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## A SCANNING ELECTRON MICROSCOPE STUDY OF SOME DIFFERENT FRUSTULE FORMS OF THE GENUS *FRAGILARIA* FOUND IN SCOTTISH LATE-GLACIAL SEDIMENTS

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The scanning electron microscope has assisted in the identification of three forms of the genus *Fragilaria* that occur in the late-glacial assemblages of some Scottish lochs. Scanning electron microscopy, light microscopy and reference to type material have confirmed the differences between *F. lapponica* Grun., *F. pinnata* Ehrenb. and *F. elliptica* Schumann.

While analysing the diatom assemblages in the late-glacial sediments of four sites in north-west Scotland it became evident that there were many forms of *Fragilaria* present (Pennington et al., 1972; Haworth, unpublished). Of the four sites (Loch Tarff in Inverness-shire, Lochs Cam and Borralan in Sutherland, and Loch Sionascaig in Ross-shire), the first three had assemblages dominated by *Fragilaria*, and at Cam Loch 16 forms could be recognised. The identification of these taxa is therefore of importance in the interpretation of the late-glacial environment.

Some of the taxa were always easily identified as *F. brevistriata* Grun., *F. brevistriata* var. *subcapitata* Grun., *F. construens* (Ehrenb.) Grun., *F. construens* var. *binodis* (Ehrenb.) Grun., *F. capucina* var. *mesolepta* Rabenh., *F. leptostauron* (Ehrenb.) Hust., *F. vaucheriae* (Kütz.) Petersen and *F. virescens* Ralfs. Other forms were not so easy to place in their correct taxon, for example, *F. construens* var. *venter* (Ehrenb.) Grun., *F. elliptica* Schumann, *F. cf. inflata* (Heiden) Hust., *F. lapponica* Grun., *F. pinnata* Ehrenb. and *F. cf. producta* (Lagst.) Grun., and at least one form is still unnamed. The identification of *F. construens*, *F. construens* var. *venter* and *F. lapponica* was confirmed by reference to the Grunow Slide Collection.

The main problem has been the separation and identification of the forms here called *F. pinnata*, *F. elliptica* and *F. lapponica*, and the scanning electron microscope (SEM) has therefore been used to study the detailed morphology of these forms.

From the Fritsch Collection of Algal Illustrations (Lund, 1971) it appears that several forms have been ascribed to the various taxa by various authors, forms that under the electron microscope can be shown to have very different structures. Reference to the original descriptions and figures does not always resolve this problem as most of these taxa were identified in the mid-nineteenth century by Ehrenberg, Grunow, Wm Smith and others; in many cases the descriptions could fit a number of different forms and the drawings are often indeterminate. There are also usually several type sites cited and either no designated type slides or the slides available contain several different forms, some so similar that it would be impossible to say which was used in the original description; in fact, it is quite possible that several forms have been lumped together in one taxon.

## METHODS

The samples of late-glacial sediment (obtained with a Mackereth corer) were heated in a mixture of two parts sulphuric acid to one part nitric acid (concentrated) in order to remove any organic matter. Slides were made using the diatom mountant Naphrax (R.I. 1.74) for study under a Leitz Dialux microscope with phase contrast illumination. Several samples were studied under Cambridge Scientific Instruments Mk 11 Stereoscans at Liverpool Polytechnic and Bristol University. The material was dried on to stubs and then coated with gold/palladium (as in Crawford, 1971).

Reference was also made to the diatom type slide collection at the British Museum (Natural History), London, and to slides loaned by the Grunow Slide Collection in the Vienna Natural History Museum.

## RESULTS AND DISCUSSION

*F. lapponica* Grun. (Figs 1–5)

One of the major difficulties in SEM diatom studies is to relate the forms seen to light microscope studies. However, in this case it has proved relatively easy to match the SEM pictures to cells on slides cited as containing *F. lapponica* in the Grunow Collection. Although there were no slides of any Belgian material, and none are cited in Van Heurck's Synopsis (1881), there is at least one slide from Finnish Lappland (Grunow Herbar. Präparat. No. 1477) with which the name *lapponica* would appear to be connected. Hustedt (1959) cites a Tempère & Peragallo slide (2nd edition, No. 764) but no specimens relating to this form could be found on the slide at the British Museum. The forms found on Grunow's slides (Figs 1, 4) correspond to his figures in Van Heurck's Synopsis and have short robust striae, approximately 7–8 in 10  $\mu\text{m}$ , leaving a large elliptical central area of up to half the width of the valve. In some oblique specimens (Fig. 4) it was possible to see the same branched spines that are so distinctive in the SEM study of a form from a fossil deposit of Loch Cuithir, Isle of Skye (Figs 2, 3, 5).

In the SEM the striae or costae appear as oval holes in the valve, crossed by bars of siliceous material (Fig. 2). Branched spines arise between the costae at the edge of the flat part of the valve, the sides being slanted rather than vertical so that the spines form a ring inside the valve edge when viewed under the light microscope. This would account for a significant difference in the width of the valve face as measured under the two systems. The spines of adjacent cells interlock loosely, as in other members of the genus, those of one cell overlying the costae of the other (Fig. 5). The spines appear hollow but this cavity does not continue through to the inside of the frustule itself. Hustedt gives the size range as 12–40  $\mu\text{m}$  long, 4–6  $\mu\text{m}$  wide and with 6–9 striae in 10  $\mu\text{m}$ ; the Loch Cuithir material contains rather shorter forms but otherwise has the same dimensions.

Both Helmcke & Krieger (1962–1963) and Miller (1969) call this SEM form *Fragilaria pinnata* but, after comparison with Grunow's own material, I have concluded that it is *F. lapponica*.

*F. pinnata* Ehrenb. (Figs 6–13)

Ehrenberg's original figure of this form (Ehrenberg, 1843) is uninformative and examination of some material from one of the sites listed by him, Santafore, failed to throw any light on identification.

Hustedt's description (Hustedt, 1959) is "frustule elliptic to linear with convex, parallel or slightly concave sides and rounded ends. Striae large, rib-like, usually radially arranged towards the ends. Pseudoraphe linear or slightly lanceolate,



FIGS 1–5. *Fragilaria lapponica* Grun. Fig. 1. Valve view of specimen on Grunow slide No. 1477. Light microscopy.  $\times 2000$ . Fig. 2. Valve view. SEM.  $\times 6700$ . Fig. 3. Girdle view of two cells. SEM.  $\times 5500$ . Fig. 4. Girdle view of specimen on Grunow slide No. 2234 to show *lapponica*-type spines. Light microscopy.  $\times 2000$ . Fig. 5. Detail of spines. SEM.  $\times 22,000$ .

central area absent; 3–35  $\mu\text{m}$  long, 2–6  $\mu\text{m}$  wide, striae 10–12 in 10  $\mu\text{m}$ , longitudinal lines (on striae) 20 in 10  $\mu\text{m}$ ". He also describes var. *intercedens* Grun. as much the same with grosser structure, striae about 6 in 10  $\mu\text{m}$ . In the taxon *pinnata*, Hustedt also includes *F. elliptica* Schumann (Schumann, 1867) and *Odontidium mutabile* Wm Smith (Smith, 1856); Patrick & Reimer (1966) include the latter in var. *intercedens* (Grun.) Hust.

Smith's own slides from his sites of *O. mutabile* contain a mixture of types and in one case, from Raasay, the slide contained the *F. lapponica* form described above. A slide cited by Hustedt (1959) from the H. L. Smith collection (a Wm Smith slide) does include a somewhat different form (Fig. 11).

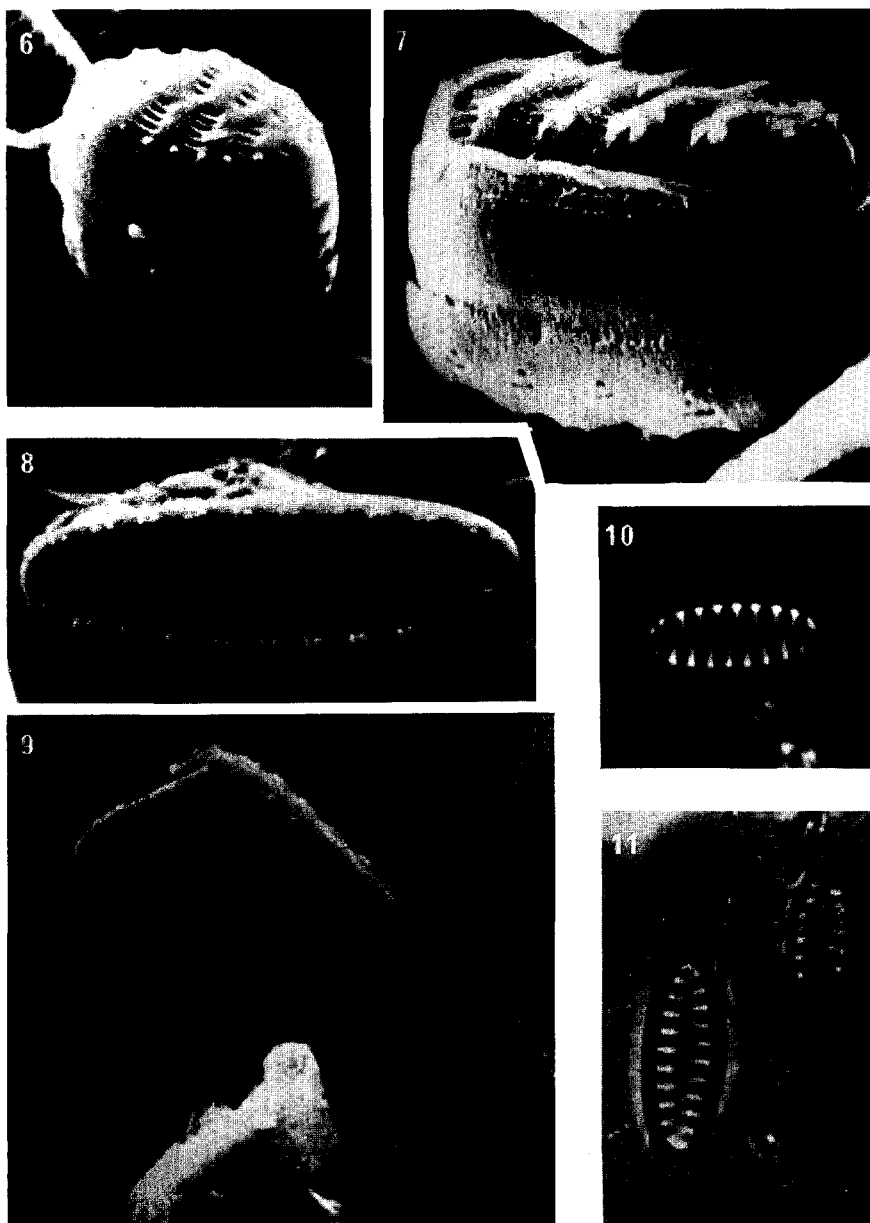
The form found in the Scottish late-glacial sediments fits Hustedt's written description but it is hard to discern the separation between this and *F. lapponica* under the light microscope, especially in Cam Loch samples (Fig. 10). In the SEM a whole range of *pinnata*-types have been photographed (Figs 6–9) where the costae are essentially the same as in *F. lapponica*, though longer and with a tendency to be pointed at the ends rather than rounded. The central area is only slightly widened and about one fifth of the valve width. The spines are variable in shape and range from simple projections placed one either side of the costae (Fig. 6) to pairs of projections between the costae (Figs 7–9) or, occasionally, even three or four spines (Figs 12, 13). There is no reason to suggest that these could merely be eroded spines of *lapponica*-type, since their point of origin is somewhat different; nothing approaching the form of the spines on *F. lapponica* has been seen. There is also a difference in the width of the central area, in the number of striae (8–14 in 10  $\mu\text{m}$ ) and in their distance from one another. No forms of *F. lapponica* were found in these samples in the SEM. Occasionally very small forms were found with a greater number of striae, 15–20 in 10  $\mu\text{m}$ , and under 5  $\mu\text{m}$  long, but these are very similar to the larger specimens (Fig. 6). It would appear that there is a wide range of types in these sediments and the range may well extend from *F. pinnata* var. *pinnata* through to *F. pinnata* var. *intercedens* without definable change.

#### *F. elliptica* Schumann (Figs 14–21).

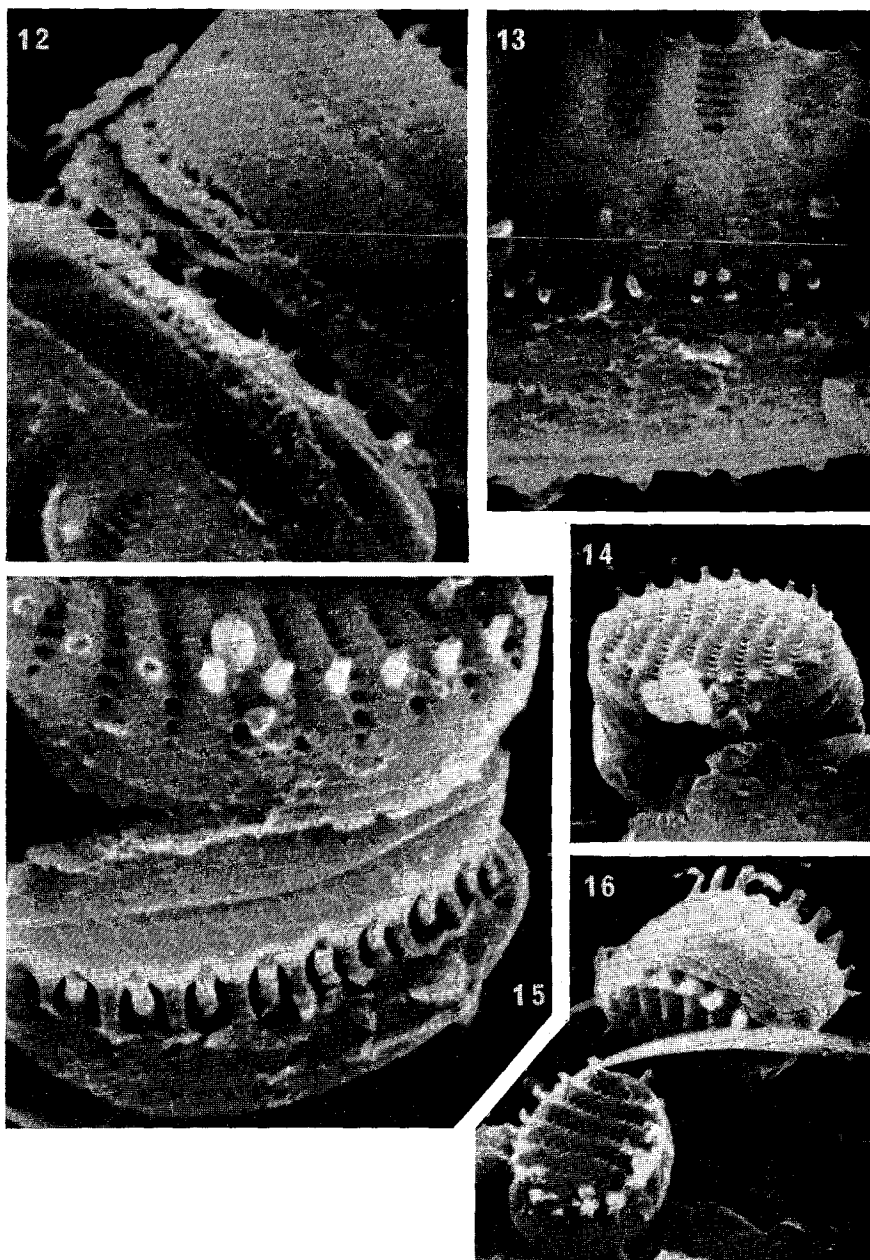
This third form was included in *F. pinnata* in the diatom analyses until it was realised that the striae were very much finer and looked different even under the light microscope (Figs 17–19). The samples were first examined in the SEM in order to elucidate these differences. This form was then identified as *F. elliptica*, in accordance with Cleve-Euler (1953, fig. 348 h–j). She described this taxon as "small, broadly elliptical (in valve view) with narrow pseudoraphe, striae 13–16/10  $\mu\text{m}$ ". These striae hardly fit into the description of large and rib-like, as in *F. pinnata*. Schumann's description (Schumann, 1867) is similar but his measurements are in Bavarian "Linie" with 25 striae in 100 Lin. which Mayer (1937) translates as being approximately 16 in 10  $\mu\text{m}$ .

In the SEM the striae resolve into a single line of pores, 16–20 in 10  $\mu\text{m}$  and 4–6 pores in 1  $\mu\text{m}$  (Figs 14–16). Single horn-shaped spines arise from the edge of the valve, and are often slightly flattened or spatulate at the tips (Figs 20, 21). Their point of origin seems to be variable, occasionally over a line of pores, but more frequently between them. As in *F. lapponica* the spines appear to be hollow.

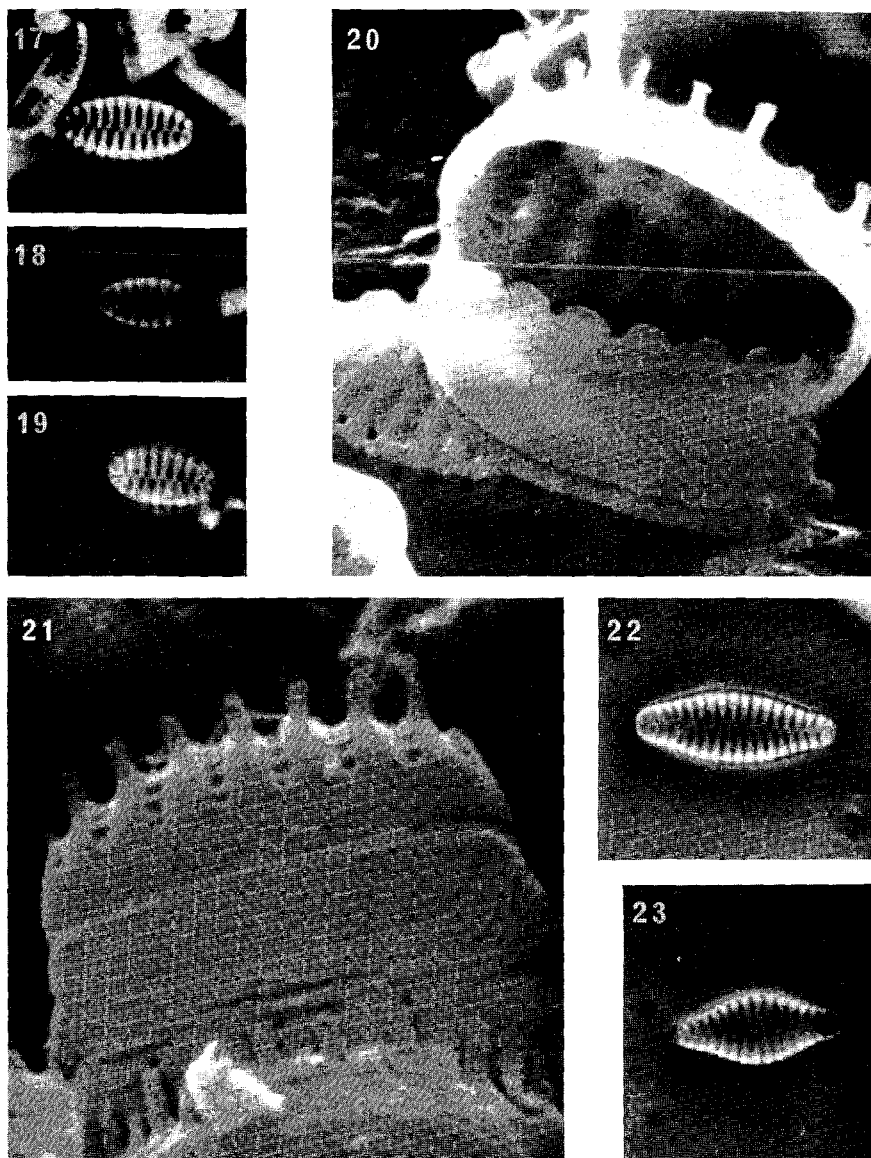
The correct taxonomic niche for this form has been more difficult to determine.



FIGS 6-11. *Fragilaria pinnata* Ehrenb. Fig. 6. Small rounded form from Loch Borrallan. SEM.  $\times 9800$ . Fig. 7. Girdle view, Loch Borrallan material. SEM.  $\times 10,500$ . Fig. 8. Valve view showing the pairs of spines between the costae, Cam Loch material. SEM.  $\times 4900$ . Fig. 9. Oblique view showing spines in profile, Cam Loch material. SEM.  $\times 5300$ . Fig. 10. Valve view, Cam Loch material. Light microscopy.  $\times 2000$ . Fig. 11. Forms of *Odontidium mutabile* on a Wm Smith slide in the H. L. Smith collection, No. 383. Light microscopy.  $\times 2000$ .



FIGS 12, 13. *Fragilaria pinnata*. FIGS 14–16. *Fragilaria elliptica* Schumann. Fig. 12. Pair of cells with three spines between costae, Cam Loch material. SEM.  $\times 8500$ . Fig. 13. Oblique view showing spines, Loch Borralan material. SEM.  $\times 10,000$ . Fig. 14. Single cell, Loch Borralan material. SEM.  $\times 5000$ . Fig. 15. Broken specimen showing valve and overlapping spines, Loch Borralan material. SEM.  $\times 10,000$ . Fig. 16. Two cells showing girde and valve views and variously shaped spines, Loch Borralan material. SEM.  $\times 4700$ .



FIGS 17–21. *Fragilaria elliptica*. FIGS 22, 23. *Fragilaria construens* var. *venter* (Ehrenb.) Grun. FIGS 17–19. Valve views, Cam Loch material. Light microscopy.  $\times 2000$ . FIG. 20. Girdle band and oblique view showing inner part of the valve, Loch Borrallan material. SEM.  $\times 10,100$ . FIG. 21. Side view showing girdle bands and overlapping spines, Cam Loch material. SEM.  $\times 10,500$ . FIG. 22. Valve view of specimen on Grunow slide No. 1062a. Light microscopy.  $\times 2000$ . FIG. 23. Valve view of specimen on Grunow slide No. 1062b. Light microscopy.  $\times 2000$ .



There are several taxa into which it might fit, namely, *F. construens* var. *venter* (Ehrenb.) Grun.; *F. construens* var. *subsalina* Hust. and *F. elliptica*. Reference to the Fritsch Collection suggests that most authors place this form in *F. construens* var. *venter*, though none of Grunow's drawings is of rounded forms. They tend instead to have pointed ends and inflated middle sections, as in my Figs 22 and 23; this is another form which is frequent in Cam Loch sediments and has been correlated with specimens on Grunow Slides Nos. 1062 a/b. As these two forms are always separable in the analyses of these sediments, the rounded form is referred to *F. elliptica*.

### CONCLUSIONS

The forms shown in Figs 1–21 have been identified as belonging to *F. lapponica*, *F. pinnata* and *F. elliptica*. In spite of the difficulties of relating these forms to the types originally described, the first two identifications seem to be satisfactory while the third form needs further study. It has become obvious that we are short of descriptive terms for the taxa of this variable genus, that most of the present descriptions can, and probably do, apply to more than one form and that differences in spines and costae are best clarified by scanning electron microscopy.

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### REFERENCES

- CLEVE-EULER, A., 1953. Die Diatomeen von Schweden und Finnland. Part II. *K. svenska Vetensk. Akad. Handl.*, 4: 1–158.
- CRAWFORD, R. M., 1971. The fine structure of the frustule of *Melosira varians* C. A. Agardh. *Br. phycol. J.*, 6: 175–186.
- EHRENBERG, C. G., 1843. Verbreitung und Einfluss des mikroskopischen Lebens in Süd- und Nord-Amerika. *Abh. K. Akad. Wiss.*, (1841): 291–445.
- HELMCKE, J. G. & KREIGER, W., 1962–63. Diatomeenschale im elektronmikroskopischen Bild. Parts I–IV. Cramer, Lehre.
- HUSTEDT, F. 1959. Die Kieselalgen Deutschlands, Österreichs und der Schweiz. Teil 2. In *Kryptogamen-Flora* (Rabenhorst, L., editor), Band 7. A.V.G., Leipzig.
- LUND, J. W. G., 1971. The Fritsch collection of illustrations of freshwater algae. *Mitt. int. Verein. Limnol.*, 19: 314–16.
- MAYER, A., 1937. Die Bacillariophyten-Gattungen *Fragilaria* und *Asterionella* in Bayern. *Ber. bayer. bot. Ges.*, 22: 50–85.
- MILLER, U., 1969. Fossil diatoms under the scanning electron microscope. *Sver. geol. Unders. Afh. ser. C.*, 63: 5–65.
- PATRICK, R. & REIMER, C. W., 1966. The diatoms of the United States. Vol. I. *Monogr. Acad. nat. sci. Philad.*, 13: 1–688.
- PENNINGTON, W., HAWORTH, E. Y., BONNY, A. P. & LISHMAN, J. P., 1972. Lake sediments in northern Scotland. *Phil. trans. R. Soc. B.*, 264: 191–294.
- SCHUMANN, J., 1867. Preussische Diatomeen, pt III. *Schr. phys.-ökon. Ges. Königsb.*, 37–68.
- SMITH, W., 1856. *Synopsis of the British Diatomaceae. Part II.* 1–107, Van Voorst, London.
- VAN HEURCK, H., 1881. *Synopsis des diatomées de Belgique*, Anvers.