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Albert D. Mahood

*California Academy of Sciences, Golden Gate Park, San Francisco, California*

John A. Barron

*USGS*

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# Late Pliocene diatoms in a diatomite from Prydz Bay, East Antarctica

Albert D. Mahood<sup>1</sup> and John A. Barron<sup>2</sup>

<sup>1</sup>California Academy of Sciences, Golden Gate Park, San Francisco, California, 94118-9961 U.S.A.

<sup>2</sup>U.S. Geological Survey MS 915, Menlo Park, California, 94025 U.S.A.

**ABSTRACT:** Very well-preserved Pliocene diatoms from a diatomite unit interbedded within glacial sediments at Ocean Drilling Program Site 742 in Prydz Bay, Antarctica are documented and illustrated. The presence of *Thalassiosira kolbei*, *T. torokina*, *Actinocyclus actinochilus*, *A. karstenii* and the absence of *Nitzschia interfrigidaria*, *T. insigna* and *T. vulnifica* in Sample 119-742A-15R-4, 44-46cm constrain its age to ca. 2.2-1.8 Ma (late Pliocene). Diatoms associated with sea ice constitute 35% of the Pliocene diatom assemblage, compared with 71% of the modern sediment assemblage at the site, suggesting that sea ice was present during the late Pliocene period of deposition of the sample, although it probably was not the significant feature it is today.

*Thalassiosira ellitipora* (Donahue) Fenner is described and illustrated in detail and is validly published. An expanded description and numerous illustrations are also presented for *T. torokina* Brady.

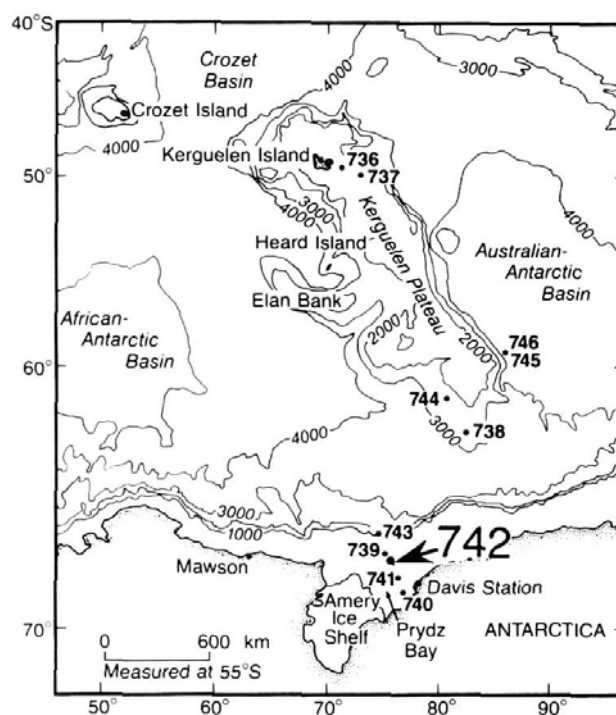
## INTRODUCTION

During Ocean Drilling Program Leg 119 on the continental shelf in Prydz Bay, Antarctica, a 60-cm-thick unit of distinctive greenish gray to gray diatomite (lithologic Subunit IIIB) was recovered within a thick (300+m) sequence of coarse-grained glacial diamictite in Core 15R of Hole 742A at 67°32.98'S, 75°24.27'E and a water depth of 426.2m (text-fig. 1) (Shipboard Scientific Party 1989). The abundant Pliocene diatoms found in this diatomite were apparently deposited during a period of enhanced biologic productivity in a distal glaciomarine setting, possibly during an interglacial period warmer than today (Shipboard Scientific Party 1989). The presence of well-preserved Pliocene diatoms within otherwise glacial sediments that typify the Antarctic shelf is relatively rare and offers an opportunity to study a nearshore environment of East Antarctica during an interval of the late Pliocene. A study of the diatoms of this Pliocene diatomite may provide evidence that bears on the hypothesis of Webb et al. (1984) and Webb and Harwood (1991) that calls for large scale deglaciation of East Antarctica during parts of the early and late Pliocene. In addition, the well-preserved nature of the diatoms in this deposit allows their study under the scanning electron microscope (SEM) and may contribute to solving some of the numerous problems of taxonomic confusion that currently plagues the study of Pliocene Antarctic diatoms (Harwood and Maruyama 1992).

## MATERIALS AND METHODS

Sample 119-742A-15R-4, 44-46cm was collected from the 60cm-thick diatomite unit. The sample was processed for light microscopy (LM) and SEM by the Van der Werff (1955) hydrogen peroxide method. Strew slides were mounted in Hyrax for LM with individual species ringed for identification and photographic reference. Examination of taxa was made using a Leitz Ortholux II and an Olympus IMT at magnifications of  $\times 500$  and  $\times 1250$ . SEM examination and photography was made using a Cambridge 250 mark II SEM at the U.S. Geological Survey (Menlo Park) and a Hitachi S520 at the California Academy of

Sciences. Diatom terminology follows that of Ross et al. (1979). Sample material (CAS number 613278, ODP 119-742A-15R-4, 44-46cm) and slides (CAS numbers 217016-217018, 217022, 217026, 217027, 217029) are deposited at the California Academy of Sciences.



TEXT-FIGURE 1  
Location of ODP Site 742 in Prydz Bay, East Antarctica, and other sites cores by ODP Leg 119. Contours in meters.

TABLE 1

Tabulation of diatom taxa in Pliocene Sample ODP-119-742A-15R-4, 44-46cm and their relative percentage compared with the relative percentage of taxa recorded in surface sediment at the site by Stockwell et al. (1991). \* = extinct; ( ) = possible decedent.

Taxon	Pliocene sediment		Modern sediment	
	# valves	%	# valves	%
<i>Actinocyclus actinochilus</i>	16	3.7	0.7	
<i>A. ingens</i>	14	3.3	*	
<i>A. karstenii</i>	3	0.7	*	
<i>A. sp.</i>	1	0.2	0	
<i>Diploneis sp</i>	1	0.2	0	
<i>Eucampia antarctica</i>	14	3.3	0.13	
<i>Fragilariopsis obliquecostata</i>	67	15.7	6.2	
<i>Nitzschia barronii</i>	13	3.0	(2.1)	
<i>Rhizosolenia styliformis</i>	7	1.6	0	
<i>R. sp. D</i>	5	1.2	*	
<i>R. sp.</i>	13	3.0	0.3	
<i>Rouxia antarctica</i>	65	15.2	*	
<i>R. diploneides</i>	25	5.9	*	
<i>Stellarima microtrias</i>	52	12.2	0.7	
<i>Thalassiosira elliptipora</i>	7	1.6	*	
<i>T. kolbei</i>	2	0.5	*	
<i>T. lentiginosa</i>	17	4.0	0.5	
<i>T. oliverana</i> var. 1	1	0.2	0	
<i>T. oliverana</i> var. 2	6	1.4	0	
<i>T. oliverana</i> var. 3	2	0.5	0	
<i>T. oliverana</i> var. 4	7	1.6	0	
<i>T. tetraoestrupii</i>	5	1.2	0	
<i>T. tetraoestrupii</i> var. <i>reimeri</i>	19	4.4	0	
<i>T. torokina</i>	47	11.0	*	
<i>Thalassiothrix spp.</i>	18	4.2	0	
total	427	100	10.63	
Additional modern taxa with a Pliocene record:				
<i>Fragilariopsis curta</i>	0	0	55.7	
<i>F. cylindrus</i>	0	0	7.5	
<i>Thalassiosira spore</i>	?	?	5.5	

## RESULTS

## Diatom Assemblage

The diatom taxa identified in Sample 119-742A-15R-4, 44-46cm are listed in the Appendix and figured in part in the plates. Selected remarks are included about the morphology and taxonomy of the taxa. Their known ecology or inferred paleoecology is included.

The frequency of these taxa in a random count of 427 individuals is given in Table 1, where it is compared with similar counts in Holocene (modern) sediment from ODP Site 742 (after

Stockwell et al. 1991). Disregarding the extinct taxa present in the Pliocene sample, the major difference between the late Pliocene and Holocene diatom assemblages is the dominance of the sea ice associated diatom *Fragilariopsis curta* (Van Heurck) Hasle in the latter and its complete absence in the former. *Fragilariopsis cylindrus* (Grunow) Hasle, another sea ice diatom which makes up 7.5% of the Holocene assemblage, is also absent from the Pliocene sample. *Nitzschia praecurta* Gersonde, a probable ancestor of *F. curta* according to Gersonde (1990), is present in the Pliocene sample (Appendix); however, it is so rare that it was not recorded in the count (Table 1). *Fragilariopsis curta* and *F. cylindrus* are recorded elsewhere in the Southern Ocean in Pliocene sediments (Gersonde and Burckle 1990; Baldauf and Barron 1991; Harwood and Maruyama 1992), so their absence in Sample ODP 119-742A-15R-4, 44-46cm may not be due to the Pliocene age of the sediment. The common occurrence of other finely-silicified *Nitzschia* and *Rouxia* taxa in the Pliocene sample would suggest that the absence of *F. curta* and *F. cylindrus* was not due to dissolution, implying that their absence may be due to reduced amounts of sea ice (Pichon et al. 1987; Stockwell et al. 1991). On the other hand, a number of the diatoms in the Pliocene assemblage do have modern associations with sea ice or the plankton near sea ice (Table 1 and notes in Appendix), namely *Fragilariopsis obliquecostata* (Van Heurck) Hasle, *Eucampia antarctica* (Castracane) Mangin, *Actinocyclus actinochilus* (Ehrenberg) Simonsen, and *Stellarima microtrias* (Ehrenberg) Hasle et Sims. These sea ice related diatoms account for nearly 35% of the Pliocene diatom assemblage in Sample 119-742A-15R-4, 44-46cm, compared with approximately 71% of the modern sediment assemblage at the site (Table 1). This suggests that sea ice was present in the vicinity of Site 742 during the late Pliocene period of deposition of the sample although probably not as important a feature as it is in the modern environment of the site.

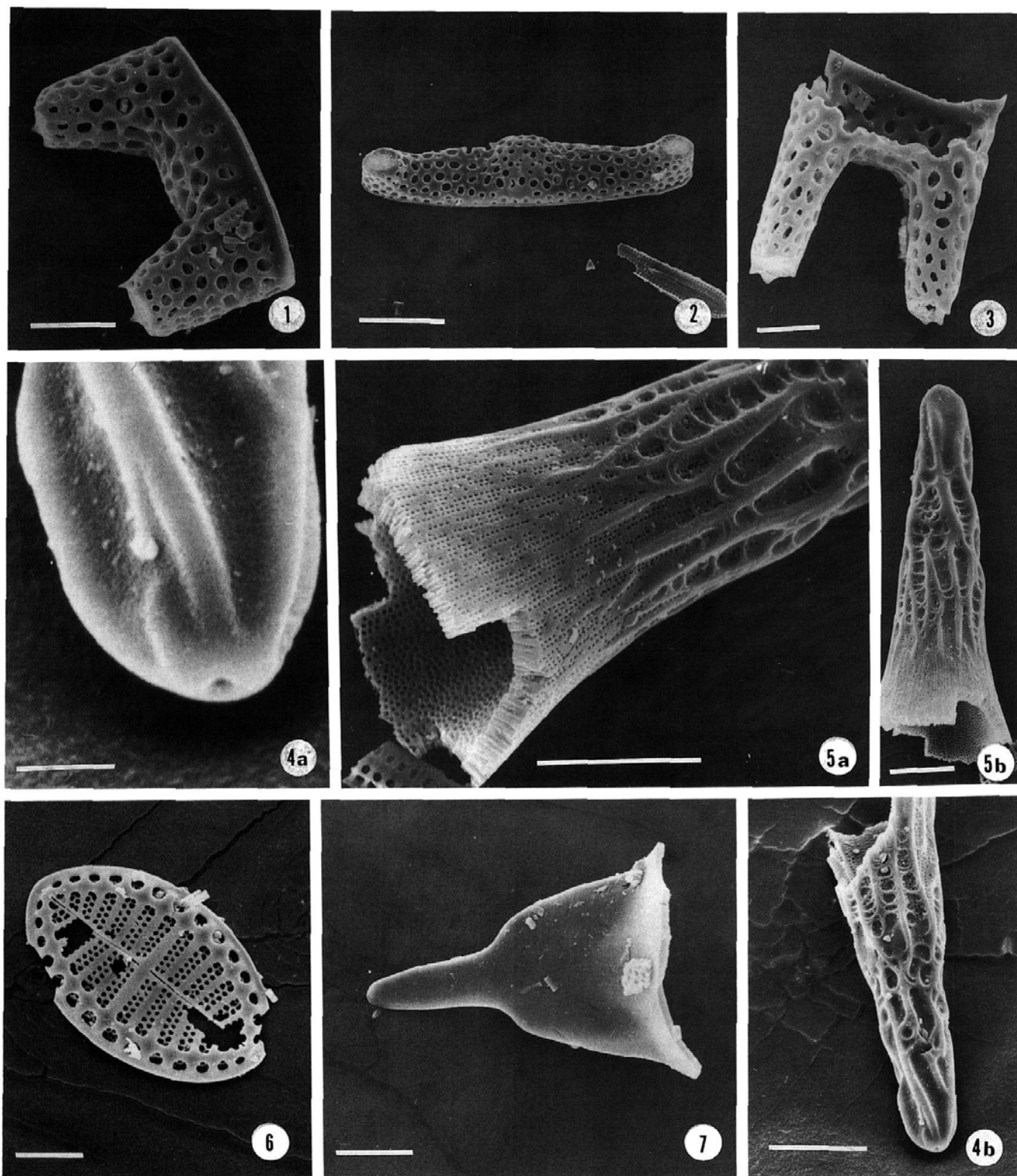
## Age

The presence of *Thalassiosira kolbei* (Jousé) Gersonde, *T. torokina* Brady, *Actinocyclus actinochilus*, and *A. karstenii* Van Heurck, along with the absence of *Nitzschia interfrigidaria* McCollum, *T. insigna* (Jousé) Harwood et Maruyama and *T. vulnifica* (Gombos) Fenner in Sample 119-742A-15R-4, 44-46cm constrain its age to ca. 2.2-1.8 Ma (late Pliocene) (Harwood and Maruyama 1992). According to Harwood and Maruyama (1992), the presence of *T. elliptipora* in this sample seems to indicate an age younger than 1.6 Ma; however, Baldauf and Barron (1991) stated that this taxon has its first occurrence immediately after the last occurrence of *T. vulnifica* (2.2 Ma) in ODP Hole 119-736A (text-fig. 1), an observation supported by the

## PLATE 1

- 1,2,3 *Eucampia antarctica* (Castracane) Mangin. 1, scale bar = 10µm; 2, scale bar = 20µm; 3, scale bar = 10µm.
- 4,5 *Rhizosolenia* sp. D of Harwood and Maruyama, 1992. 4a, scale bar = 2µm, apex of fig. 4b; 4b, scale bar = 10µm; 5a, base of fig. 5b, scale bar = 10µm; 5b, scale bar = 10µm.

- 6 *Cocconeis costata* var. *antarctica* Manguin. scale bar = 10µm.
- 7 *Rhizosolenia styliformis* Brightwell. scale bar = 10µm.





junior author in selected deep-sea cores of the Southern Ocean (Barron, unpublished data).

# ACKNOWLEDGMENTS

This paper benefitted from the reviews of David Harwood, Lloyd Burckle, Greta Fryxell, and Scott Starratt. We would like to acknowledge the use of the California Academy of Sciences diatom library and facilities. Robert Oscarson of the U.S. Geological Survey and Darrell Ubick from the California Academy of Sciences assisted in the SEM photography. Kevin Purcell of the U.S. Geological Survey assisted in the LM photography. Special thanks are given to G.A. Fryxell of the Texas A&M University, D.M. Harwood of the University of Nebraska and J.P. Kociolek of the California Academy of Sciences for their helpful comments. The Ocean Drilling Program is thanked for contributing the sample.

# APPENDIX

Taxonomic remarks and floral references. Original, recent and easily available references are given for each identified species.

*Actinocyclus actinochilus* (Ehrenberg) Simonsen  
Plate 7, figure 22

*Actinocyclus actinochilus* (Ehrenberg) SIMONSEN 1982, p. 101-116, pl. 1-4. — VILLAREAL AND FRYXELL 1983, p. 461, fig. 21-32.  
*Charcotia actinochilus* (Ehrenberg) HUSTEDT 1958, p. 122, pl. 7, figs. 57-80  
*Actinocyclus* sp. cf. *A. actinochilus* (older form) sensu HARWOOD AND MARUYAMA 1992, pl. 12, fig. 9-11).  
See Simonsen (1982) for full list of synonyms.

**Remarks:** Usually seen with eroded mantle. As Simonsen (1982), we found that *A. actinochilus* displayed a continuum of variations in the central area from hyaline to many areolae as well as variations in the number and density of fascicles similar to the illustrations of Hustedt (1958, pl. 7, figs. 57-80). Examination of a slide prepared from material from the *Challenger* Expedition, courtesy of the British Museum, prepared by A. Truan, "January (19)68" has helped to verify this species. The *Challenger* sample, Exp 3/3 1874, 53°55'S, 105°35'W from a depth of 3672 m was listed as ocean glacial.

**Ecology:** Fenner et al. (1976) reported this species as *Charcotia actinochilus* (Ehrenberg) Hustedt, and noted that it was restricted to Antarctic surface waters. Hargraves (1968) found it to be abundant in the pack-ice zone.

*Actinocyclus fasciculatus* Harwood and Maruyama  
*Actinocyclus fasciculatus* HARWOOD AND MARUYAMA 1992, p. 700, pl. 13, figs. 14, 15.

**Remarks:** Rare, not recorded in Table 1.

*Actinocyclus ingens* Rattray  
Plate 3, figures 1 a-4; plate 7, figures 20a, 20b, 21

*Actinocyclus ingens* RATTRAY 1890, p. 149, pl. 11, fig. 7. — GERSONDE 1990, pl. 1, fig. 7, pl. 3, fig. 8, 9, pl. 6, fig. 1. — BALDAUF AND BARRON 1991, p. 58, pl. 5, fig. 2. — HARWOOD AND MARUYAMA 1992, p. 700, pl. 8, fig. 10, pl. 11, figs. 4, 6, pl. 12, fig. 8.

**Remarks:** This species displays considerable variation in the number of radiating rows, fascicles and number of areolae within a row.

**Paleoecology:** Fenner (1991) reported that *A. ingens* inhabited both subantarctic and Antarctic surface waters during the late Pliocene and early Pleistocene and inferred that it may have been most common beneath the Polar Frontal Zone (PFZ).

*Actinocyclus karstenii* Van Heurck  
Plate 3, figure 5

*Actinocyclus karstenii* VAN HEURCK 1909, p. 44, pl. 12, fig. 158. — HARWOOD AND MARUYAMA 1992, p. 700, pl. 13, figs. 1, 2, 6-8, 10, 11 and 13.

**Remarks:** Although specimens that are clearly referable to *A. karstenii* were rarely encountered, the variation in row density, characteristic hyaline space at the margin and alternating radiating rows of areolae, many specimens suggest a similarity to *A. actinochilus*. A clear separation of *A. karstenii* and *A. actinochilus* may not always be possible (see Harwood and Maruyama 1992, pls. 12, 13).

*Asterolampra* sp.  
**Remarks:** Rare, badly eroded. Not recorded in Table 1.

*Biddulphia weissflogii* Grunow  
*Biddulphia weissflogii* Grunow in VAN HEURCK 1882, pl. 100, figs. 1, 2. — JOUSÉ 1977, pl. 68, fig. 20.

**Remarks:** Fragment, rare. Not recorded in Table 1.

*Cocconeis costata* var. *antarctica* Manguin  
Plate 1, figure 6

*Cocconeis costata* var. *antarctica* MANGUIN 1960, p. 304, pl. 14, figs. 154, 155 a-c. — FENNER ET AL. 1976, p. 771, pl. 11, fig. 12.

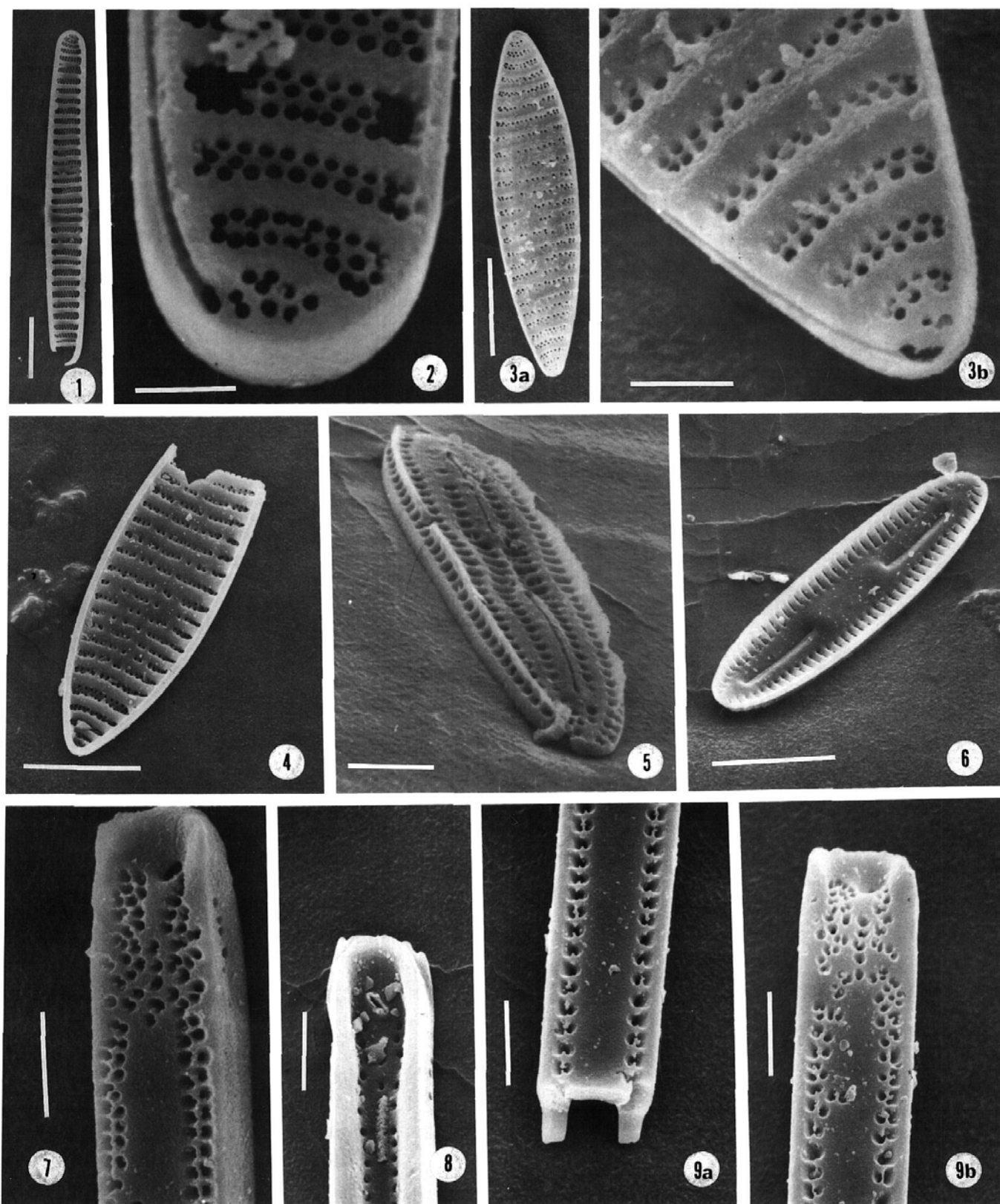
**Remarks:** very rare, not recorded in Table 1.

**Ecology:** Littoral taxon occurring in the plankton (Manguin 1960).

# PLATE 2

- 1,2 *Fragilariopsis obliquecostata* (Van Heurck) Hasle. 1, scale bar = 10µm, interior; 2, scale bar = 2µm.
- 3,4 *Nitzschia barronii* Gersonde. 3a, scale bar = 10µm; 3b, scale bar = 2µm, apex of fig. 3a; 4, scale bar = 10µm, internal.

- 5,6 *Rouxia antarctica* Heiden. 5, scale bar = 4µm, external; 6, scale bar = 10µm, internal.
- 7-9 *Thalassiothrix* sp. 7, scale bar = 4µm, external; 8, scale bar = 4µm, internal; 9a, scale bar = 4µm, external, opposite end of 9b; 9b, scale bar = 4µm.



*Diploneis* sp.

**Remarks:** A single specimen of this benthic diatom was observed.

*Eucampia antarctica* (Castracane) Mangin

Plate 1, figures 1-3; plate 7, figures 1, 2

*Eucampia antarctica* (Castracane) MANGIN 1914, p. 480, figs. 7-8.  
*Eucampia balaustium* Castracane. — MCCOLLUM 1975, p. 534, pl. 16, figs. 8, 9. — FENNER ET AL. 1976, p. 774, pl. 5, figs. 7-9.

**Remarks and Ecology:** Fryxell and Prasad (1990) distinguish two varieties of *E. antarctica*: the type variety *E. antarctica* (Castracane) Mangin var. *antarctica*, which occurs north of the summer Antarctic Convergence Zone, and *E. antarctica* var. *recta* (Mangin) Fryxell et Prasad, which is truly an ice-edge diatom. Fryxell (1991) notes that unlike valves of the nominate variety, valves of *E. antarctica* var. *recta* tend to be larger, lack spines on the elevations and form chains that are straight in broad girdle view. We question the diagnostic value of the presence or absence of spines in fossil specimens where physical abrasion is common. We have chosen not to separate the two varieties. We note, however, that the presence of spines on figures 1 and 3 of plate 1 are indicative of *E. antarctica* var. *antarctica*. The nomenclatural history of *E. antarctica* is summarized by Fryxell et al. (1989).

*Fragilariopsis obliquecostata* (Van Heurck) Hasle

Plate 2, figures 1, 2; plate 7, figures 9-14

*Fragilariopsis obliquecostata* (Van Heurck) HASLE 1965, p. 18, pl. 7, figs. 2-7. — FENNER ET AL. 1976, p. 12, figs. 15-18. — GERSONDE 1986, pl. 1, fig. 2. — GERSONDE AND WEFER 1987, pl. 4, fig. 5.

**Remarks:** Strongly silicified, well preserved specimens of *Fragilariopsis* were examined and found to closely resemble *F. obliquecostata*, which is characterized by length 57-110µm, width 8-10µm, 6.5-8 costae in 10µm, 21-22 intercostae poroids in 10µm, and an expansion of the middle portion of the valve according to Hasle (1965). Specimens from the Pliocene sample measure as follows: length 38-64µm, width 6.4-7.6µm, 5.5-9.8 costae in 10µm and intercostae poroids 14-22 (24) in 10µm, which also fits the parameters of Fenner et al. (1976). The costae are only slightly oblique, as seen in the illustrations of both Hasle (1965) and Fenner et al. (1976).

Because most of the *Fragilariopsis* have been described from Recent material (Hustedt 1958; Hasle 1965), not all descriptive characteristics can be used when evaluating the fossil record. *Fragilariopsis* is described by Round et al. (1990) as "usually

united in flat ribbon-like colonies", a characteristic rarely useful in stratigraphic studies. Age in itself is not a species characteristic although there is evidence that some species described from recent material, morphologically identically under the LM, are distinctly different from fossil material when careful SEM is used. A number of the *Fragilariopsis*, including *F. kerguelensis* (O'Meara) Hustedt, *F. obliquecostata*, *F. curta*, *F. cylindrus* and *F. linearis* (Castracane) Frenguelli, from fossil material appear to be morphologically identical to the recent forms when viewed under LM and have been listed as such. It is apparent that more careful studies like Gersonde (1991) are needed to clarify the taxonomic differences between fossil and recent species of very similar morphology.

With this discussion in mind we have chosen to use *F. obliquecostata* as the species name until more extensive evaluation of the specimen can be made.

**Ecology:** Although various authors (Hustedt 1958; Hasle 1965; Fenner et al. 1976) report a rather widespread distribution of *F. obliquecostata* in both Antarctic and subantarctic waters. Kozlova (1962) finds this taxon to be restricted to the Antarctic coastline and waters lying near the ice edge. Based on her study of siliceous microorganisms recovered from sea ice and from surface sediment in the southern Weddell Sea, Gersonde (1986) concluded that *F. obliquecostata* may be a useful guide species for a neritic environment that is strongly influenced by sea ice, supporting Kozlova's (1962) conclusion.

*Nitzschia barronii* Gersonde

Plate 2, figures 3a, 3b, 4; plate 7, figures 16, 17

*Nitzschia barronii* GERSONDE 1991, p. 146, pl. 3, fig. 6, pl. 4, fig. 1-3, pl. 5, figs. 7-17. — GERSONDE AND BURCKLE 1990, p. 78, pl. 1, figs. 11-13. — HARWOOD AND MARUYAMA 1992, p. 704, pl. 17, figs. 27, 28.

**Remarks:** This species shows considerable variation in length, width and shape. Gersonde (1991) remarks that *N. barronii* differs from *N. angulata* (O'Meara) Hasle by its distinctly coarser stria structure and the presence of hyaline, non-perforated areas on the valve face.

**Paleoecology:** Abelman et al. (1990) suggest that *N. barronii* preferred Antarctic waters, a hypothesis also favored by Barron (in press).

*Nitzschia praeurta* Gersonde

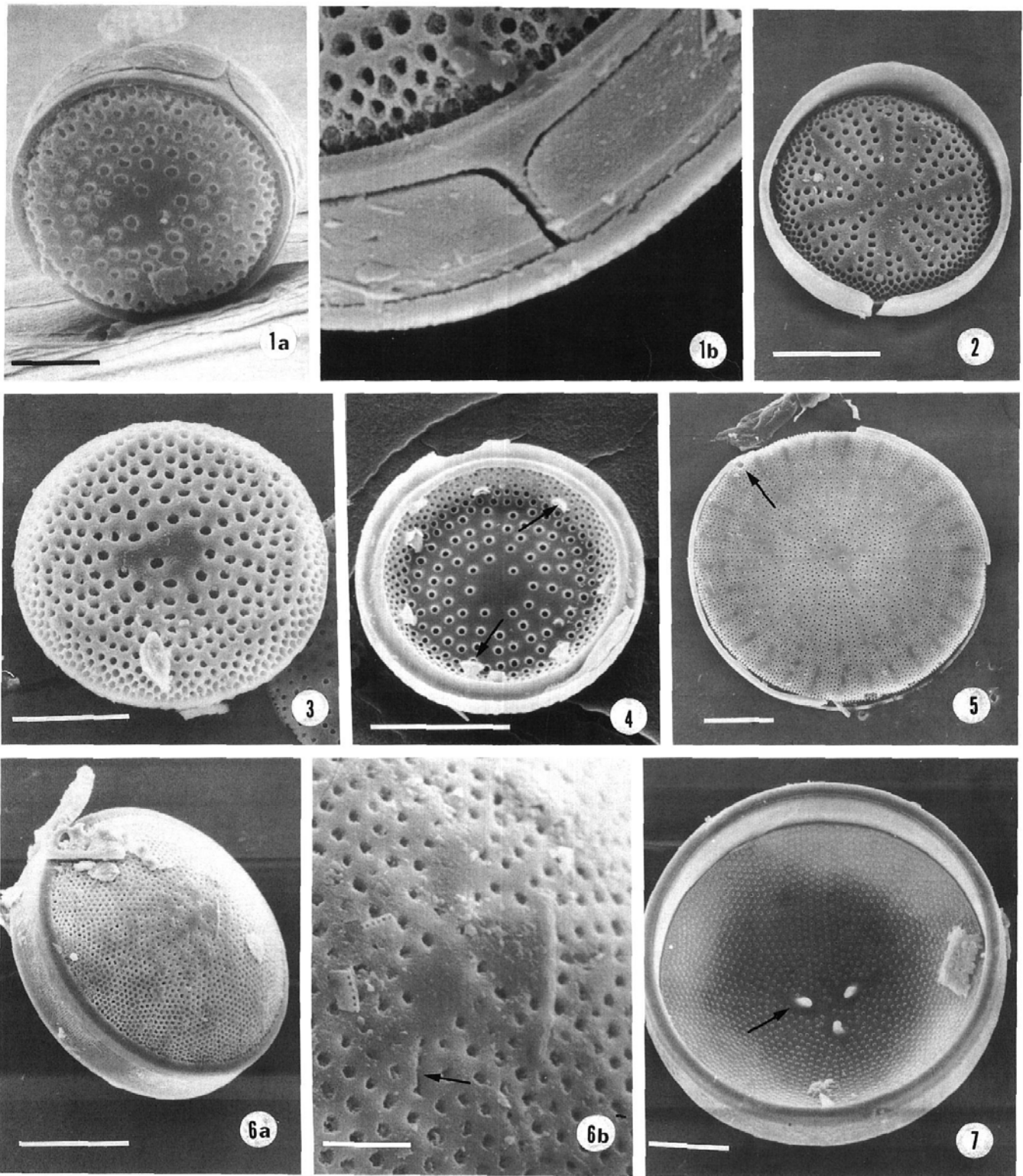
Plate 7, figure 15

PLATE 3

1-4 *Actinocyclus ingens* Rattray. 1a, scale bar = 5µm, frustule; 1b, valvocopula (arrow) of 1a; 2, scale bar = 10µm, external, valvocopula; 3, scale bar = 10µm, external; 4, scale bar = 10µm, internal, labiate processes (arrows).

5 *Actinocyclus karstenii* Van Heurck. 5, scale bar = 20µm, external, pseudonodule (arrow).

6-7 *Stellarima microtrias* (Ehrenberg) Hasle and Sims. 6a, scale bar = 20µm, frustule; 6b, scale bar = 4µm, central area of 6a, external labiate aperture (arrow); 7, scale bar = 10µm, internal, labiate processes (arrows).





*Nitzschia praeurta* GERSONDE 1991, p. 148, pl. 1, figs. 7-17; pl. 2, fig. 5,6; pl. 3, fig. 3,4; pl. 10, fig. 7.

**Remarks:** Rare, not recorded in Table 1. Apices rounded, three apical costae turned towards the apex. Gersonde suggests *N. praeurta* is a precursor of *N. curta* (*Nitzschia curta* = *Fragilariopsis curta*). As discussed under *F. obliquecostata*, until a detailed SEM study is made of the *Fragilariopsis*, their taxonomic position is in question. Harwood and Maruyama (1992) list the last occurrence of *N. praeurta* at 3.6 Ma, substantially older than the estimated age of Sample 119-742A-15R-4, 44-46cm (2.2-1.8 Ma).

*Rhizosolenia hebetata* f. *bidens* Heiden

Plate 7, figure 8

*Rhizosolenia hebetata* f. *bidens* Heiden in HEIDEN AND KOLBE 1928. — FENNER ET AL., 1976, p. 778, pl. 13, fig. 8. — JOUSÉ 1977, pl. 8, fig. 18 as *R. spp.*

**Remarks:** Rare, not recorded in Table 1.

**Ecology:** Fenner et al. (1976) reported this taxon from both Antarctic and subantarctic waters but note that it had its maximum abundance in the region of the PFZ.

*Rhizosolenia hebetata* f. *hiemalis* Gran

Plate 7, figures 5, 7

*Rhizosolenia hebetata* f. *hiemalis* GRAN 1905, p. 527, pl. 27, fig. 9; FENNER ET AL., 1976, p. 778, pl. 13, figs. 10-12.

**Remarks:** Rare, not recorded in Table 1.

**Ecology:** Fenner et al. (1976) reported this taxon from both Antarctic and subantarctic waters but note that it had its maximum abundance in the region of the PFZ.

*Rhizosolenia styliformis* Brightwell

Plate 1, figure 7; plate 7, figures 4, 7

*Rhizosolenia styliformis* Brightwell. — FENNER ET AL. 1976, p. 779, pl. 13, figs. 3-5, 9. — HARWOOD AND MARUYAMA 1992, p. 705, pl. 18, fig. 20.

**Ecology:** Fenner et al. (1976) notes that *R. styliformis* is generally reported to be a cosmopolitan species. She recorded it in both Antarctic and Subantarctic waters.

*Rhizosolenia* sp. D

Plate 1, figures 4a, 4b, 5a, 5b; plate 7, figure 3

*Rhizosolenia* sp. D of HARWOOD AND MARUYAMA 1992, p. 705, pl. 18, figs. 7-10.

**Remarks:** The robust apical end of this distinctive diatom contains irregularly-shaped areolae that are separated by prominent marginal ridges (pl. 1, figs. 4b, 5a, 5b). These ridges are twisted around the apical horn in a screw-like fashion (pl. 1, figs. 4b, 5b).

*Rouxia antarctica* Heiden

Plate 2, figures 5, 6, plate 7, figures 18, 19

*Rouxia antarctica* Heiden in HEIDEN AND KOLBE 1928, p. 632, pl. 4, fig. 90. — MCCOLLUM 1975, p. 535, pl. 11, figs. 11-12. — HARWOOD AND MARUYAMA 1992, p. 705, pl. 18, fig. 24.

**Remarks:** Abundant (Table 1).

*Rouxia diploneides* Schrader

*Rouxia diploneides* SCHRADER 1973, p. 710, pl. 3, figs. 27-32. — HARWOOD AND MARUYAMA 1992, p. 705, pl. 17, fig. 12.

**Remarks:** Common but usually broken.

*Stellarima microtrias* (Ehrenberg) Hasle and Sims

Plate 3, figures 6a, 6b, 7

*Stellarima microtrias* (Ehrenberg) HASLE AND SIMS 1986, p. 111, figs. 18-27. — HARWOOD 1989, p. 80, pl. 1, fig. 3.

*Coscinodiscus furcatus* KARSTEN 1905, p. 82, pl. 4, fig. 7 — HUST-EDT 1958, p. 113, pl. 3, figs. 18, 19.

*Coscinosira stellaris* (Roper) Heiden var. *symbolophora* (Grun.) HEIDEN AND KOLBE, p. 471.

**Ecology:** According to Hasle et al. (1988), *S. microtrias* is confined to Antarctic waters and is particularly common on or in shelf-ice or in the surrounding plankton.

*Thalassiosira elliptipora* (Donahue) Fenner ex Mahood and Barron

Plate 4, figure 3; plate 5, figures 4a-7c; plate 8, figure 6

*Thalassiosira elliptipora* (Donahue) Fenner ex Mahood and Barron, herein. — FENNER 1991, pp. 104 and 108, pl. 1, fig. 3, pl. 3, fig. 2. — HARWOOD AND MARUYAMA 1992, p. 707, pl. 16, fig. 12.

*Coscinodiscus elliptipora* DONAHUE 1970, p. 183, pl. 4, figs. e, i-m. — MCCOLLUM 1975, p. 526, pl. 16, fig. 10. — GOMBOS 1977, p. 592, pl. 3, figs. 1-3, 6, pl. 9, fig. 3.

**Validation:** *Coscinodiscus elliptipora* Donahue, was described in an unpublished (and difficult to obtain) Ph.D. dissertation (Donahue 1970) and is therefore invalid under Article 29 of the International Code of Botanical Nomenclature. It is also invalid because Donahue (1970) failed to designate a type (Art. 37,

#### PLATE 4

1,2 *Thalassiosira kolbei* (Jousé) Gersonde. 1, scale bar = 20µm; 2, scale bar = 20µm, internal.

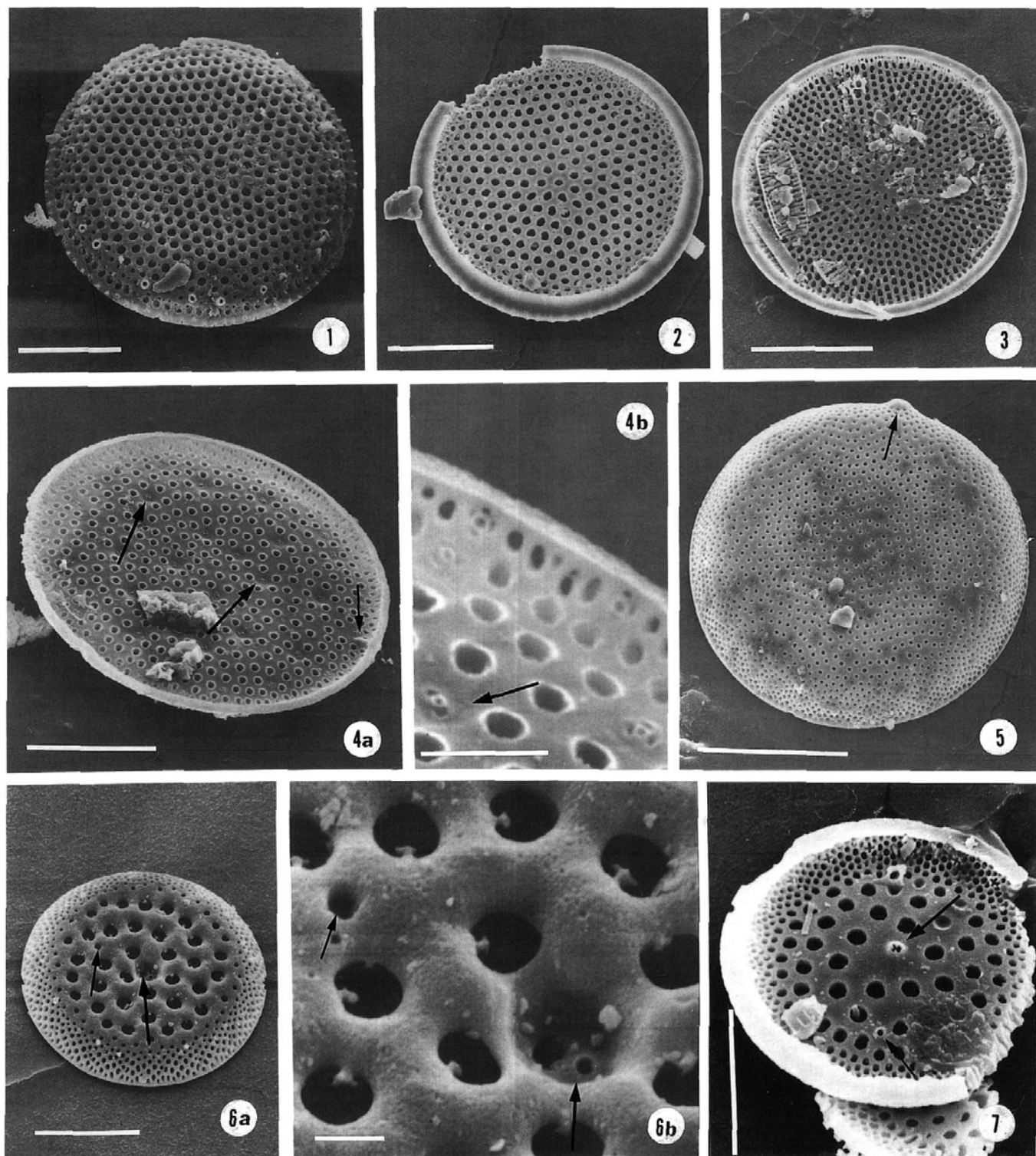
3 *Thalassiosira elliptipora* (Donahue) Fenner ex Mahood and Barron. scale bar = 20µm, internal.

4-5 *Thalassiosira lentiginosa* (Janisch) G. Fryxell. 4a, scale bar = 20µm, internal, labiate process (small arrow), strutted process depressions (large arrow); 4b, scale bar = 2µm, internal, margin of fig. 4b, strutted

process depression (arrow); 5, scale bar = 20µm, labiate aperture (arrow).

6-7 *Thalassiosira tetraoestrupii* var. *reimeri* Mahood and Barron. 6a, scale bar = 10, labiate aperture (small arrow), central depression with strutted process aperture (large arrow); 6b, scale bar = 2µm, labiate process (small arrow), central strutted process aperture (large arrow); 7, scale bar = 10µm, labiate process (small arrow), central strutted process (large arrow).





ICBN). This taxon has been recognized and illustrated by numerous subsequent authors (see Fenner 1991; Harwood and Maruyama 1992); however, only Harwood and Maruyama (1992) have questioned its legitimacy. These authors suggested (Harwood and Maruyama 1992, p. 707) that *Coscinodiscus planisculus* Rattray 1890 may have priority over *C. elliptipora* Donahue. Although Rattray's drawing (1890, pl. I, fig. 22) of *C. planisculus* does resemble *C. elliptipora* with its elliptical, radiating areolae, Rattray (p. 42) cites as the source of his illustration figure 12 of plate VI of Janisch's 1888 unpublished manuscript on diatoms from the *Gazelle Expedition*. Examination of a photographic copy of Janisch's (1888) excellent plates at the California Academy of Sciences reveals that figure 12 of plate VI is closer in appearance to *Thalassiosira vulnifica* (Gombos) Fenner and is definitely not comparable with *C. elliptipora*.

The occurrence of excellently preserved specimens referable to *C. elliptipora* sensu Donahue 1970 in Sample 119-742A-15R-42-44cm offers the opportunity to validly publish and illustrate this taxon. Because it has been widely used, we have chosen to preserve the original epithet.

**Description:** Valve circular and flat, ranging in diameter from about 45 to 90µm. The species is characterized by fasciculated areolae (pl. 5, figs. 4a, 5, 6a, 7b) (5-7 in 10µm toward the center) that develop an elongated, elliptical shape toward the valve's margin (pl. 5, fig. 4a, 6a, 6b). A distinctive T-shaped external labiate process (pl. 5, figs. 4b, 6b) is present on the margin; however, due to the elaborate and fragile external areolae at the margin (pl. 5, figs. 4a, 5, 6a, 7c), the interior margin is frequently missing from the valve. In well preserved specimens, strutted processes are scattered over the valve face (pl. 5, figs. 7a, 7b, 7c), where they take the place of areolae in a manner reminiscent of *T. lentiginosa* (Janisch) G. Fryxell.

**Holotype:** Plate 8, figure 6, CAS 217029, Sample 119-742A-15R-42-44cm, Prydz Bay, East Antarctica.

**Isotype:** Plate 8, figure 7, CAS 217018.

**Remarks:** Fenner (1991) observed a variety of *T. elliptipora* in which only the areolae just above the margin are elongated ranging older and younger than the peak abundance of the more characteristic forms of *T. elliptipora* which have elongated areolae throughout the valve. Gombos (1977) noted and illustrated the variation in the ellipticity of the pores and noted that the elliptical areolae may be present only on the margins.

From the same Challenger slide described under the *Actinocyclus actinochilus*, observations were made of a valve that matches the description for *T. elliptipora*. The areolae on this valve are clearly elliptical, fasciculated across the whole valve face. The margin was missing in a manner similar to valves in this sample.

**Paleoecology:** Fenner's (1991) studies suggest that this endemic Southern Ocean species was most common in northern Antarctic surface waters, but it also was found within the PFZ and in subantarctic surface waters.

***T. kolbei* (Jousé) Gersonde**

Plate 4, figures 1, 2; plate 8, figures 1a, 1b

*T. kolbei* (Jousé) GERSONDE 1990, p. 793, pl. 1, fig. 2, pl. 5, figs. 3, 5, 6. — GERSONDE AND BURCKLE 1990, p. 782, pl. 3, fig. 1. *Coscinodiscus kolbei* Jousé. — MCCOLLUM 1975, p. 527, pl. 4, figs. 7-9.

**Remarks:** Valve flat, distinctive eccentric pattern, robust external marginal strutted processes and prominent poroid areolae. A strutted processes between most valve face areolae.

Rare.

**Paleoecology:** Fenner (1991) believes that *T. kolbei* was endemic to the Southern Ocean and preferred subantarctic surface waters.

***T. lentiginosa* (Janisch) G. Fryxell**

Plate 4, figures 4a, 4b, 5; plate 8, figures 2a, 2b

*T. lentiginosa* (Janisch) G. FRYXELL 1977, p. 100, figs. 13a-14d. — HARWOOD AND MARUYAMA 1992, p. 707, pl. 19, fig. 8. *Coscinodiscus lentiginosus* Janisch in SCHMIDT ET AL. 1878, pl. 58, fig. 11.

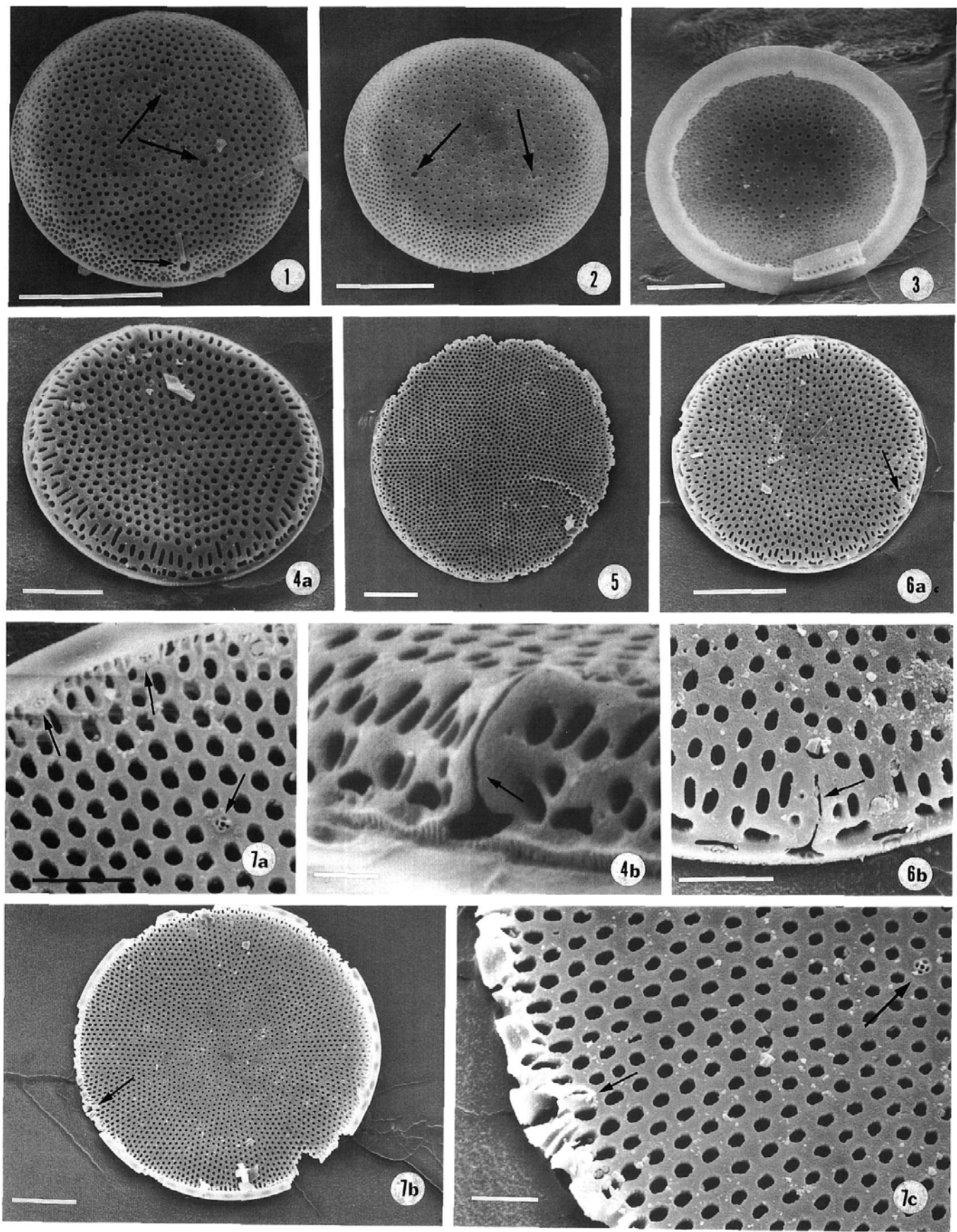
**Remarks:** The morphological structures of *T. lentiginosa*, a recent species present "south of the Antarctic Convergence" (Fryxell 1977) and *T. lentiginosa* from this sample differ only in the internal silica structure surrounding the strutted processes. Each of the internal valve strutted processes is set within a distinctive depression (pl. 4, figs. 4a, 4b). The internal valve of Fryxell's *T. lentiginosa* is flat and level surrounding the strutted processes (Fryxell 1977, figs. 14a, 14b, and 14c).

**Ecology:** Fenner et al. (1976) report *T. lentiginosa* (as *Coscinodiscus lentiginosus* Janisch) in both subantarctic and Antarctic waters, but note that maximum abundances occur in Antarctic waters.

## PLATE 5

- 1-3 *Thalassiosira oliverana* (O'Meara) Makarova and Nikolaev. 1, scale bar = 10µm, labiate aperture (small arrow), valve face strutted process apertures (large arrows); 2, scale bar = 10µm, valve face strutted process apertures (arrows); 3, scale bar = 10µm, internal.
- 4-7 *Thalassiosira elliptipora* (Donahue) Fenner ex Mahood and Barron. 4a, scale bar = 10µm, elongated marginal areolae; 4b, scale bar = 2µm, labiate aperture

(arrow); 5, scale bar = 20µm, external, random strutted processes; 6a, scale bar = 20µm, fasciculated areolae, labiate aperture (arrow); 6b, scale bar = 5µm, elongate mantle areolae, labiate aperture (arrow); 7a, scale bar = 5µm, internal margin of 7b, strutted process (small arrow); 7b, scale bar = 20µm, internal, labiate process (arrow); 7c, scale bar = 4µm, internal, margin at labiate process (large arrow), strutted process (second arrow).





*T. oliverana* (O'Meara) Makarova and Nikolaev  
Plate 5, figures 1, 2, 3; plate 8, figures 3, 4, 5

*T. oliverana* (O'Meara) MAKAROVA and NIKOLAEV 1984, p. 89, pl. 1, figs. 1-11, pl. 2, figs. 1-11. — GERSONDE AND BURCKLE 1990, p. 782. — HARWOOD and MARUYAMA 1992, p. 708, pl. 14, figs. 1, 2, 6, 7, 11, 17.

*Schimperella antarctica* KARSTEN 1905, p. 88, fig. 6.

**Remarks:** This is a highly variable species and is presently under investigation by David Harwood and his students (personal communication, 1994). In Table 1 we have listed four variations of *T. oliverana* based on the number of areolae present in the central hyaline area, which typically occupies less than one third of the diameter of the valve: variety 1, clear; variety 2, 1-4 areolae; variety 3, 5-10 areolae; variety 4, filled with areolae but less dense than the center of the valve. If these forms represent winter growth stages, morphological variations might reflect different conditions (G. Fryxell, written comm., 1995).

**Ecology:** Fenner et al. (1976) record this taxon (as *S. antarctica*) in both subantarctic and Antarctic waters, with a maximum abundance in the PFZ.

*T. tetraoestrupii* Bodén 1993

*T. tetraoestrupii* Bodén 1993, p. 63, pl. 1, figs. A-G, pl. 2, figs. A, B, H, J. — MAHOOD AND BARRON, in press, figs. 9-19, 25, 26, 28-46.

**Remarks:** Bodén (1993) determined that the characteristics describing *T. oestrupii* (Ostenfeld) Hasle, a recent species, were different than those of fossil species referred to *T. oestrupii*, although they were of very similar appearance under LM. Bodén's SEM (1993) studies of fossil forms clearly demonstrated that the strutted processes at the margin and central area have four satellite pores rather than three as found in the recent form. Secondly, Bodén (1993) found the margin of the fossil species to have more areolae in 10µm than that of the recent species. It is important to note that neither of these characteristics, satellite pores and marginal areolae, can be seen easily in fossil material. Mahood and Barron (in press) comment on the presence of *T. tetraoestrupii* in Pliocene material from the Southern Ocean.

*T. tetraoestrupii* var. *reimeri* Mahood and Barron  
Plate 4, figures 6a, 6b, 7, plate 8, figures 9-12

*T. tetraoestrupii* var. *reimeri* MAHOOD and BARRON (in press), pl. 4, figs. 6a, 6b, 7, pl. 8, figs. 9-12.

**Remarks:** *T. tetraoestrupii* Bodén (Bodén 1993) exhibits a wide spread variability in number of areolae across the valve face, pattern change at the valve face-mantle interface and the relative placement of the central strutted process and labiate process. *T. tetraoestrupii* var. *reimeri* is easily distinguished from other forms of *T. tetraoestrupii* by its distinct central depression (plate 4, figures 6a, 6b, 7, plate 8, figures 9-12) which contains the central strutted process. See Bodén (1993) and Mahood and Barron (in press) for a thorough discussion.

*T. torokina* Brady 1977

Plate 6, figures 1a-3c; plate 8, figure 8

*T. torokina* BRADY 1977, pp. 122-123, figs. 1-5. — HARWOOD 1986, p. 87, pl. 8, figs. 2, 3.

*T. gerloffii*? RAMIREZ 1981, pp. 73-82, pls. 26-28, figs. 164-177.

**Remarks:** Expanded description; Valve circular, convex, 37 to 45µm in diameter (pl. 6, figs. 1a, 1b). The areolae are linear, fasciculate on valve face, 7-8 in 10µm, external poroid, internal with cribrum (fig. 3b). Valve face separated from mantle by closely abutted marginal strutted processes (pl. 6, figs. 1d, 1e), 10 in 10µm, each with four satellite pores (pl. 6, figs. 3b, 3c). Areolae on mantle in 3-4 linear rows 10 in 10µm. Central cluster of 10 to 19 strutted processes each with 3-5 satellite pores, usually 4 (pl. 6, figs. 1c, 3c). Prominent labiate process takes place of a strutted process (pl. 6, figs. 3a); external tube prominent (pl. 6, figs. 1a, 1d, 2).

In most aspects *T. torokina* and *T. gerloffii* show some striking similarities. The row of marginal strutted process in *T. torokina* (pl. 6, figs. 1a, 1e, 3a, 3b) and *T. gerloffii* (Ramirez 1981, fig. 176, 172) are linked without an areolae separating the processes. *T. torokina* from this sample is convex and heavily silicified while *T. gerloffii* is concave (Ramirez, 1981) and weakly silicified. A comparison of figures 175 and 176 (Ramirez 1981) and plate 6, figures 1a, 1b, and 1e (this paper) show dissimilar areolae mantle patterns. (G.A. Fryxell, personal communication, 1994). Further studies will be necessary to determine synonymy if any and the relationship between the two taxa.

*Thalassiothrix* spp.

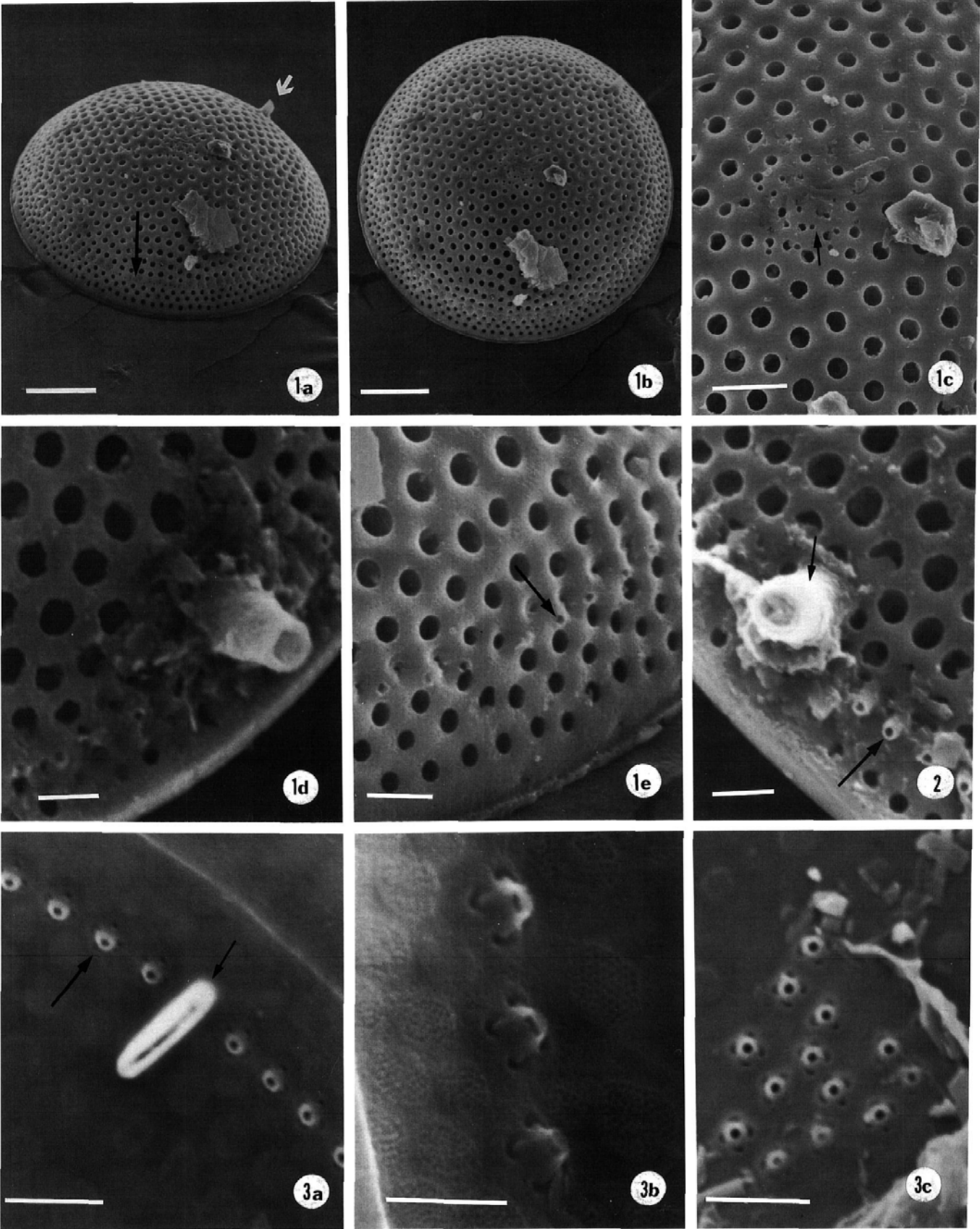
Plate 2, figures 7, 8, 9a, 9b

**Remarks:** Many specimens resemble *Thalassiothrix longissima* Cleve et Grunow sensu Schrader 1973, p. 713, pl. 23, figs. 7, 17, 18; Schrader 1976, p. 637, pl. 1, figs. 5-6 and 17; Harwood and Maruyama, 1992, p. 708, pl. 11, fig. 12. However, the frag-

## PLATE 6

1-3 *Thalassiosira torokina* Brady. 1a, scale bar = 10µm, 45° of tilt, labiate process (white arrow), marginal strutted processes (large arrow); 1b, scale bar = 10µm, same specimen as 1a, 20° of tilt; 1c, scale bar = 4µm, center of fig. 1b, cluster of central strutted process apertures (arrow); 1d, scale bar = 2µm, labiate process of 1a; 1e, scale bar = 2µm, margin of fig. 1a, strutted process (arrow); 2, scale bar = 2µm, margin with labiate process (small arrow) and strutted processes

(large arrow); 3a, scale bar = 2µm, internal, labiate process (small arrow) replacing a marginal strutted process (large arrow); 3b, scale bar = 1µm, internal of 3a, strutted process with 4 satellite pores, cribra; 3c, scale bar = 2µm, internal of 3a, cluster of central strutted processes with 3-5 satellite pores.





mented nature of specimens and Fenner et al.'s (1976) observation of a continuous transition between *T. longissima* and *T. antarctica* Schimper, calls for caution in assigning a specific epithet to our specimens.

**Ecology:** *Thalassiothrix longissima* is reported from both Antarctic and subantarctic surface waters by Fenner et al. (1976).

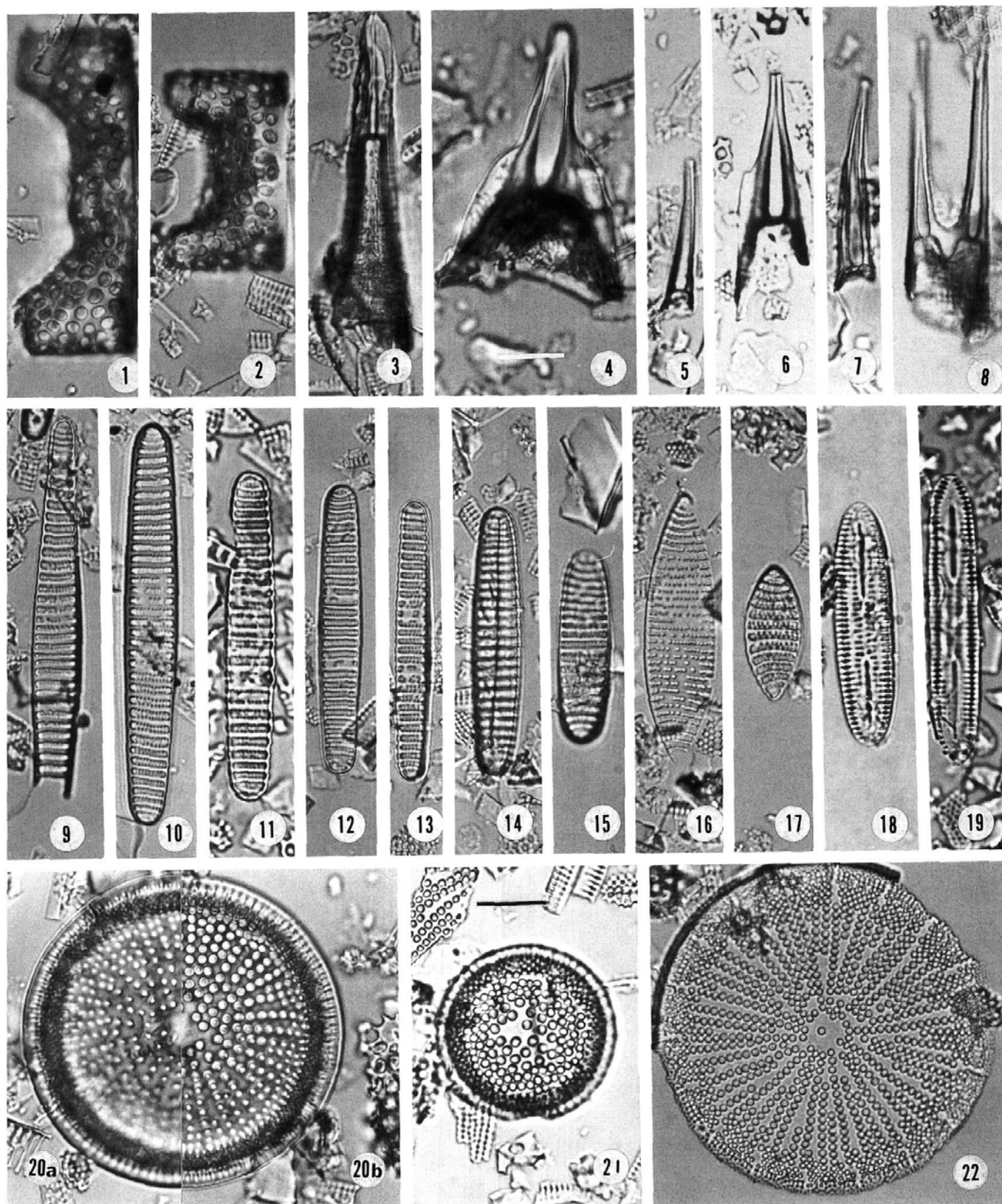
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## PLATE 7

Scale Bar = 10µm for all figures of Plate 7

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|------|---|-------|--|
| 1,2  | <i>Eucampia antarctica</i> (Castracane) Mangin. CAS 217018.   | 15    | <i>Nitzschia praecurta</i> Gersonde. CAS 217016.   |
| 3    | <i>Rhizosolenia</i> sp. D of Harwood and Maruyama, 1992. CAS 217016.  | 16,17 | <i>Nitzschia barronii</i> Gersonde. CAS 217018.  |
| 4,6  | <i>Rhizosolenia styliformis</i> Brightwell. 4, CAS 217016; 6. CAS 217017.   | 18,19 | <i>Rouxia antarctica</i> Heiden. CAS 217027.   |
| 5,7  | <i>Rhizosolenia hebetata</i> f. <i>hiemalis</i> Gran. 5, CAS 217017; 7, CAS 217018.   | 20,21 | <i>Actinocyclus ingens</i> Rattray. 20a, CAS 217018, low focus; 20b, CAS 217018, high focus; 21, CAS 217027. |
| 8    | <i>Rhizosolenia hebetata</i> f. <i>bidens</i> Heiden. CAS 217017.   | 22    | <i>Actinocyclus actinochilus</i> (Ehrenberg) Simonsen. CAS 217022.   |
| 9-14 | <i>Fragilariopsis obliquecostata</i> (Van Heurck) Hasle. 9, CAS 217016; 10, CAS 217017; 11, CAS 217027; 12, 13, 14, CAS 217016. |       |  |



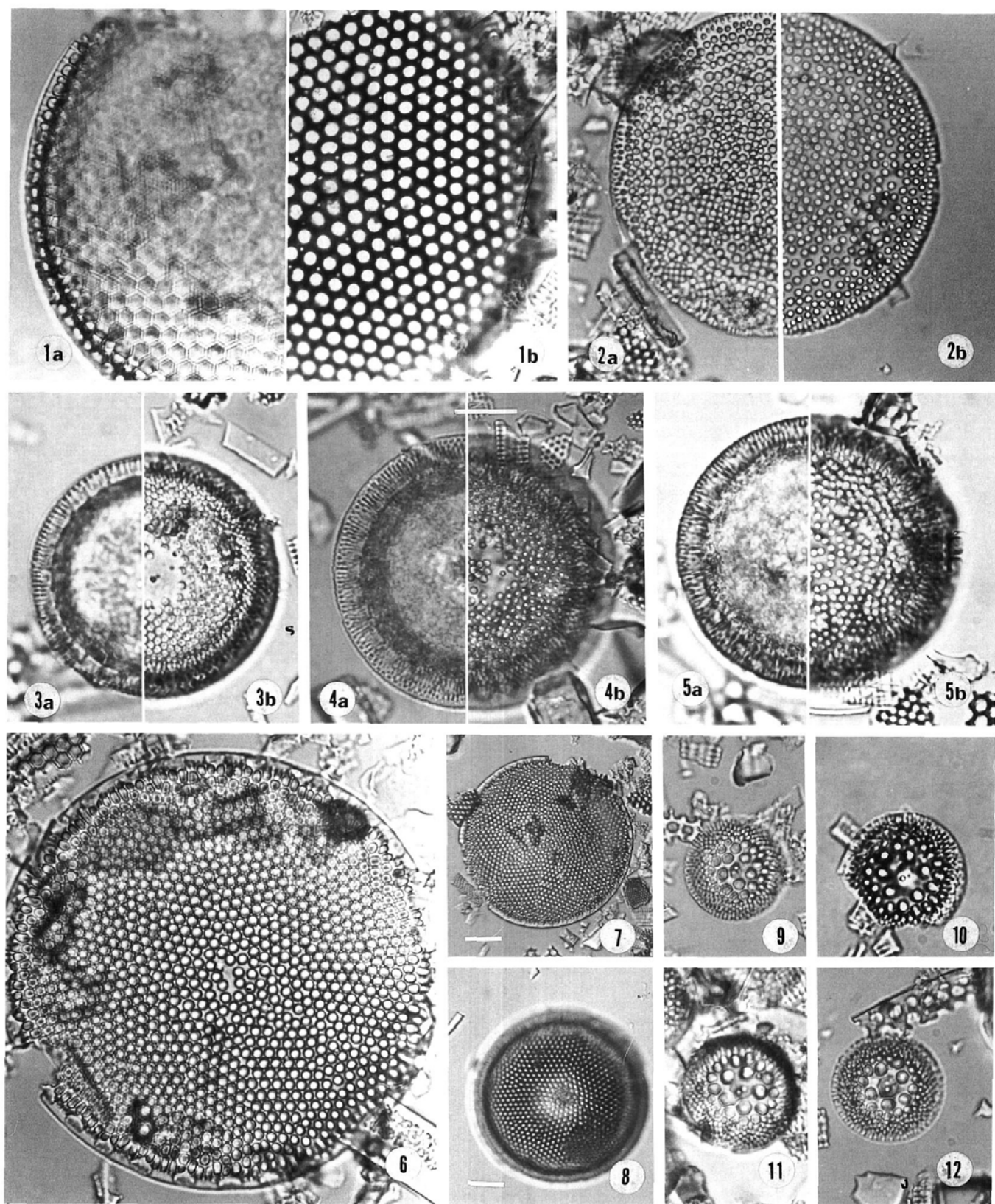
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# PLATE 8

Scale Bar = 10µm for all figures on plate 8 with the exception of figures 7 and 8 which are individually labeled.

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|--|---|
| <p>1 <i>Thalassiosira kolbei</i> (Jousé) Gersonde. CAS 217026. 1a, high focus; 1b, low focus.</p> <p>2 <i>Thalassiosira lentiginosa</i> (Janisch) G. Fryxell. CAS 217026. 2a, low focus; 2b, high focus.</p> <p>3-5 <i>Thalassiosira oliverana</i> (O'Meara) Makarova and Nikolaev. 3a, CAS 217027, high focus; 3b, CAS 217027, low focus; 4a, CAS 217018, high focus; 4b, CAS 217018, low focus; 5a, CAS 217027, high focus; 5b, CAS 217027, low focus.</p> | <p>6/7 <i>Thalassiosira ellitipora</i> (Donahue) Fenner ex Mahood and Barron. 6, Holotype, CAS 217029; 7, scale bar = 10, Isotype, CAS 217018.</p> <p>8 <i>Thalassiosira torokina</i> Brady. scale bar = 10, CAS 217018.</p> <p>9-12 <i>Thalassiosira tetraoestrupii</i> var. <i>reimeri</i> Mahood and Barron. Central depressed areolae with strutted process (arrow). 9, CAS 217016; 10, CAS 217027; 11, CAS 217017; 12, CAS 217022.</p> |
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Manuscript received June 9, 1995

Manuscript accepted September 23, 1995