11.

CONTRIBUTIONS TO THE DIATOM FLORA OF ARCTIC CANADA: REPORT 1. SCANNING ELECTRON MICROGRAPHS OF SOME FRESHWATER SPECIES FROM ELLESMERE ISLAND

Project 720078

Sigrid Lichti-Federovich
Terrain Sciences Division

Lichti-Federovich, S., Contributions to the diatom flora of Arctic Canada: Report 1. Scanning electron micrographs of some freshwater species from Ellesmere Island; in Current Research, Part B, Geological Survey of Canada, Paper 79-1B, p. 71-82, 1979.

Abstract

*Scanning electron micrographs of the diatoms **Achnanthes flexella**, **Amphora veneta**, **Ceratoneis arcus**, **Cyclotella antiqua**, and **Navicula tuscula** are presented, together with a description of their respective ecological and environmental characteristics. This report represents the first contribution to a comprehensive illustrated floristic account of the diatoms of the Canadian Arctic.*

Introduction

This paper is the first contribution to a comprehensive illustrated account of the diatom flora of the Canadian Arctic. This larger endeavour is designed to enumerate the diatom taxa of arctic regions, to characterize their respective ecologies, and to delineate their climatic/geographic affinity. The extensive use of scanning electron micrographs is aimed principally to aid in the description of new taxonomic entities, to clarify phylogenetic relationships, and specifically to facilitate and assist in critical identification since the effectual application of diatom analysis as a paleoecological tool and the validity of paleoenvironmental interpretations rest foremost upon the ability to identify correctly the various taxa present.

Acknowledgments

I extend my appreciation to W. Blake, Jr. for collecting the sample material, to D.A. Walker for his technical skill in taking the scanning electron micrographs, and to the members of the Photographic Section for preparation of the photographic prints. The manuscript has been read critically, and helpful comments provided as to the distribution of the species reported, by M.R. Sreenivasa, University of New Brunswick, Fredericton.

Materials and Methods

The diatoms illustrated in this report (Plates 11.1-11.5 on following pages) were obtained from samples collected by W. Blake, Jr. during glacial geological studies in eastern and southern Ellesmere Island in July and August 1977.

Preparation of the samples followed the conventional methods employed by most diatomists. Plankton samples were treated with concentrated sulphuric acid and potassium dichromate; diatoms in sediment samples were cleaned with cold 15% hydrogen peroxide. Variations in the treatment as to its duration, application of heat, strength of acid, etc. depend on the organic content of the sample material. After several washings with distilled water to remove any trace of acid or oxydizing agent, a small amount of the diluted diatom-bearing suspension was filtered using a 0.45 µm polycarbonate filter. Preparation for electron-microscopic studies (Walker, 1978) consisted in mounting a 1/2 inch disc of the diatom-bearing 'Nuclepore' filter onto a SEM stub covered with a thin layer of carbon paint to eliminate heat build up, and coating it with gold/palladium. All electron micrographs were taken with the Geological Survey's ETEC Autoscan at 20 kV, and the light micrographs were obtained with a Leitz Ortholux x90 oil immersion objective and the Wild Photoautomat MPS50.

References

Cleve-Euler, A.
1953: Die Diatomeen von Schweden und Finnland, III; Kungliga Svanska Vetenskaps-akademiens Handlingar, Fjärde Serien, v. 4, no. 5, p. 1-255.

Cholnoky, B.J.
1968: Die Ökologie der Diatomeen in Binnengewässern; Verlag J. Cramer, 699 p.

Florin, M.B.
1944: En sensubarktisk transgression i trakten av södra Kilsbergen enligt diatomacésuccessionen i områdets högre belägna fornsjölagerföljder; Stockholm, Geologiska Förening i Stockholm Förhandlingar, v. 66, p. 417-448.

Foged, N.
1953: Diatoms from West Greenland; Meddelelser om Grønland, v. 4, no. 6, p. 1-86.

1954: On the diatom flora of some Funen lakes; Folia Limnologica Scandinavica, no. 6, p. 1-75.

1955: Diatoms from Peary Land, North Greenland; Meddelelser om Grønland, v. 128, no. 7, p. 1-90.

1958: The diatoms in the basalt area and adjoining areas of Archean rock in West Greenland; Meddelelser om Grønland, v. 156, no. 4, p. 1-146.

1964: Freshwater diatoms from Spitsbergen; Tromsö Museums Skrifter, v. 11, 204 p.

1973: Diatoms from Southwest Greenland; Meddelelser om Grønland, v. 194, no. 5, p. 1-84.

Gandhi, H.P.
1966: The freshwater diatom flora of the Jog-Falls, Mysore State; Nova Hedwigia, v. 11, p. 89-197.

Halme, E. and Mölder, K.
1958: Planktologische Untersuchungen in der Pojo-bucht und angrenzenden Gewässern. III. Phytoplankton; Annales Botanici Societatis "Vanamo", v. 30, no. 3, p. 1-70.

Haworth, E.Y.
1972a: The recent diatom history of Loch Leven, Kinross; Freshwater Biology, v. 2, p. 131-141.

1972b: Diatom succession in a core from Pickerel Lake, northeastern South Dakota; Geological Society of America Bulletin, v. 83, p. 157-172.

1974: Some problems of diatom taxonomy in Scottish lake sediments; British Phycological Journal, v. 9, p. 47-55.

(References continue p. 82)

Achnanthes flexella (Kützing) Brun

Diat. des alpes, p. 29, 1880.

Synonymy: See Van Landingham, 1967, p. 26-28.

Ecology: Foged (1954) characterized this boreal cold water form as being limnophilous and indifferent to salinity and pH, whereas Jørgensen (1948) and Round (1957) considered the species to be acidophilous. Cholnoky (1968) assigned **Achnanthes flexella** a pH optimum of about 6.0; he also included this taxon in the list of indicator species for high oxygen concentration. Hustedt (1942) listed a pH range of 6.2 to 9.0 with maximum abundance at pH 6.3 as well as pH 7.0.

Occurrence and Distribution: **Achnanthes flexella** was reported from northern Sweden by Hustedt (1942) and Cleve-Euler (1953), from Finnish lakes by Mölder and Tynni (1972), and from Greenland and Spitsbergen by Foged (1955, 1958, 1964, 1973).

In eastern Ellesmere Island, **Achnanthes flexella** occurs as common co-dominant or attendant species in many freshwater diatom associations from arctic ponds.

Plate 11.1

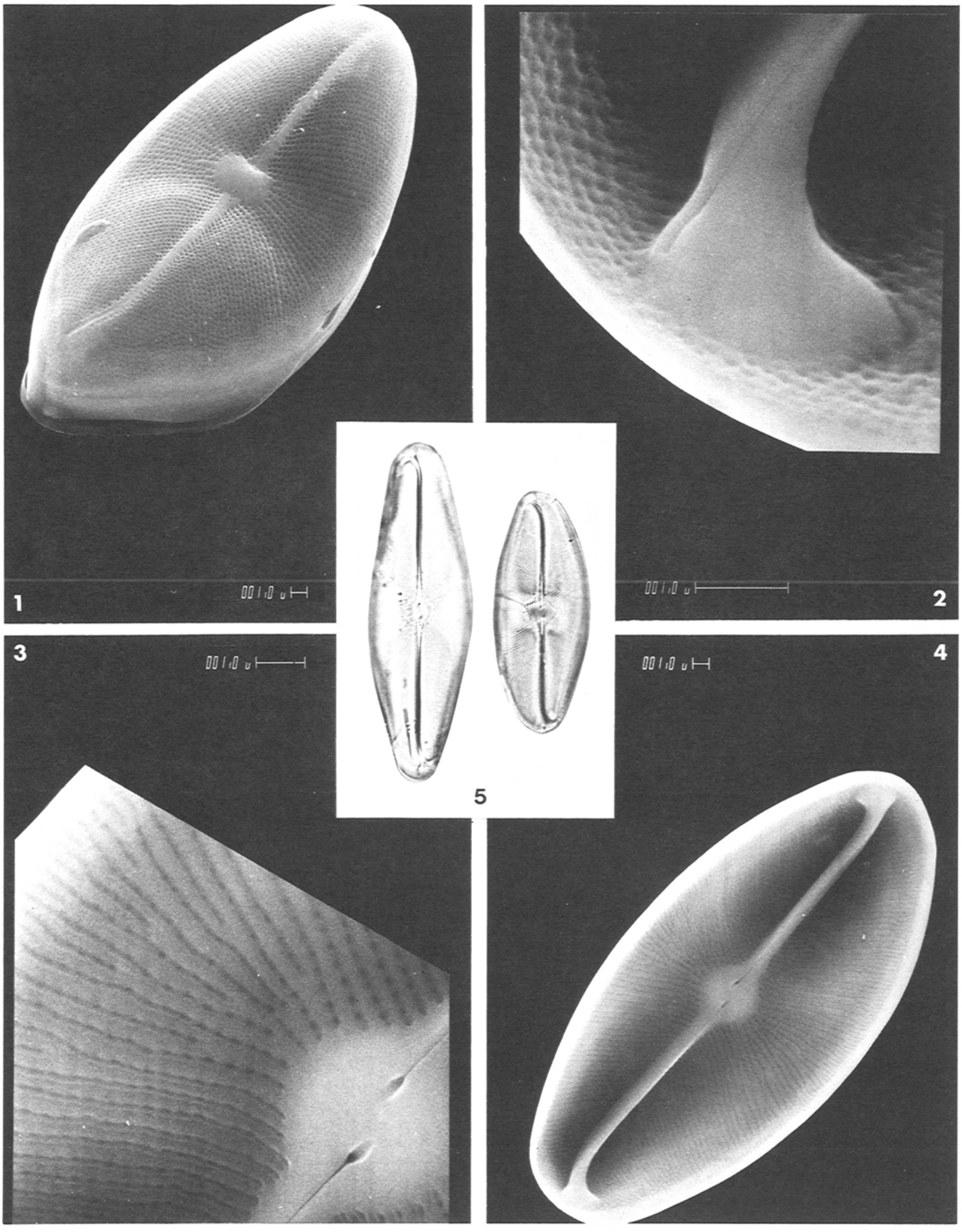
Figure 1. Scanning electron micrograph (GSC 61769): Frustule in valve view (magnification x3000, tilt 30°). The sample is from the water of some moss collected along the shore of the largest low-level lake in the northwestern part of the Cape Herschel Peninsula (78°37.6'N, 74°43'W).

Figure 2. Scanning electron micrograph (GSC 61770): Higher magnification of inner marginal zone illustrating the deflected polar raphe fissure ending (magnification x19 000, tilt 30°). Figures 2 to 5 are of diatoms from the mud-water interface in a pond on raised beaches north of the head of Herschel Bay (78°36.3'N, 74°45'W).

Figure 3. Scanning electron micrograph (GSC 61770): Magnified central area of inner valve surface showing the expanded central raphe fissure ending (magnification x10 000, tilt 30°).

Figure 4. Scanning electron micrograph (GSC 61770): Inside view of valve (magnification x900, oil immersion, Hyrax mount).

Figure 5. Light photomicrographs (GSC 61771 and GSC 61772): General picture. Valvar view (magnification x900, oil immersion, Hyrax mount).


1
2
3
4
5

Amphora veneta Kützing

Die Kieselschal. Bacill. od. Diat., Nordhausen, p. 108, Pl. 3, Fig. 24, 1844.

Synonymy: See Van Landingham, 1967, p. 276-277.

Var. **capitata** Haworth
Br. phycol. J., v. 9, p. 48, Fig. 6, 19, 1974

Ecology: The ecology of this new variety is insufficiently known; however, it may be assumed that it is similar to that of the nominate variety.

Amphora veneta has been characterized by Hustedt (1957) as oligohalobous (indifferent), pH indifferent, meso-oxybiontic, indifferent to current rate but not limnobiontic. Foged (1953) regarded this form a halophil, alkaliphil, and limnophil, and Cholnoky (1968) assigned **Amphora veneta** a pH optimum at or perhaps above pH 8.5. Whereas Hustedt (1930) and Halme and Mölder (1958) considered this diatom to be a littoral form of fresh as well as brackish water, Cholnoky (1968) negated its brackish water affinity and stated that **Amphora veneta** occurs as an inhabitant of highly alkaline waters, but that it cannot tolerate changes in osmotic pressure.

Occurrence and Distribution: According to Haworth (1974), who described and named this variety, it has been found in late-glacial and early postglacial sediments of Loch Borrelan and Loch Sionascaig, Scotland (cf. Pennington et al., 1972), in recent sediments of Loch Leven (cf. Haworth, 1972a), and in collections of algal material from the Isle of Mull. As Haworth stated, and I agree, the specimen of Foged's (1955) drawing (his Table XVI, Fig. 21) from Peary Land, North Greenland is likely to belong to var. **capitata.**

The occurrence of the nominate variety has been recorded by Gandhi (1966) in ditches and pools and in marked abundance on vegetable detritus. Haworth (1972b) reported **Amphora veneta** as a benthic form from Minnesota lakes or associated with **Typha.** Hustedt (1957) found it on stones, mosses, **Hydrocharis,** and **Lemna.** In addition, Van Landingham (1966) indicated its rare to locally abundant occurrence in dry lakes in Nevada, and Hendey (1964) stated its common occurrence on all British coasts, where it has been observed as "flat mucous films tightly adpressed to the substratum".

In eastern Ellesmere Island only a few single occurrences of **Amphora veneta** and its variety **capitata** have been noted to date.

Plate 11.2

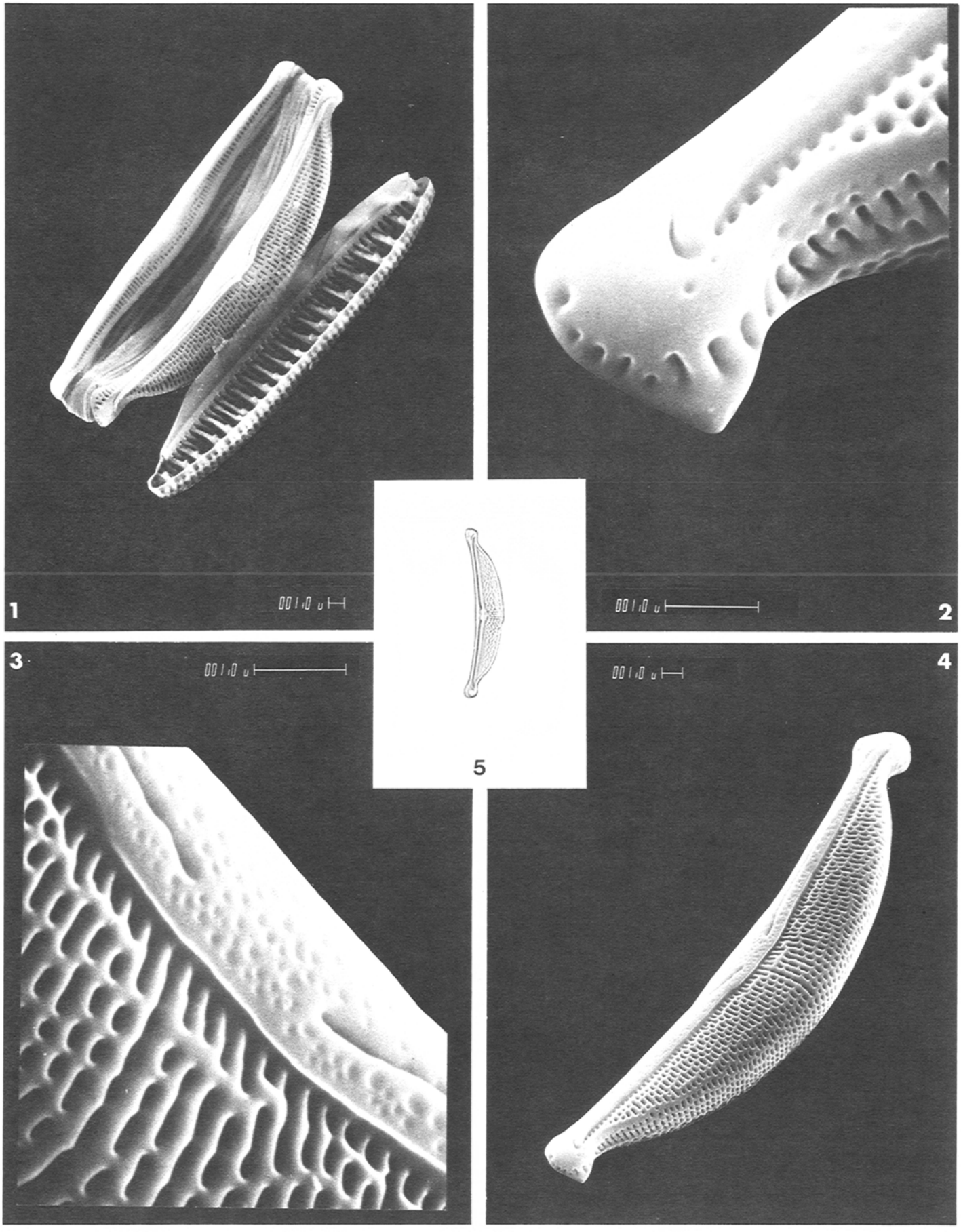
Figure 1. Scanning electron micrograph (GSC 61773): Oblique internal view of entire frustule (magnification x3000, tilt 30°). The sample is from 'red snow' collected from a snowbank along the north side of a river valley, ca. 6.5 km north-northeast of Cape Storm (76°23.9'N, 87°32'W).

Figure 2. Scanning electron micrograph (GSC 61774): Valve end showing structural detail (magnification x19 000, tilt 30°). Figures 2 to 5 are from the same mud-water interface sample as figures 2 to 5, Plate 11.1.

Figure 3. Scanning electron micrograph (GSC 61774): Enlarged central area of outer valve surface (magnification x90 000, tilt 30°).

Figure 4. Scanning electron micrograph (GSC 61774): Outside view of valve (magnification x4000, tilt 30°).

Figure 5. Light photomicrograph (GSC 61775): General picture. Valvar view (magnification x900, oil immersion, Hyrax mount).


1
2
3
4
5

Ceratoneis arcus (Ehrenberg) Kützing

Bacill., p. 104, Pl. 6, Fig. X, 1844.

Synonymy: See Van Landingham, 1968, p. 687-688.

Ecology: This freshwater form has its optimal development in cold flowing water, especially mountainous areas (Hustedt, 1930, 1959; Patrick and Reimer, 1966). Sovereign (1958) suggested a pH range from 6.0 to 8.0 for this species. Hustedt (1957) assigned **Ceratoneis arcus** the following ecological characteristics: alkaliphilous (alkalibiontic?), oligohalobous, and rheobiontic. A pH optimum of slightly above pH 7.0 (at about pH 7.2 to 7.3) has been cited by Cholnoky (1968). He also stated that this taxon is unable to withstand changes in osmotic pressure.

Occurrence and Distribution: According to Hustedt (1959) **Ceratoneis arcus** is common in flowing water throughout Europe where it occurs in great abundance in mountain streams and springs. Mölder and Tynni (1970) reported it as a frequent inhabitant of clear water lakes and fast flowing streams in northern Finland, and Sovereign (1958) stated its frequent occurrence in mountain streams of the Pacific Northwest. Additional distribution of this species in the United States has been listed by Patrick and Reimer (1966).

In eastern Ellesmere Island, the marked preponderance of **Ceratoneis arcus** in stream water samples, its less frequent occurrence in collections from lakes with fluvial influx, and its absence from floristic enumerations of pond samples clearly denote the highly specific autecology of this rheobiontic form.

Plate 11.3

Figure 1a. Scanning electron micrograph (GSC 61776): Exterior view of a valve (magnification x1800, tilt 30°). The sample is from stream water on the north side of the northernmost tidal glacier on the west side of Bentham Fiord, Makinson Inlet (77°10.5'N, 80°10'W).

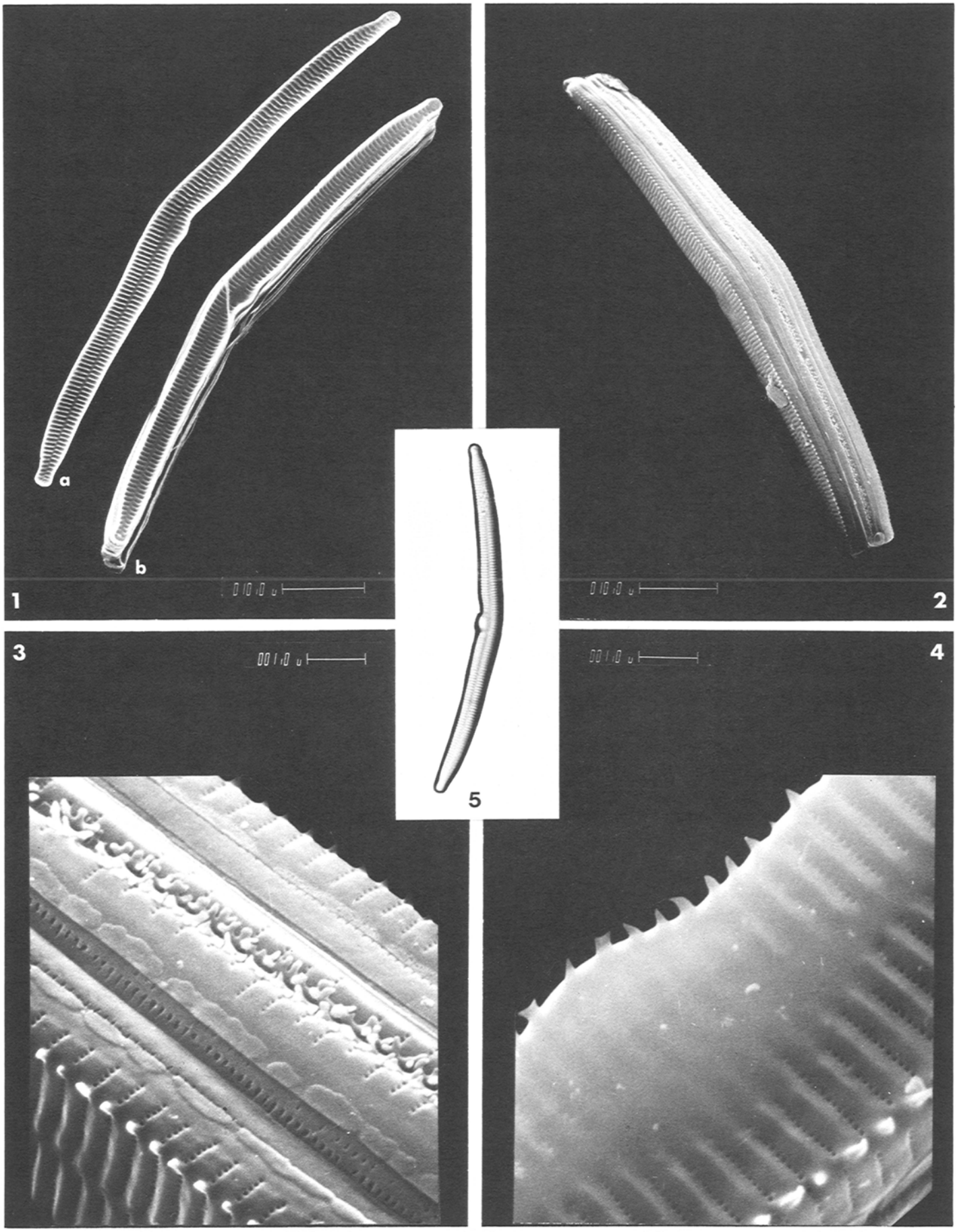
Figure 1b. Scanning electron micrograph (GSC 61777): Interior view of a valve (magnification x1700, tilt 30°).

Figure 2. Scanning electron micrograph (GSC 61778): Oblique dorsal girdle view of joint frustules (magnification x1600, tilt 30°).

Figure 3. Scanning electron micrograph (GSC 61778): Detail of two joined frustules in girdle view with marginal and linking spines (magnification x12 000, tilt 30°).

Figure 4. Scanning electron micrograph (GSC 61779): Enlarged central region of frustule displaying structureless area of ventral margin (magnification x13 000, tilt 30°).

Figure 5. Light photomicrograph (GSC 61780): General picture. Valvar view (magnification x900, oil immersion, Hyrax mount).


a
b
1
2
3
4
5

Cyclotella antiqua W. Smith

Syn. Brit. Diat., v. I, p. 28, Pl. V, Fig. 49, 1853.

Synonymy: See Van Landingham, 1969, p. 1099-1100.

Ecology: Foged (1953) considered **Cyclotella antiqua** a halophob and an acidophil. Hustedt (1942) listed a pH range of 6.3 to 8.4, but stated that the taxon always occurs most abundantly at a pH below 7.0.

Occurrence and Distribution: The general distribution of this boreal cold water species is limited to northern or mountainous regions (Hustedt, 1930). **Cyclotella antiqua** has been found in northern Russia, Fennoscandia, the British Isles, Germany, and Austria. It also has been recorded from the littoral zone of oligotrophic lakes in Lapland (Mölder and Tynni, 1968), and its frequent occurrence as a benthic form in Peary Land has been described by Foged (1955). The subfossil occurrence of this boreal species has been reported by Mölder and Tynni (1968). Round (1957) characterized this form as important indicator species of glacial and late-glacial sediments.

In eastern Ellesmere Island **Cyclotella antiqua** occurs as frequent but never abundant floristic component of the diatom associations from freshwater collections.

Plate 11.4

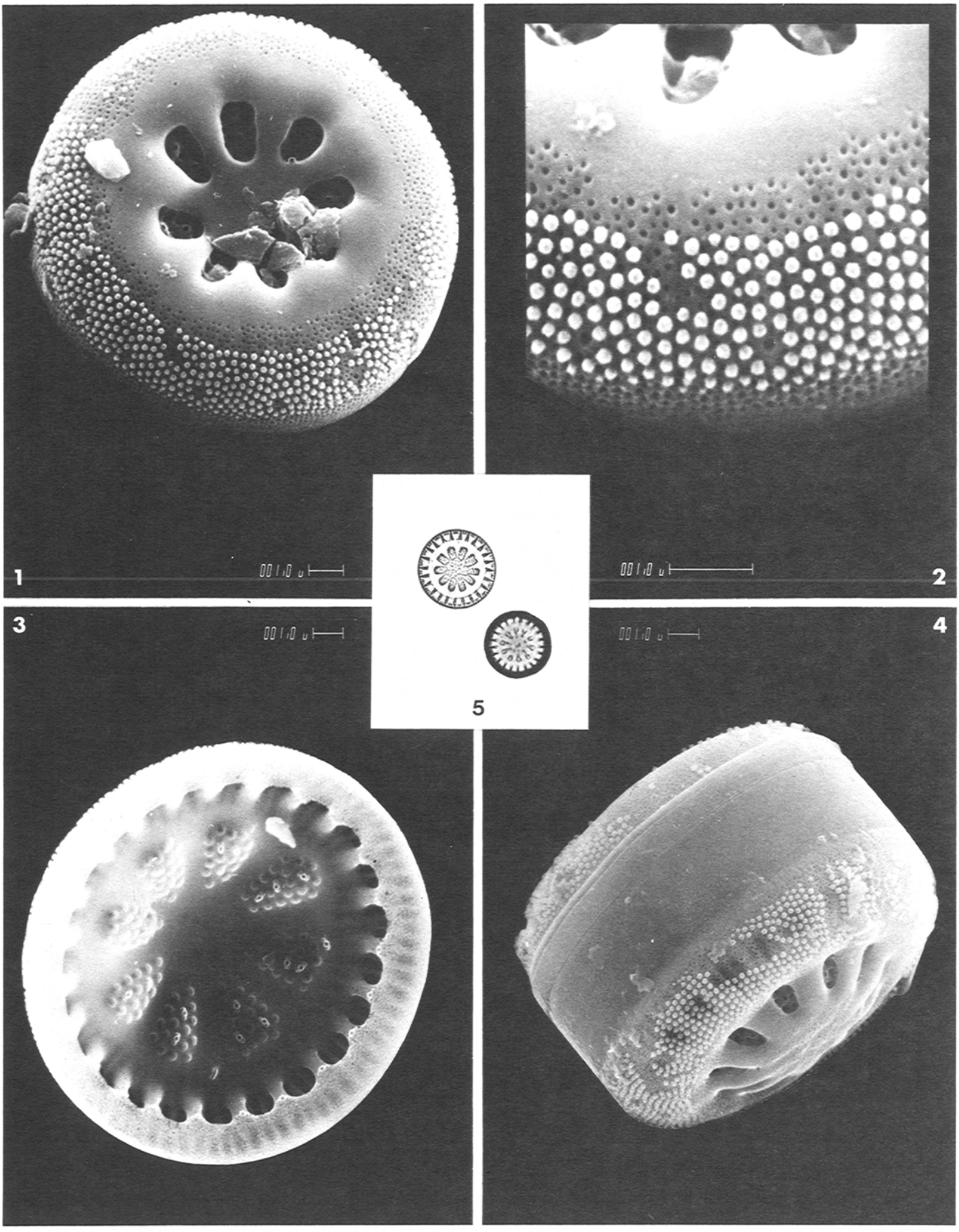
Figure 1. Scanning electron micrograph (GSC 61781): Exterior view of valve (magnification x7000, tilt 30°). The sample shown in figures 1 and 2 is from the water of a pond adjacent to the RCMP post at Alexandra Fiord (78°52.9'N, 75°47'W).

Figure 2. Scanning electron micrograph (GSC 61781): Enlarged part of outer marginal valve zone (magnification x17 000, tilt 30°).

Figure 3. Scanning electron micrograph (GSC 61782): Inside view of valve showing poroids with cribra, central and marginal fultoportules, and a single rimoportule (labiate process). (Magnification x6000, tilt 30°.) This sample is from the same mud-water interface sample as figures 2 to 5, Plates 11.1 and 11.2.

Figure 4. Scanning electron micrograph (GSC 61783): Oblique girdle view of entire frustule (magnification x6000, tilt 30°).

Figure 5. Light photomicrograph (GSC 61784 and GSC 61785): General picture. Valvar view at different focal depth (magnification x900, oil immersion, Hyrax mount).


1
2
3
4
5

Navicula tuscula Ehrenberg

Ber. Akad. Wiss. Berlin for 1840, p. 215.

Synonymy: See Van Landingham, 1975, p. 2861-2863.

Ecology: This taxon is listed as halobion indifferent (Foged, 1954; Hustedt, 1957; Simonsen, 1962), alkalibiontic (Jørgensen, 1948; Foged, 1954; Hustedt, 1957), and limnobiontic (Foged, 1954). Jørgensen (1948), in his investigations of the diatom flora of Danish lakes and ponds, stated a pH range of 7.7 to 8.5 for this species; Hustedt (1957), as a result of his researches in Swedish Lapland, suggested a range of pH 6.1 to 9.0; and Cholnoky (1968) assigned **Navicula tuscula** a pH optimum at or slightly below pH 8.0. According to Cleve-Euler (1953) this clear water form is found in fresh to slightly brackish or calcium-rich water, and Jørgensen (1948) limited its occurrence to eutrophic lakes and ponds.

Occurrence and Distribution: **Navicula tuscula** is common in the Baltic region and in Germany (Hustedt, 1930). It has been reported from Greenland (Foged, 1953, 1955, 1958, 1973) and from several American states (Patrick and Reimer, 1966). Florin (1944) cited fossil occurrences in central Swedish deposits from both the Yoldia Sea and Ancyclus Lake.

In eastern Ellesmere Island, **Navicula tuscula** represents a significant floristic element of the recent diatom population of lakes and ponds.

Plate 11.5

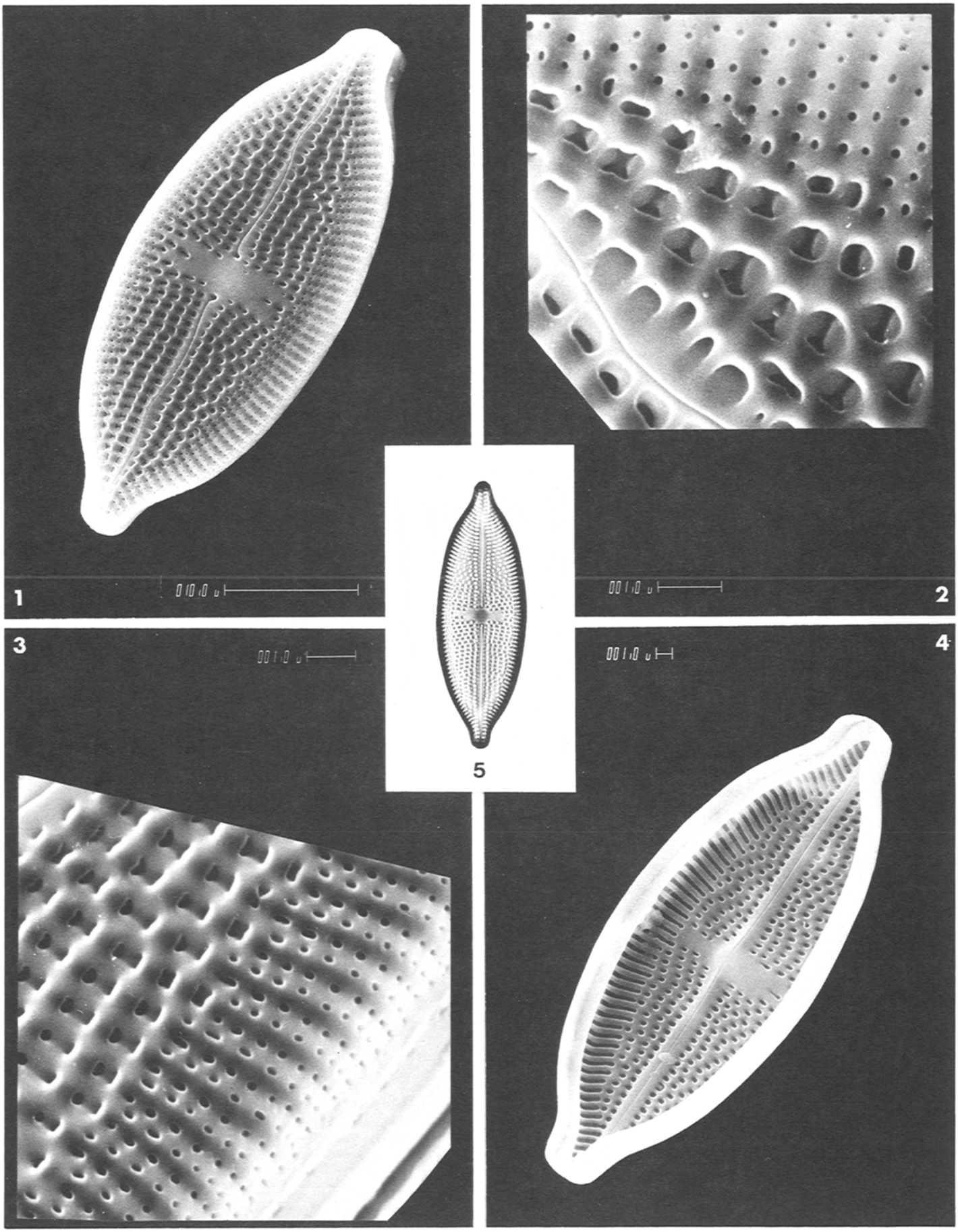
Figure 1. Scanning electron micrograph (GSC 61786): External view of valve (magnification x2800, tilt 30°). The sample is from the same mud-water interface sample as figures 2 to 5, Plates 11.1 and 11.2, and figures 3 to 5, Plate 11.4.

Figure 2. Scanning electron micrograph (GSC 61786): Enlarged part of valve face denoting the raphe fissure undulation, the sunken slit-like central and round marginal areolae. (magnification x13 000, tilt 30°).

Figure 3. Scanning electron micrograph (GSC 61787): Part of outer valve margin illustrating the structural difference between marginal and central areolae (magnification x10 000, tilt 30°). tilt 30°).

Figure 4. Scanning electron micrograph (GSC 61788): Internal view of valve (magnification x3000, tilt 30°).

Figure 5. Light photomicrograph (GSC 61789): General picture. Valvar view (magnification x900, oil immersion, Hyrax mount).


1
2
3
4
5

Hendey, I.N.
1964: An introductory account of the smaller algae of British coastal waters; Fisheries Investigation Series IV, Ministry of Agriculture, Fisheries and Food, London, 317 p.

Hustedt, F.
1930: Die Süsswasser – Flora Mitteleuropas; Heft 10: Bacillariophyta (Diatomeae), Verlag G. Fisher, Jena, 466 p.

1942: Diatomeen aus der Umgebung von Abisko in Schwedisch-Lappland; Archiv für Hydrobiologie, v. 39, no. 1, p. 82-174.

1957: Die Diatomeenflora des Flusssystems der Weser im Gebiet der Hansestadt Bremen; Abhandlungen. Naturwissenschatlicher Verein, Bremen, v. 34, no. 3, p. 181-440.

1959: Die Kieselalgen. 2. Teil; in Kryptogamen-Flora von Deutschland, Österreich und der Schweiz, Bd. II, L. Rabenhorst, ed.; Akademische Verlagsgesellschaft Geest und Portig K.-G., Leipzig, 845 p.

Jørgensen, E.G.
1948: Diatom communities in some Danish lakes and ponds; Det Kongelige Danske Videnskabernes Selskab. Biologiske Skrifter, v. 5, no. 2, p. 1-140.

Mölder, K. and Tynni, R.
1968: Über Finnlands rezente und subfossile Diatomeen II; Geological Society of Finland Bulletin, v. 40, p. 151-170.

1970: Über Finnlands rezente und subfossile Diatomeen IV; Geological Society of Finland Bulletin, v. 42, p. 129-144.

1972: Über Finnlands rezente und subfossile Diatomeen VI; Geological Society of Finland Bulletin, v. 44, p. 141-149.

Patrick, R. and Reimer, C.W.
1966: The diatoms of the United States; Academy of Natural Sciences, Philadelphia, v. 1, Monograph no. 13, 688 p.

Pennington, W., Haworth, E.Y., Bonny, A.P., and Lishman, J.P.
1972: Lake sediments in northern Scotland; Royal Society of London, Philosophical Transactions, Series B, v. 264, p. 191-294.

Round, F.E.
1957: The late-glacial and post-glacial diatom succession in the Kentmere Valley deposit. Part I. Introduction, methods and flora; New Phytologist, v. 56, p. 98-126.

Simonsen, R.
1962: Untersuchungen zur Systematik und Ökologie der Bodendiatomeen der westlichen Ostsee; Akademie-Verlag, Berlin, p. 1-144.

Sovereign, H.E.
1958: The diatoms of Crater Lake, Oregon; American Microscopical Society, Transactions, v. 77, p. 96-134.

Van Landingham, S.L.
1966: Diatoms from dry lakes in Nye and Esmeralda counties, Nevada, U.S.A.; Nova Hedwigia, v. 11, p. 221-241.

1967: Catalogue of the Fossil and Recent Genera and Species of Diatoms and their Synonyms. Part I. **Acanthoceras** through **Bacillaria**; J. Cramer, Lehre, 493 p.

1968: Part II. **Bacteriastrum** through **Coscinodiscus**; J. Cramer, Lehre, p. 494-1086.

1969: Part III. **Coscinophaena** through **Fibula**; J. Cramer, Lehre, p. 1087-1756.

1975: Part V. **Navicula**; J. Cramer, Lehre, p. 2386-2963.

Walker, D.A.
1978: Preparation of geological samples for scanning electron microscopy; Scanning Electron Microscopy, v. 1, p. 185-192.