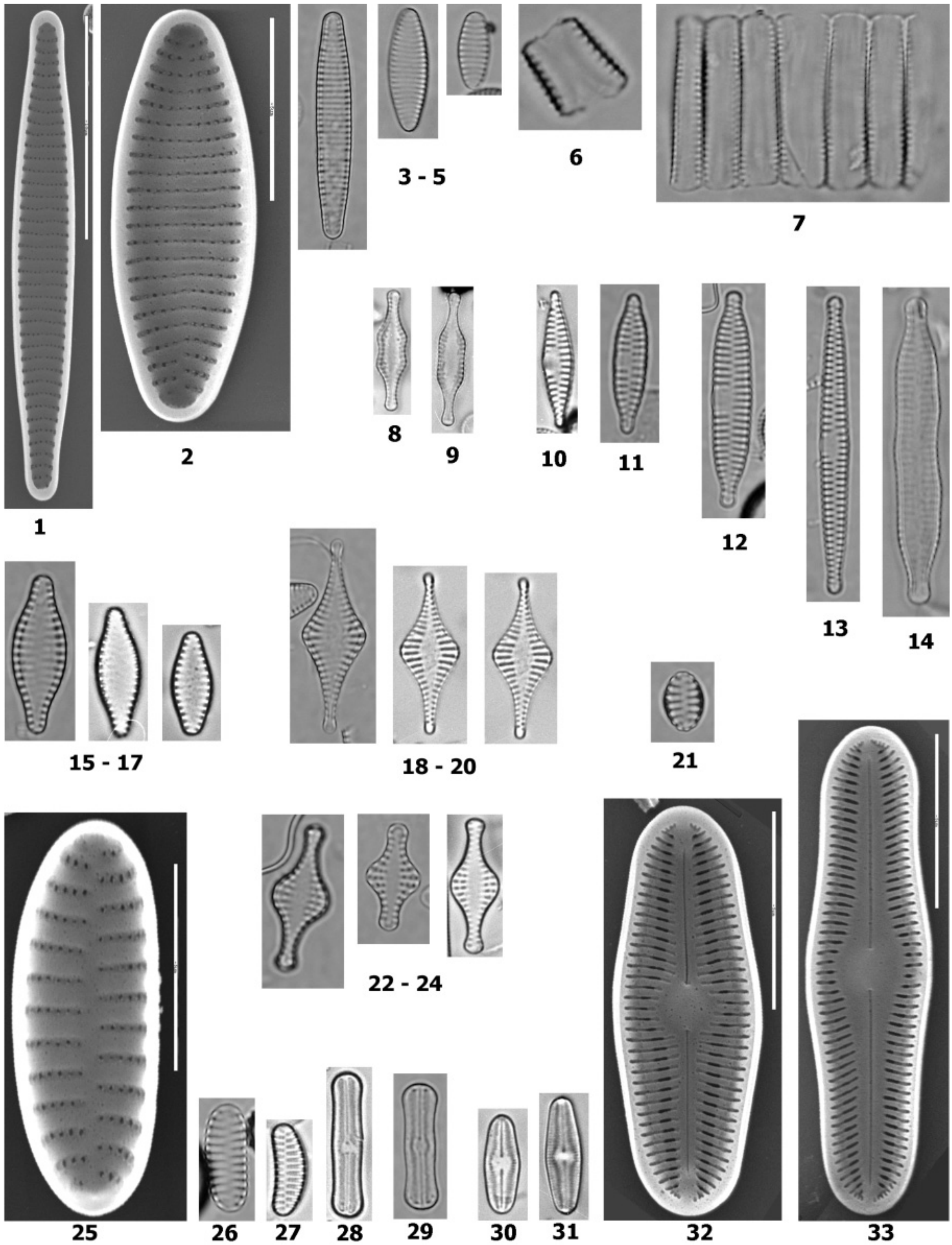
Explanation of Plate 6.

figs 1–3. *Cavinula cocconeiformis* (Gregory) D.G. Mann & Stickle. **fig. 4.** *Eucocconeis flexella* (Kützing) Cleve var. *flexella*. **fig. 5.** *Eucocconeis alpestris* (Brun) Lange-Bertalot. **fig. 6.** *Didymosphenia geminata* (Lyngbye) M. Schmidt, Morphotyp *geminata sensu* Metzeltin & Lange-Bertalot (1995). **fig. 7.** *Craticula cuspidata* (Kützing) D. G. Mann. **figs 8–10.** *Cocconeis placentula* var. *lineata* (Ehrenberg) Van Heurck. **fig. 11.** *Placoneis* cf. *clementis* (Grunow). **fig. 12.** *Surirella amphioxys* W. Smith. figs 1–4, 6–12 LM micrographs (magnification ×1500); fig. 5 SEM micrograph (scale bar: 10 µm).



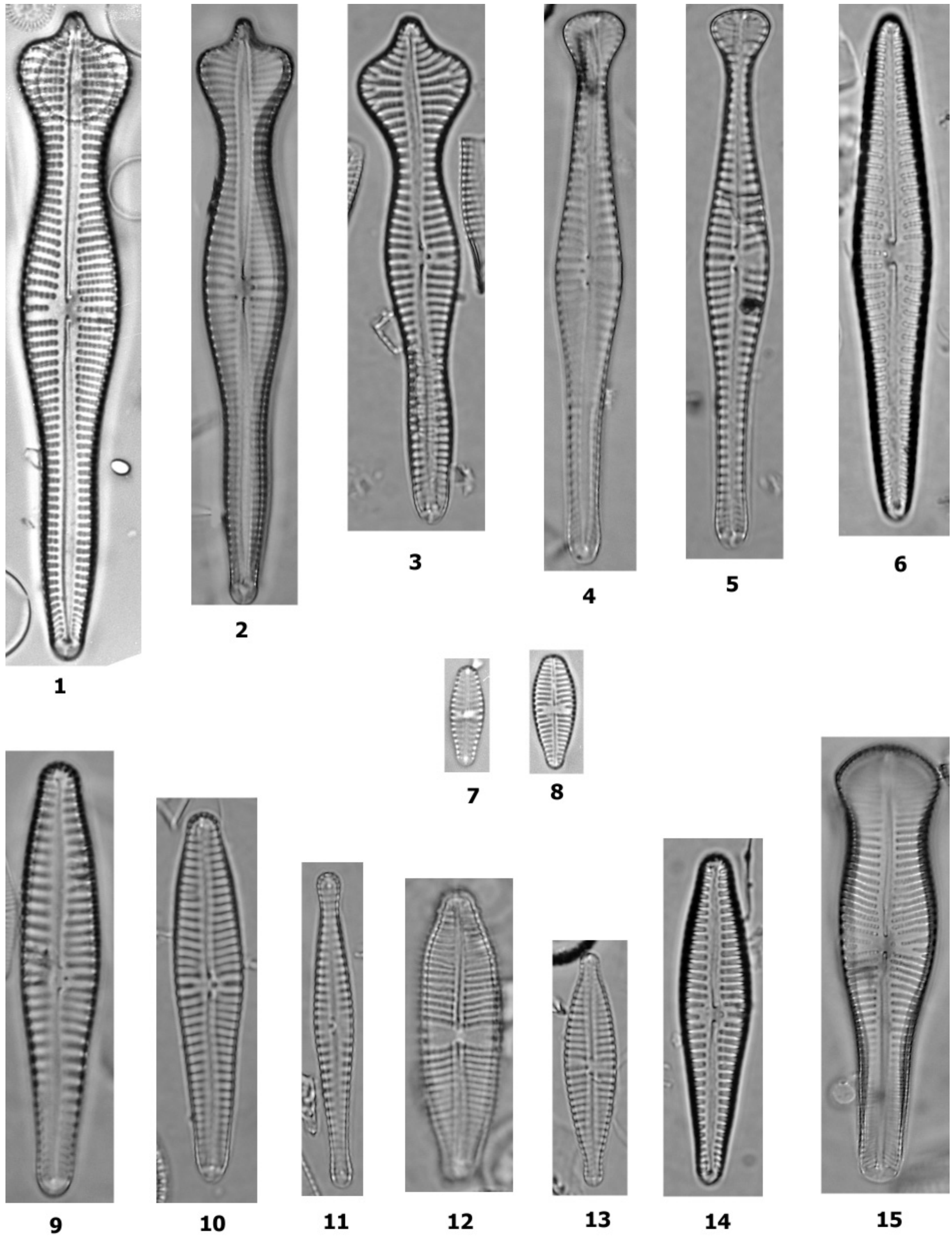
Explanation of Plate 7.

figs 1–5. *Meridion circulare* (Greville) Agardh. **fig. 6.** *Diatoma tenuis* Agardh. **figs 7–9.** *Diatoma mesodon* (Ehrenberg) Kützing. **figs 10–12.** *Denticula tenuis* Kützing. **figs 13–19.** *Diatomella balfouriana* Greville. **figs 20–23.** *Tabellaria flocculosa sensu lato* (Roth) Kützing. **figs 24, 25.** *Tabellaria flocculosa sensu stricto* (Roth) Kützing. **figs 26–28.** *Ceratoneis arcus* (Ehrenberg) Kützing var. *arcus*. All LM micrographs (magnification ×1500).



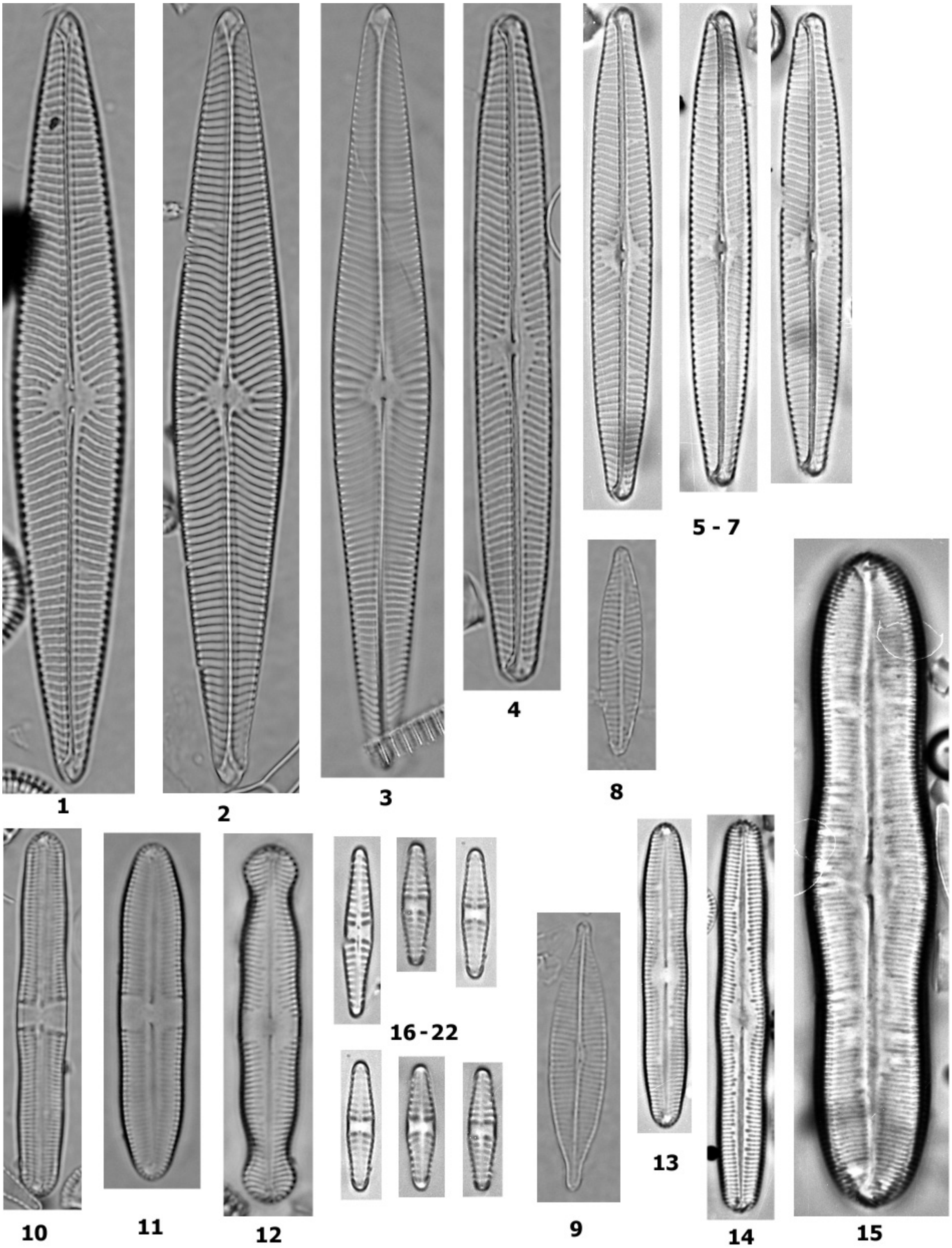
Explanation of Plate 8.

figs 1–5, 7. *Fragilaria exigua* Grunow. **fig. 6.** *Staurosira martyi* (Héribaud) Bukhtiyarova. **figs 8, 9.** *Fragilaria construens* var. *binodis* fo. *borealis*? Foged. **figs 10, 11.** *Fragilaria capucina* var. *perminuta* (Grunow) Lange-Bertalot. **fig. 12.** *Fragilaria capucina* var. *vaucheriae* (Kützing) Lange-Bertalot. **fig. 13.** *Fragilaria capucina* var. *distans* (Grunow) Lange-Bertalot. **fig. 14.** *Fragilaria alpestris* Krasske. **figs 15–17.** *Fragilaria opaclineolata* Lange-Bertalot. **figs 18–20.** *Fragilaria parasitica* (W. Smith) Grunow. **fig. 21.** *Staurosira construens* (Ehrenberg) Grunow. **figs 22–24.** *Staurosira pseudoconstruens* (Marciniak) Lange-Bertalot. **figs 25–27**. *Staurosira* sp.. **figs 28, 29.** *Diadesmis biceps* Arnott. **figs 30–33.** *Diadesmis perpusilla* (Grunow) Lange-Bertalot. figs 3–24, 26–31 LM micrographs (magnification ×1500); figs 1, 2, 25, 32, 33 SEM micrographs (scale bars: 1=10 μm; 2, 25, 32, 33=5 μm).



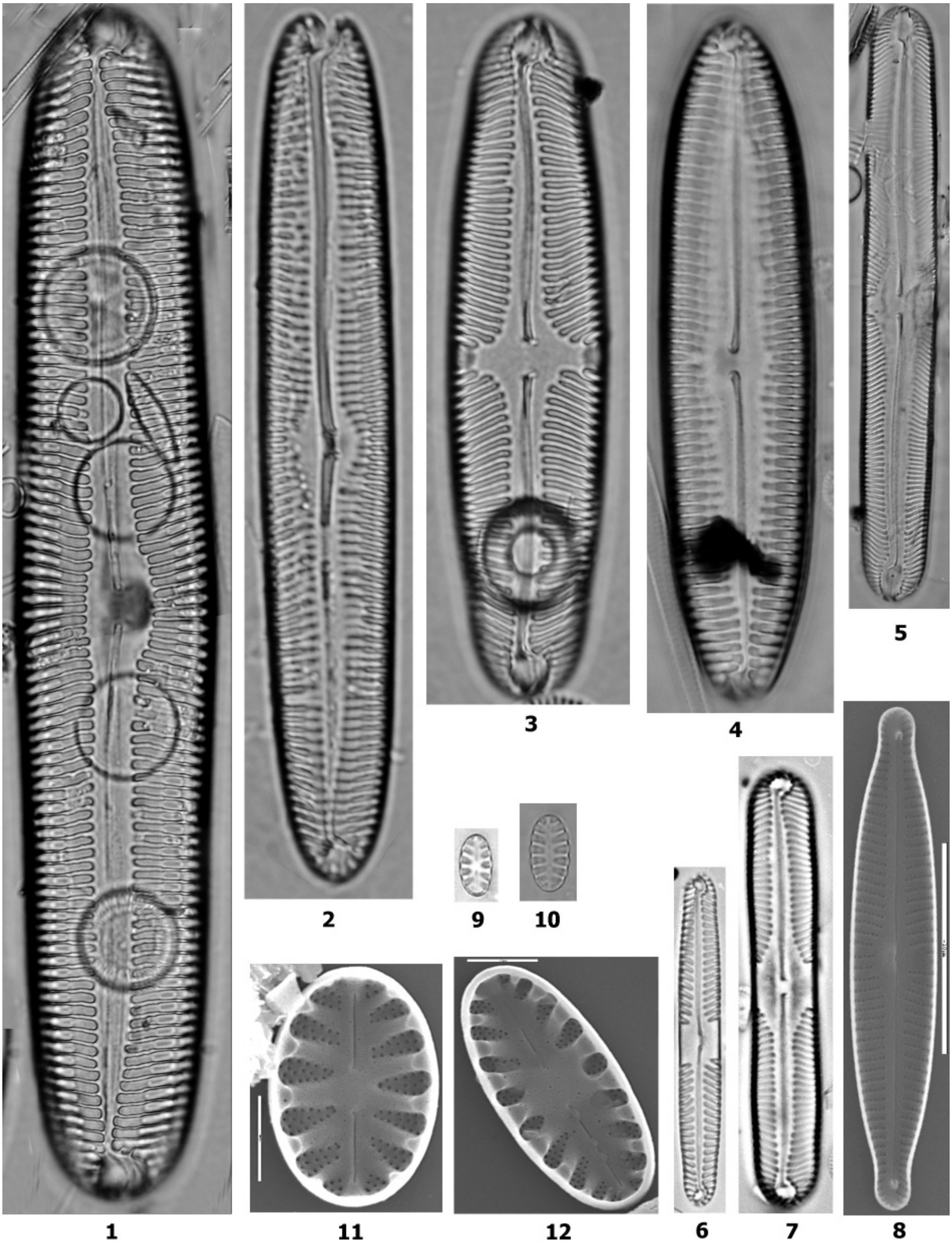
Explanation of Plate 9.

figs 1–3. *Gomphonema coronatum* Ehrenberg. **figs 4, 5.** *Gomphonema subtile* Ehrenberg. **fig. 6.** *Gomphonema vibrio* Ehrenberg. **figs 7, 8.** *Gomphonema calcifugum* Lange-Bertalot & Reichardt. **figs 9–11.** *Gomphonema clavatum* Ehrenberg *s. l.* **fig. 12.** *Gomphonema lapponicum* (A. Cleve) Cleve-Euler. **fig. 13.** *Gomphonema parvulum* Kützing. **fig. 14.** *Gomphonema sagitta* Schumann. **fig. 15.** *Gomphonema truncatum* Ehrenberg. All LM micrographs (magnification ×1500).



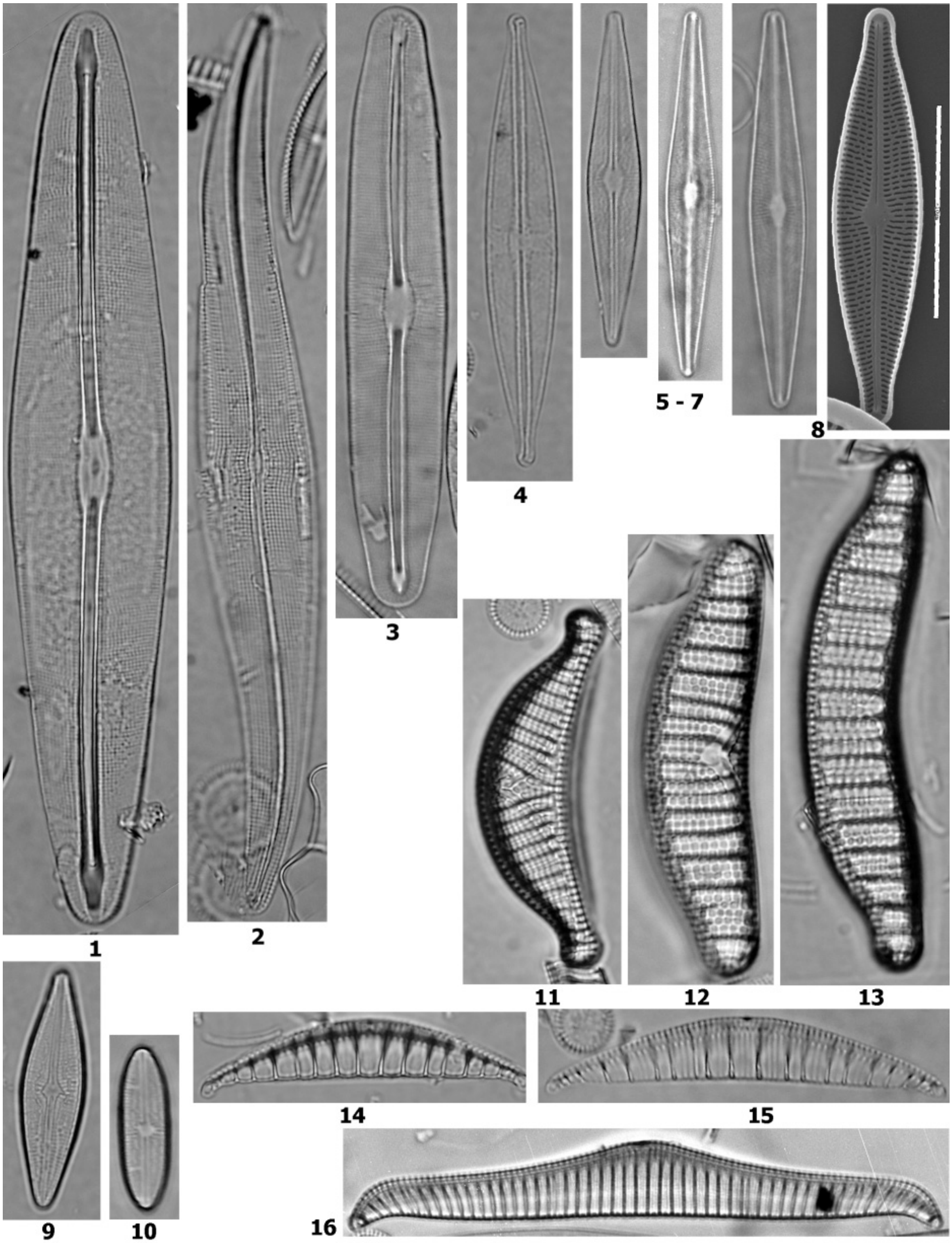
Explanation of Plate 10.

figs 1–3. *Navicula radiosa* Kützing. **figs 4–7.** *Navicula angusta* Grunow. **fig. 8.** *Navicula veneta* Kützing. **fig. 9.** *Navicula gregaria* Donkin *s. l.* **figs 10, 11.** *Caloneis bacillum s. auct*. **fig. 12.** *Caloneis undulata* (Gregory) Krammer. **fig. 13.** *Caloneis tenuis* (Gregory) Krammer. **fig. 14.** *Caloneis pulchra* Messikommer. **fig. 15.** *Caloneis silicula* (Ehrenberg) Cleve. **figs 16–22.** *Hippodonta subcostulata* (Hustedt) Lange-Bertalot, Metzeltin & Witkowski. All LM micrographs (magnification ×1500).



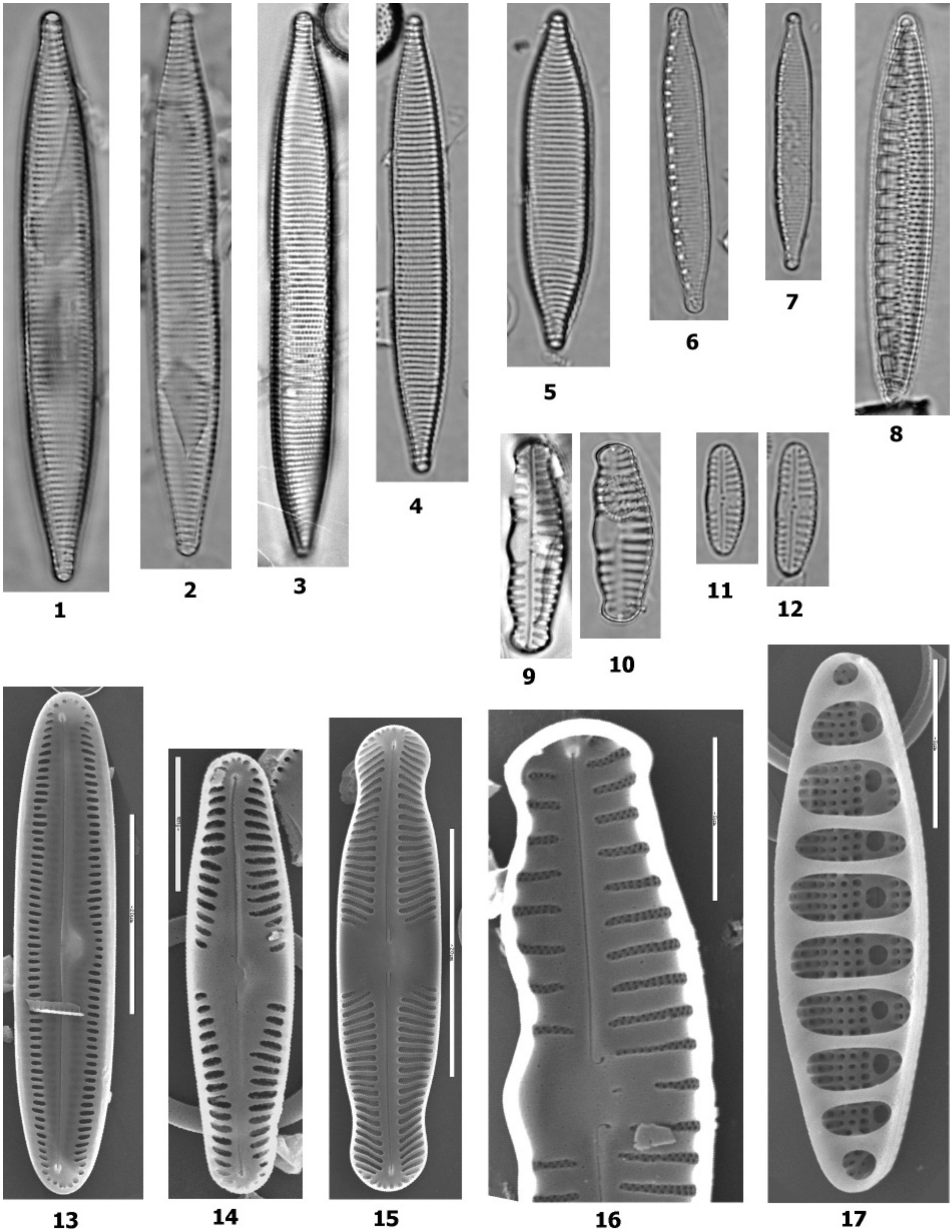
Explanation of Plate 11.

fig. 1. *Pinnularia viridis* (Nitzsch) Ehrenberg. **fig. 2.** *Pinnularia viridiformis* Krammer. **fig. 3.** *Pinnularia divergens* var. *sublinearis* Cleve, **fig. 4.** *Pinnularia hemiptera* (Kützing) Rabenhorst. **fig. 5.** *Pinnularia stomatophora* (Grunow) Cleve. **fig. 6.** *Pinnularia subcapitata* var. *subrostrata* Krammer. **fig. 7.** *Pinnularia brandeli* Cleve. **fig. 8.** *Kobayasiella* sp.. **figs 9–12.** *Hygropetra balfouriana* (Grunow ex. Cleve) Krammer & Lange-Bertalot. figs 1–7, 9, 10 LM micrographs (magnification ×1500); figs 8, 11, 12 SEM micrographs (scale bars: 8=10 µm; 11, 12=2 µm).



Explanation of Plate 12.

fig. 1. *Frustulia erifuga* Lange-Bertalot & Krammer. **fig. 2.** *Gyrosigama acuminatum* (Kützing) Rabenhorst. **fig. 3.** *Frustulia vulgaris* (Thwaites) De Toni. **fig. 4.** *Stauroneis neohyalina* Lange-Bertalot. **figs 5–8.** *Brachysira procera* Lange-Bertalot. **fig. 9.** *Brachysira brebissonii* Ross. **fig. 10.** *Brachysira zellensis* (Grunow) Round & Mann. **fig. 11.** *Epithemia sorex* Kützing. **figs 12, 13.** *Epithemia adnata* (Kützing) Brébisson. **figs 14, 15.** *Rhopalodia rupestris* (W. Smith) Krammer. **fig. 16.** *Rhopalodia gibba* (Ehrenberg) O. Müller var. *gibba*. figs 1–7, 9–16 LM micrographs (magnification ×1500); fig. 8 SEM micrograph (scale bar: 10 μm).



Explanation of Plate 13.

figs 1–5. *Nitzschia angustata* Grunow. **fig. 6.** *Nitzschia hantzschiana* Rabenhorst. **fig. 7.** *Nitzschia* cf. *hantzschiana* Rabenhorst. **fig. 8.** *Nitzschia denticula* Grunow. **figs 9, 10.** *Reimeria uniseriata* Sala *et al.* **figs 11, 12.** *Reimeria sinuata* (Gregory) Kociolek & Stoermer. **fig. 13.** *Caloneis* sp. **figs 14, 15**. *Pinnularia* sp.. **fig. 16.** *Reimeria* sp.. **fig. 17.** *Denticula tenuis* Kützing. figs 1–12 LM micrographs (magnification ×1500); figs 13–17 SEM micrographs (scale bars: 13, 15=20 μm; 14, 16, 17=5 μm).

Holmboe; *Hannaea arcus* (Ehrenberg) Patrick *in* Patrick & Reimer
Lit.: Krammer & Lange-Bertalot (1991a, p. 134, fig. 117: 8–13)
Pl. 7, figs 26–28

Craticula cuspidata (Kützing) D.G. Mann
Syn.:*Frustulia cuspidata* Kützing; *Navicula cuspidata* (Kützing) Kützing; *Navicula cuspidata* var. *heribaudii* M. Pergallo in Héribaud
Lit.: Lange-Bertalot (2001, p. 111, fig. 82: 1–3, fig. 83: 1–2)
Pl. 6, fig. 7

Cyclostephanus invisitatus (Hohn & Hellerman) Theriot, Stoermer & Håkansson
Syn.: *Stephanodiscus invisitatus* Hohn & Hellerman; *Stephanodiscus hantzschii* var. *striator* Kalbe; *Stephanodiscus incognitos* Kuzmin & Genkal
Lit.: Krammer & Lange-Bertalot (1991a, p. 63, fig. 67: 3–4), Håkansson (2002, p. 70, fig. 221–225)
Pl. 1, figs 12, 13; Pl. 2, fig. 4

Cyclotella antiqua W. Smith
Syn.: *Cyclotella operculata* var. *antiqua* Héribaud
Lit.: Krammer & Lange-Bertalot (1991a, p. 48, fig. 47: 5–6, fig. 48: 1a–3)
Pl. 1, figs 14, 15

Cyclotella rossii Håkansson
Syn.: *Discoplea oligactis* Ehrenberg; *Cycotella oligactis* (Ehrenberg) Ralphs in Pritchard; *Cyclotella comta* var. *oligactis* (Ehrenberg) Grunow in Van Heurck
Lit.: Krammer & Lange-Bertalot (1991a, p. 60, fig. 64: 1–8)
Pl. 1, figs 1–5; Pl. 2, figs 3, 4

Cymbella excisiformis Krammer
Lit.: Krammer (2002, p. 31, fig. 11: 1–23, fig. 12: 3–5, fig. 13: 1–8)

Cymbella helvetica Kützing
Syn.: *Cymbella compacta* Østrup
Lit.: Krammer & Lange-Bertalot (1986, p. 324, fig. 132: 2–4, fig. 133: 1–8)
Pl. 4, figs 1, 2

Cymbella lange-bertalotii Krammer
Lit.: Krammer (2002, p. 152, fig. 179: 1–6)
Pl. 4, figs 3–5

Cymbella aff. *neocistula* Krammer
Lit.: Krammer (2002, p. 94, fig. 85: 1–4, fig. 86: 1–7, fig. 87: 1–9, fig. 88: 1–8, fig. 89: 1–7, fig. 90: 1–8, fig. 91: 1–6)
So far this taxon has only been found with 3–5 stigmata and this is the first report of a form with 6.

Cymbella neoleptoceros var. *tenuistriata* Krammer
Lit.: Krammer (2002, p. 135, fig. 160: 1–6)
Pl. 4, figs 7, 8

Cymbella pervarians Krammer
Lit.: Krammer (2002, p. 58, fig. 39: 8–18, fig. 41: 1–12, fig. 42: 1–12)
Pl. 4, fig. 9

Cymbella proxima Reimer
Syn.: *Cocconema cistulum* A. Schmidt; *Cymbella cistula sensu* Grunow in Van Heurck
Lit.: Krammer (2002, p. 106, fig. 92: 4–6, fig. 108: 1–6, fig. 109: 1–5, fig. 110: 1–3, fig. 111: 1–3)
Pl. 5, fig. 1

Cymbella cf. *subtruncta* Krammer
Lit.: Krammer (2002, p. 39, fig. 18: 16–21, fig. 19: 1–21)
Pl. 4, figs 10, 11

Cymbella vulgata Krammer
Lit.: Krammer (2002, p. 55, fig. 32: 7–13, fig. 36: 1–14, fig. 37: 16–21, fig. 38: 1–18, fig. 39: 1–7)
Pl. 4, fig. 6

Diadesmis biceps Arnott
Syn.: *Navicula contenta* Grunow; *Navicula trinodis* W. Smith f. *minuta* Grunow
Lit.: Krammer & Lange-Bertalot (1986, p. 219, fig. 75: 1–5)
Pl. 8, figs 28, 29

Diadesmis perpusilla (Grunow) Lange-Bertalot
Syn.: *Navicula prepusilla* Grunow; *Navicula gallica* var. *prepusilla* (Grunow) Lange-Bertalot; *Navicula flotowii* Grunow
Lit.: Krammer & Lange-Bertalot (1986, p. 220, fig. 75: 12–17)
Pl. 8, figs 30–33

Diatoma mesodon (Ehrenberg) Kützing
Syn.: *Fragilaria mesodon* Ehrenberg. *Diatoma hiemalis* var. *mesodon* (Ehrnberg) Grunow in Van Heurck
Lit.: Krammer & Lange-Bertalot (1991a, p. 60, fig. 92: 1–4, fig. 99: 1–12)
Pl. 7, figs 7–9

Diatoma tenuis Agardh
Syn.: *Diatoma tenuis* var. *elongatum* Lyngbye; *Diatoma elongatum* (Lyngbye) Agardh; *Diatoma mesoleptum* Kützing
Lit.: Krammer & Lange-Bertalot (1991a, p. 97, fig. 96: 1–9)
Pl. 7, fig. 6

Diatomella balfouriana Greville
Lit.: Krammer & Lange-Bertalot (1986, p. 436, fig. 205: 4–8)
Pl. 7, figs 13–19

Didymosphenia geminata (Lyngbye) M. Schmidt
Syn.: *Echinella geminata* Lyngbye; *Gomphonema geminatum* (Lyngbye) Agardh
Lit.: Krammer & Lange-Bertalot (1986, p. 381, fig. 166: 15)
Pl. 6, fig. 6

Encyonema neogracile Krammer
Syn.: (?) *Cocconema gracile*? Ehrenberg; (?)*Cymbella gracilis* Kützing; (?)*Encyonema gracile* Rabenhorst; *Encyonema gracile* var. Grunow in Van Heurck; *Encyonema gracile* f. *minor* Grunow in Van Heurck
Lit.: Krammer (1997, p. I/142, fig. 82: 1–13, fig. 83: 1–7, fig. 85: 1–12)
Pl. 5, figs 2, 3

Encyonema procerum Krammer
Lit.: Krammer (1997, p. I/95, fig. 32: 9–19)
Pl. 5, fig. 4

Encyonema silesiacum (Bleisch) D.G. Mann
Syn.: *Cymbella ventricosa* Agardth; *Cymbella silesiaca* Bleisch in Rabenhorst; *Cymbella minuta* var. *silesiaca* (Bleisch) Reimer in Patrick & Reimer
Lit.: Krammer (1997, p. I/72, fig. 4: 1–18, fig. 7: 6–19, fig. 9: 1–8, fig. 16: 1–11, fig. 17: 5–8)
Pl. 5, figs 2, 3

Eunotia arcus Ehrenberg
Syn.: *Himantidium arcus* Ehrenberg *pro parte*
Lit.: Krammer & Lange-Bertalot (1991a, p. 184, fig. 147)
Pl. 2, figs 1, 2

Eunotia circumborealis Nörpel-Schempp & Lange-Bertalot
Syn.: *Eunotia septentrionalis* var. *bidens* Hustedt *sensu* Simonsen; (?)*Eunotia scandinavica* f. *angusta* (Fontell) Cleve-Euler; *Eunotia pectinalis* var. *undulata sensu* Krasske
Lit.: Krammer & Lange-Bertalot (1991a, p. 197, fig. 143: 16–23)
Pl. 2, fig. 17

Eunotia implicata Nörpel-Schempp, Lange-Bertalot & Alles
Syn.: *Eunotia impressa* var. *angusta* Grunow in Van Heurck; *Eunotia impressa* var. *angusta* f. vix *impressa* Grunow in Van Heurck; *Eunotia pectinalis* var. *minor* f. *impressa* (Ehrenberg) Hustedt; *Eunotia impressa* Ehrenberg *sensu* Cleve-Euler; *Eunotia impressa* Ehrenberg; *Himantidium minus* Kützing; *Himantidium pectinale* var. *minus* (Kützing) Grunow; *Eunotia pectinalis* var. *minor* (Kützing) Rabenhorst *sensu* Grunow
Lit.: Krammer & Lange-Bertalot (1991a, p. 197, fig. 143: 1–9A)
Pl. 2, fig. 9

Eunotia media A. Cleve
Syn.: *Eunotia parallela* var. *parallela* Ehrenberg; *Eunotia crassa* Pantocsek & Greguss; *Eunotia pseudoparallela* Cleve-Euler;
Eunotia parallela var. *pseudoparallela* Cleve-Euler
Lit.: Krammer & Lange-Bertalot (1991a, p. 209, fig. 152: 4–7)
Pl. 2, fig. 18

Eunotia praerupta Ehrenberg
Syn.: *Himantidium praeruptum* Ehrenberg
Lit.: Krammer & Lange-Bertalot (1991a, p. 186, fig. 148: 1–17, fig. 149: 1–7, fig. 150: 1–7)
Pl. 2, fig. 19

Fragilaria alpestris Krasske
Syn.: (?) *Fragilaria capucina* var. *amphicephala* (Kützing) Lange-Bertalot
Lit.: Krammer & Lange-Bertalot (1991a, p. 141, fig. 111: 25–28)
Pl. 8, fig. 14

Fragilaria exigua Grunow *in* Cleve & Moller
Syn.: *Fragilaria virescens* var. ? *exigua* Grunow in Van Heurck; *Fragilaria exigua* (W. Smith) Lemmermann; *Triceratium*
exiguum W. Smith; *Fragilaria construens* f. *exigua* (W. Smith) Hustedt
Lit.: Krammer & Lange-Bertalot (1991a, p. 137, fig. 126: 11–18)
Pl. 8, figs 1–5, 7

Fragilaria construens var. *binodis* fo. *borealis* Foged
Lit.: Foged (1974, p. 56, fig. 3: 6), Krammer & Lange-Bertalot (1991a, p. 164, fig. 130: 18, 19?)
Foged (1974) described *F. construens* v. *binodis* fo. *borealis* in a sample from an outflow of a small lake near Thingvellir in Iceland. He established a new forma based on faintly concave margins and coarsely punctate striae. Krammer & Lange-Bertalot included this taxon with a question mark in *Fragilaria robusta* (Fusey) Manguin. The species, to a certain extent, resembles *Fragilaria pseudoconstruens* Marciniak, however, it differs with respect to valve shape, the sternum and the striation pattern.
Pl. 8, figs 8, 9

Fragilaria opacolineata Lange-Bertalot
Lit.: Lange-Bertalot & Metzeltin (1996, p. 132, 340, fig. 7: 36–41B, fig. 111: 2–3)
Pl. 8, figs 15–17

Fragilaria parasitica (W. Smith) Grunow
Syn.: *Synedra parasitica* (W. Smith) Grunow *in* Van Heurck
Lit.: Krammer & Lange-Bertalot (1991a, p. 133, fig. 130: 1–8)
Pl. 8, figs 18–20

Frustulia vulgaris (Thwaites) De Toni
Syn.: *Schizonema vulgare* Thwaites
Lit.: Krammer & Lange-Bertalot (1986, p. 260, fig. 97: 1–6)
Pl. 12, fig. 3

Frustulia erifuga Lange-Bertalot & Krammer
Syn.: *Colletonema viridulum* Brébisson ex Kützing; *Schizonema viridulum* (Brébisson) Rabenhorst; *Vanheuricka viridula* (Brébisson) Brébisson; *Frustulia viridula* (Brébisson) De Toni; *Frustulia rhomboides* var. *viridula* (Brébisson) Cleve; *Frustulia rhomboides* var. *viridula* f. *hustedtii* Germain
Lit.: Lange-Bertalot (2001, p. 167, fig. 131: 9–10, fig. 132: 1–6, fig. 140: 1–2)
Pl. 12, fig. 1

Gomphomena acuminatum Ehrenberg var. *acuminatum*
Syn.: *Gomphonema brebissonii* Kützing
Lit.: Krammer & Lange-Bertalot (1986, p. 365, fig. 160: 1–12)

Gomphonema cf. *affine* Kützing
Syn.: *Gomphonema lanceolatum sensu* Hustedt (*et al.*) *non* Ehrenberg nec Agardh. (?)*Gomphonema magnificum* Gandhi
Lit.: Krammer & Lange-Bertalot (1986, p. 366, fig. 161: 1–3)

Gomphonema calcifugum Lange-Bertalot & Reichardt
Syn.: *Gomphonema olivaceum* var. *minutissimum* Hustedt
Lit.: Hustedt (1930, p. 378, fig. 720), Lange-Bertalot & Genkal (1999, p. 53)
Pl. 9, figs 7, 8

Gomphonema clavatum Ehrenberg
Syn.: *Gomphonema longiceps* Ehrenberg; *Gomphonema mustela* Ehrenberg; *Gomphonema montanum* Schumann; *Gomphonema subclavatum* Grunow; *Gomphonema commutatum* Grunow; *Gomphonema* (*commutatum* var.?) *mexicanum* Grunow; *Gomphocymbella obliqua* (Grunow) O. Müller
Lit.: Krammer & Lange-Bertalot (1986, p. 367, fig. 163: 1-12)
Pl. 9, figs 9–11

Gomphonema capitatum Ehrenberg
Syn.: *Gomphonema trunctatum* Ehrenberg; *Gomphonema constrictum* Ehrenberg; *Gomphonema turgidum* Ehrenberg
Lit.: Krammer & Lange-Bertalot (1986, p. 369, fig. 159: 11–18)

Gomphonema coronatum Ehrenberg
Syn.: *Gomphonema acuminatum* var. *coronatum* (Ehrenberg) W. Smith
Lit.: Reichardt (1999, p. 43, fig. 49: 1–5, fig. 7–11, fig. 50: 1–8, fig. 51: 1–8)
Pl. 9, figs 1–3

Gomphonema lapponicum (A. Cleve) Cleve-Euler
Syn.: *Navicula petersenii* f. *gomphonemoides* Hustedt
Lit.: Reichardt (1999, p. 42, fig. 46: 1–10)
Pl. 9, fig. 12

Gomphonema sagitta Schumann
Syn.: *Gomphonema subtille* Ehrenberg; *Gomphonema minusculum* Krasske
Lit.: Krammer & Lange-Bertalot (1986, p. 369, fig. 162: 10–13)
Pl. 9, fig. 14

Hippodonta subcostulata (Hustedt) Lange-Bertalot, Metzeltin & Witkowski
Valves linear-lanceolate, with obtusely rounded apices, 14–20 µm long, 2.75–3.3 µm broad. Raphe straight with relatively distinct, somewhat expanded external central endings and straight terminal endings. Axial area very narrow, barely distinguishable, central area in a form of relatively broad fascia reaching the valve margins. Transapical striae relatively robust in the middle radiate, towards apices becoming convergent, 13–14 in 10 µm. The valve outline and the shape of central area of this taxon resembles *Hippodonta costulata* (Grunow) Lange-Bertalot, Metzeltin & Witkowski
Pl. 10, figs 16–22

Hygropetra balfouriana (Grunow ex Cleve) Krammer & Lange–Bertalot
Bas.: *Pinnularia balfouriana* Grunow ex. Cleve
Lit.: Krammer (2000, p. 207, fig. 216: 1–9, fig. 15–19)
Pl. 11, figs 9–12

Navicula angusta Grunow
Syn.: *Navicula cari* var. *angusta* Grunow in Van Heurck; *Navicula cincta* var. *angusta* (Grunow) Cleve; *Navicula cincta* var. *linearis* Østrup; *Navicula pseudocari* Krasske; *Navicula lobeliae* Jørgensen
Lit.: Krammer & Lange-Bertalot (1986, p. 97, fig. 28: 1–5)
Pl. 10, figs 4–7

Navicula gregaria Donkin
Syn.: *Navicula cryptcephala* Kützing; *Navicula gregalis* Cholonky; *Navicula gotlandica* Grunow *sensu* Hustedt; *Navicula phyllepta* Kützing *sensu* Brockmann and *sensu* Hendey
Lit.: Krammer & Lange-Bertalot (1986, p. 116, fig. 38: 10–15)
Pl. 10, fig. 9

Navicula veneta Kützing
Syn.: *Navicula cryptocephala* var. *veneta* (Kützing) Rabenhorst; *Navicula cryptocephala* var. *subsalina* Hustedt; *Navicula lancettula* Schumann
Lit.: Krammer & Lange-Bertalot (1986, p. 104, fig. 32: 1–4)
Pl. 10, fig. 8

Neidium apiculatum Reimer
Lit.: Krammer & Lange-Bertalot (1986, p. 250, fig. 100: 9)
Pl. 5, fig. 17

Nitzschia angustata (W.Smith) Grunow in Cleve & Grunow
Syn.: *Tryblionella angustata* W. Smith
Lit.: Krammer & Lange-Bertalot (1997, p. 48, fig. 36: 1–5)
Pl. 13, figs 1–5

Nitzschia denticula Grunow
Syn.: *Denticula kuetzingii* Grunow; *Denticula obtusa* W. Smith; *Denticula inflata* W. Smith; *Denticula decipiens* Arnott
Lit.: Krammer & Lange-Bertalot (1991a, p. 143, fig. 94: 3, 4, fig. 99: 11–23, fig. 100: 1–14, 18–22)
Pl. 13, fig. 8

Nitzschia hantzschiana Rabenhorst
Syn.: *Nitzschia perpusilla* Rabenhorst; *Nitzschia frustulum* var. *glacialis* Grunow in Van Heurck; *Nitzschia frustulum* f. *subserians* Grunow in Van Heurck
Lit.: Krammer & Lange-Bertalot (1997, p. 101, fig. 73: 9–18)
Pl. 13, figs 6, 7

Pinnularia brandeli Cleve
Lit.: Lange-Bertalot & Metzeltin (1996, p. 206, fig. 44: 1–6)
Pl. 11, fig. 7

Pinnularia divergens var. *sublinearis* Cleve
Syn.: *Pinnularia divergens* f. *linearis* Fontell; *Pinnularia divergens* var. *fontellii* Cleve-Euler; *Pinnularia divergens* var. *elliptica sensu* Krammer
Lit.: Krammer (2000, p. 62, fig. 30: 1–7, fig. 31: 1–8, fig. 32: 9)
Pl. 11, fig. 3

Pinnularia hemiptera (Kützing) Rabenhorst
Syn.: *Pinnularia acuminata* W. Smith; *Navicula instabilis* A. Schmidt; *Navicula hybrida* Peragallo et Héribaud; *Pinnularia debilis* (Pantocsek) Cleve-Euler
Lit.: Krammer & Lange-Bertalot (1986, p. 410, fig. 182: 1–3)
Pl. 11, fig. 4

Pinnularia neomajor Krammer
Syn.: *Navicula major* ex. rec Grunow *in* A. Schmidt; (?)*Frustulia major* Kützing; *Navicula major* Kützing; *Pinnularia major sensu* Cleve
Lit.: Krammer (2000, p. 165, fig. 6: 1–4, fig. 62: 1–5, fig. 63: 1)

Pinnularia ovata Krammer
Syn.: *Navicula divergens* var. *elliptica* Grunow; *Pinnularia divergens* var. *elliptica* (Grunow) Cleve; *Pinnularia episcopalis sensu* Hustedt
Lit.: Krammer (2000, p. 64, fig. 35: 5–8, fig. 36: 1–5, fig. 37:1–4)

Pinnularia platycephala (Ehrenberg) Cleve
Bas.: *Stauroptera platycephala* Ehrenberg
Syn.: *Pinnularia platystoma* Hustedt

Lit.: Krammer (2000, p. 68, fig. 2: 1, fig. 39: 6, fig. 44: 1–7)

Pinnularia rupestris Hantzsch in Rabenhorst
Syn.: *Pinnularia viridis* var. *rupestris* (Hantzsch) Cleve; *Pinnularia reinschiana* A. Mayer
Lit.: Krammer (2000, p. 135, fig. 118: 1–12)

Pinnularia stomatophora (Grunow) Cleve
Syn.: *Navicula stomatophora* Grunow; *Pinnularia stomatophora* var. *triundulata* Fontell; *Pinnularia substomatophora* Hustedt; *Pinnularia stomatophoroides* A. Mayer
Lit.: Krammer & Lange-Bertalot (1986, p. 406, fig. 178: 8–10, fig. 179: 1, fig. 18: 5)
Pl. 11, fig. 5

Pinnularia subcapitata var. *subrostrata* Krammer
Lit.: Krammer (2000, p. 118, fig. 38: 12–18, fig. 90: 18–23)
Pl. 11, fig. 6

Pinnularia turbulenta (Cleve-Euler) Krammer
Bas.: *Pinnularia mesolepta* var. *turbulenta* Cleve-Euler
Lit.: Krammer (2000, p. 100, fig. 83: 1–6)

Placoneis cf. *clementis* Grunow
Bas.: *Navicula clementis* Grunow
Syn.: *Navicula exigua* (Gregory) Grunow; *Navicula clementis* var. *rhombica* Brockmann; *Navicula inclementis* Hendey
Lit.: Krammer & Lange-Bertalot (1986, p. 139, fig. 47: 1–9, fig. 53: 3)
Pl. 6, fig. 11

Reimeria sinuata (Gregory) Kociolek & Stoermer
Lit.: Sala *et al.* (1993, p. 442–443, fig. 2–10)
Pl. 13, figs 11, 12

Reimeria uniseriata (Gregory) Sala, Guerrero & Ferrario
Syn.: *Cymbella sinuata* Gregory *sensu* Schumann & Archibald
Lit.: Sala *et al.* (1993, p. 445)
Pl. 13, figs 9, 10

Rhopalodia gibba (Ehrenberg) O. Müller var. *gibba*
Syn.: *Navicula gibba* Ehrenberg; *Epithemia gibba* (Ehrenberg) Kützing; *Epithemia ventricosa* Kützing; *Rhopalodia ventricosa* (Kützing) O. Müller; *Rhopalodia gibba* var. *ventricosa* (Kützing) Pergallo
Lit.: Krammer & Lange-Bertalot (1997, p. 159, fig. 110: 1, fig. 111: 1–13)
Pl. 12, fig. 16

Rhopalodia rupestris (W. Smith) Krammer
Syn.: *Epithemia rupestris* W. Smith; *Rhopalodia gibberula* var. *rupestris* (W. Smith) O. Müller
Lit.: Krammer & Lange-Bertalot (1997, p. 165, fig. 115: 1–8)
Pl. 12, figs 14, 15

Stauroneis neohyalina Lange-Bertalot & Krammer
Syn.: *Stauroneis anceps* var. *siberica* Grunow *in* Cleve & Grunow
Lit.: Lange-Bertalot & Metzeltin (1996, p. 104, fig. 35: 7–10)
Pl. 12, fig. 4

Staurosira construens Ehrenberg
Syn.: *Fragilaria construens* (Ehrenberg) Grunow
Lit.: Krammer & Lange-Bertalot (1991a, p. 153, fig. 132: 1–34, fig. 129: 21–27, fig. 131: 5–6), Krammer & Lange-Bertalot (2000, p. 584)
Pl. 8, fig. 21

Staurosira martyi (Héribaud) Lange-Bertalot
Bas.: *Opephora martyi* Héribaud
Syn.: *Fragilaria martyi* (Héribaud) Lange-Bertalot; *Martyana martyi* (Héribaud) Round *in* Round *et al.* (1990)
Lit.: Krammer & Lange-Bertalot (1991a, p. 160, fig. 133: 28–31), Witkowski *et al*. (1996). Krammer & Lange-Bertalot (2000, p. 586)
Pl. 8, fig. 6

Staurosira pseudoconstruens (Marciniak) Lange-Bertalot
Bas.: *Fragilaria pseudoconstruens* Marciniak
Pl. 8, figs 22–24
Lit.: Krammer & Lange-Bertalot (1991a, p. 163, fig. 130: 25–30), Krammer & Lange-Bertalot (2000, p. 587)

Surirella amphioxys W. Smith
Syn.: *Surirella moelleriana* Grunow ex Moller; *Surirella moelleriana sensu* Germain
Lit.: Krammer & Lange-Bertalot (1986, p. 189, fig. 138: 1–5, fig. 39: 1–8)
Pl. 6, fig. 12

Tabellaria flocculosa sensu lato (Roth) Kützing
Syn.: *Diatoma fenestratum* Lyngbye
Lit.: Krammer & Lange-Bertalot (1991, p. 106, fig. 105: 1–4, fig. 107: 8)
Pl. 7, figs 20–23

Tabellaria flocculosa sensu stricto (Roth) Kützing
Syn.: *Conferva flocculosa* Roth
Lit.: Krammer & Lange-Bertalot (1997, p. 108, fig. 106: 1–3, fig. 107: 7, 11, 12)
Pl. 7, figs 24, 25

APPENDIX B: SPECIES LIST

Freshwater species

Achnanthes daonensis Lange-Bertalot
Achnanthes didyma Hustedt
Achnanthes holstii Cleve
Achnanthes lanceolata (Brébisson) Grunow
Achnanthes laterostrata Hustedt
Achnanthes pusilla (Grunow) de Toni
Amphora copulata (Kützing) Schoeman
Amphora inariensis Krammer
Amphora veneta Kützing
Aneumastus rostratus (Hustedt) Lange-Bertalot
Aulacoseira distans (Ehrenberg) Simonsen
Aulacoseira italica (Ehrenberg) Simonsen
Aulacoseira subarctica (O. Müller) Haworth
Aulacoseira valida (Grunow) Krammer
Brachysira brebissonii Ross
Brachysira procea Lange-Bertalot & Moser
Brachysira zellensis (Grunow) Round & D.G. Mann
Caloneis cf. *bacillum* (Grunow) Cleve
Caloneis pulchra Messikommer
Caloneis silicula (Ehrenberg) Cleve

Caloneis tenuis (Gregory) Krammer
Caloneis undulata (Gregory) Krammer
Cavinula cocconeiformis (Gregory) D.G. Mann & Stickle
Ceratoneis arcus (Ehrenberg) Kützing var. *arcus*
Cocconeis placentula var. *lineata* (Ehrenberg) Van Heurck
Craticula cuspidata (Kützing) D.G. Mann
Cyclostephanos invisitatus (Hohn & Hellerman) Theriot, Stoermer & Håkansson
Cyclotella antiqua W. Smith
Cyclotella ocellata Pantocsek
Cyclotella radiosa (Grunow) Lemmermann
Cyclotella rossii Håkansson
Cymbella aff. *neocistula* Krammer
Cymbella cf. *subtruncta* Krammer
Cymbella excisiformis Krammer
Cymbella helvetica Kützing
Cymbella lange-bertalotii Krammer
Cymbella neoleptoceros var. *tenuistriata* Krammer
Cymbella pervarians Krammer
Cymbella proxima Reimer
Cymbella vulgata Krammer
Denticula tenuis Kützing
Diadesmis biceps Arnott
Diadesmis perpusilla (Grunow) Lange-Bertalot
Diatoma mesodon (Ehrenberg) Kützing
Diatoma tenuis Agardh
Diatomella balfouriana Greville
Didymosphenia geminata (Lyngbye) M. Schmidt
Diploneis petersenii Hustedt
Diploneis pseudovalis (Hilse) Cleve
Encyonema neogracile Krammer
Encyonema procerum Krammer
Encyonema silesiacum (Bleisch) D.G. Mann
Epithemia adnata (Kützing) Brébisson
Epithemia sorex Kützing
Epithemia turgida (Ehrenberg) Kützing
Eucocconeis alpestris (Brun) Lange-Bertalot
Eucocconeis flexella (Kützing) Cleve var. *flexella*
Eucocconeis laevis (Østrup) Lange-Bertalot
Eunotia arcus Ehrenberg
Eunotia circumborealis Nörpel-Schempp & Lange-Bertalot
Eunotia implicata Nörpel-Schempp, Lange-Bertalot & Alles
Eunotia media Cleve
Eunotia praerupta Ehrenberg
Eunotia pseudopectinalis (Brébisson) Kützing
Fragilaria alpestris Krasske
Fragilaria capucina var. *distans* (Grunow) Lange-Bertalot
Fragilaria capucina var. *perminuta* (Grunow) Lange-Bertalot
Fragilaria capucina var. *vaucheriae* (Kützing) Lange-Bertalot
Fragilaria construens var. *binodis* fo. *borealis* Foged
Fragilaria exigua Grunow in Cleve & Moeller
Fragilaria opacolineata Lange-Bertalot
Frustulia erifuga Lange-Bertalot & Krammer
Frustulia vulgaris (Thwaites) De Toni
Gomphomena acuminatum Ehrenberg var. *acuminatum*
Gomphonema calcifugum Lange-Bertalot & Reichardt
Gomphonema capitatum Ehrenberg
Gomphonema cf. *affine* Kützing
Gomphonema clavatum Ehrenberg
Gomphonema coronatum Ehrenberg
Gomphonema lapponicum (Cleve) Cleve-Euler
Gomphonema parvulum Kützing
Gomphonema sagitta Schumann
Gomphonema truncatum Ehrenberg
Gomphonema vibrio Ehrenberg
Gomphonemma subtile Ehrenberg
Gyrosigma acuminatum (Kützing) Rabenhorst
Hippodonta subcostulata (Hustedt) Lange-Bertalot, Metzeltin & Witkowski
Hygropetra balfouriana (Grunow ex Cleve) Krammer & Lange–Bertalot
Meridion circulae (Greville) Agardh
Navicula angusta Grunow
Navicula gegaria Donkin
Navicula radiosa Kützing
Navicula schmasmannii Hustedt
Navicula veneta Kützing
Neidium apiculatum Reimer
Nitzschia angustata (W. Smith) Grunow in Cleve & Grunow
Nitzschia denticula Grunow
Nitzschia hantzschiana Rabenhorst
Pinnularia brandeli Cleve
Pinnularia cf. *viridis* (Nitzsch) Ehrenberg
Pinnularia divergens var. *sublinearis* Cleve
Pinnularia hemiptera (Kützing) Rabenhorst
Pinnularia neomajor Krammer
Pinnularia ovata Krammer
Pinnularia platycephala (Ehrenberg) Cleve
Pinnularia rupestris Hantzsch in Rabenhorst
Pinnularia stomatophora Grunow
Pinnularia subcapitata var. *subrostrata* Krammer
Pinnularia turbulenta (Cleve-Euler) Krammer
Pinnularia viridiformis Krammer
Placoneis cf. *clementis* Grunow
Reimeria sinuata (Gregory) Kociolek & Stoermer
Reimeria uniseriata (Gregory) Kociolek & Stoermer
Rhopalodia rupestris (W. Smith) Krammer
Stauroneis neohyalina Lange-Bertalot & Krammer
Staurosira construens Ehrenberg
Staurosira martyi (Héribaud) Lange-Bertalot
Staurosira parasitica (W. Smith) Grunow
Staurosira pseudoconstruens (Marciniak) Lange-Bertalot
Surirella amphioxys W. Smith
Tabelaria flocculosa (Roth) Kützing

Brackish-water species
Achnanthes brevipes Agardh var. *brevipes*
Campylodiscus clypeus Ehrenberg
Cocconeis scutellum Ehrenberg var. *scutellum*
Cocconeis speciosa Gregory
Diploneis litoralis (Donkin) Cleve var. *litoralis*
Diploneis smithii (Brébisson) Cleve var. *smithii*
Diploneis stroemii Hustedt
Fallacia forcipata (De Toni) Stickle & D.G. Mann
Grammatophora oceanica (Ehrenberg 1854 pro parte) Grunow
Nitzschia coarctata Grunow
Pleurosigma normanii Ralfs
Rhabdonema arcuatum (? Agardh) Kützing var. *arcuatum*

Rhabdonema minutum Kützing
Rhopalodia gibba (Ehrenberg) O. Müller var. *gibba*
Synedra tabulata (Agardh) Kützing var. *tabulata*
Thalassiosira eccentrica (Ehrenberg) Cleve

Marine species
Actinoptychus senarius (Ehrenberg) Ehrenberg
Amphora marina W. Smith
Bacterosira batyomphala (Cleve) Syvertsen & Hasle
Caloneis undulata (Gregory) Krammer
Cocconeis costata Gregory var. *costata*
Cocconeis gutatta Hustedt
Cocconeis pinnata Gregory ex Greville
Cocconeis pseudomarginata Gregory
Dimeregramma fulvum (Gregory) Ralfs in Pritchard
Diploneis bombus Ehrenberg
Diploneis notabilis (Greville) Cleve
Diploneis vacillans (A. Schmidt) Cleve var. *vacillans*
Grammatophora angulosa var. *islandica* (Ehrenberg) Grunow
Grammatophora marina (Lyngbye) Kützing
Lyrella lyra (Ehrenberg) Karayeva
Navicula distans (W. Smith) A. Schmidt
Navicula normalis Hustedt
Odontella aurita (Lyngbye) Agardh
Opephora marina (Gregory) Petit
Paralia sulcata (Ehrenberg) Cleve
Plagiogramma staurophorum (Gregory) Heiberg
Rhizosolenia hebetata Bailey
Rhoicosphenia marina (W. Smith) M. Schmidt
Rhopalodia acuminata Krammer
Thalasionema nitzschioides Grunow
Thalassiosira decipiens (Grunow) Jørgensen
Thalassiosira nordenskioeldii Cleve
Trachyneis aspera (Ehrenberg) Cleve

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