

## 34.5. THE MEDITERRANEAN DIATOMS

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## INTRODUCTION

Ten washed samples taken at eight levels from the drill cores of the Mediterranean expedition of the Deep Sea Drilling Project were sent for study to the present writer by Paulian Dumitrica of the Geological Institute, Bucharest, Rumania. He had found these samples to be the richest diatom-bearing sediments both in terms of species and individuals.

Two samples from Core 13 of Site 124—Balearic Rise<sup>1</sup> were selected near levels of finely laminated dolomitic marls with dark green to black interbeds. This dolomitic unit is part of the evaporite series cored in the deep Balearic Basin. All six samples from Sites 127 and 128 in the Hellenic Trench of the Ionian Basin<sup>2</sup> are from layers of dark sapropelitic ooze, where the siliceous microfauna is particularly abundant. The remaining two samples are from Site 130 on the Mediterranean Ridge in the Levantine Basin<sup>3</sup>, and represent the siliceous microfossil content of dark blue black terrigenous clays believed to have been transported to this site from the Nile Cone (see Conclusions of Chapters 11, 25.2, and 35 of this volume).

## Procedures

The author's study has been restricted to investigating the available washed samples. It must be taken into consideration that because a sizable portion of the flora may have been lost in sample preparation, the assemblages reported here may not be representative of the original thanatocoenosis, nor of the original depositional environment. The investigations were carried out on strewn slides mounted in Caedex with the aid of an Opton binocular photomicroscope; the documented taxa were photographed with the same instrument.

## DISCUSSION

In the plates enclosed herewith (Plates 1-9) only a few characteristic species of the rich floral assemblages are shown. The complete floral list is shown on Table 1, with indication of the characteristic ecologies and ranges of the

species. The relevant information has been obtained from the references cited at the end of this chapter and from investigations of Hungarian fossiliferous localities.

The 175 taxa investigated belong primarily to the phyla Chrysophyta and Bacillariophyta, and are accompanied in subordinate numbers by representatives of Phytolitharia, Acritarcha, Radiolaria and Porifera.

The paleoecological assignments shown in Table 1 and the complete floral spectrum allow three paleo-ecological divisions, representing three areas of the Mediterranean and three different sedimentary facies, to be distinguished.

## Division 1 – Siliceous Dolomitic Marls of Site 124

The sediments of the two samples from Site 124 (124-13-2, 89-90 cm and 124-13-2, 127-129 cm) were apparently deposited under the same ecological conditions. The predominantly littoral planktonic forms are accompanied by brackish water, and even freshwater, euryhaline, benthonic, and epiphytic species in considerable numbers.

Taxa characteristic of stagnant brackish waters and landlocked salinas and lagoons are present in such great numbers as to suggest reduced salinity, shallow water depth, and a landlocked, stagnant sedimentary environment. As for salinity, it may have been upper brackish (0 to 5‰) or possibly lower brackish (5 to 20‰). Since the species indicative of low salinity are benthonic, they must be autochthonous rather than allochthonous. The littoral brackish water forms living in salinas and stagnant waters found in these samples include:

- Achnanthes brevipes* (epiphytic)
- Campylodiscus clypeus* var. *bicostata* (benthonic) Salinity: 0-5‰
- Cocconeis pediculus* (epiphytic)
- Diploneis didyma* (benthonic). Salinity: 5-20‰
- Diploneis ovalis*. Salinity: 0-5‰
- Epithemia Sorex* (epiphytic)
- Grammatophora angulosa* var. *islandica* (epiphytic).  
River-mouth-dwelling form
- Mastogloia brauni* (epiphytic). Frequent
- Mastogloia elliptica* var. *dansei* (epiphytic). Frequent
- Mastigloia* sp. I, sp. II, sp. III (epiphytic). Frequent
- Navicula humerosa*. River-mouth-dwelling form
- Nitzschia granulata* (benthonic)
- Nitzschia parvula*
- Rhopalodia gibbetula* var. *Van Heurckii*
- Rhopalodia musculus*. River-mouth-dwelling form
- Surirella striatula*. Salinity: 5-20‰

The presence of freshwater and river-mouth-dwelling species indicates a considerable influx of fresh waters into a landlocked basin at the time of formation of the dolomitic marls. These species include:

<sup>1</sup>Site 124, Latitude: 38° 52.4'N; Longitude: 04° 59.7'E; water depth 2726 meters; Core 13 at 417 meters below the sea floor.

<sup>2</sup>Site 127, Latitude: 35° 43.9'N, Longitude: 22° 29.8'E; water depth 4654 meters; Core 5 at 101 meters and Core 14 at 380 meters below the sea floor, respectively.

Site 128, Latitude: 35° 42.6'N; Longitude: 22° 28.1'E; water depth 4640 meters; Core 3 at 88 meters, Core 10 at 418 meters, and Core 11 at 474 meters below the sea floor, respectively.

<sup>3</sup>Site 130, Latitude: 33° 36.3'N; Longitude: 27° 52.0'E; water depth 2979 meters; Core 3 at 86 meters and Core 4 at 150 meters below the sea floor, respectively.

TABLE 1  
The Distribution of Siliceous Microfossils in the Samples Studied

Species	Extinct Species	Ecologies <sup>a</sup>	Locality						Ages <sup>b</sup>			
			124-13-2; 89-90 cm	124-13-2; 127-129 cm	127-5-6; 136-139 cm	127-14-4; 144-147 cm	128-3-6; 97-100 cm	128-10-3; 5-8 cm		128-10-3; 59-62 cm	128-11-3; 148-150 cm	130-3 CC
<b>CHRYSOPHYTA</b>												
<b>ARCHAEOMONADALES:</b>												
<i>Archaeomonadopsis</i> cfr. <i>lagenula</i> Defl.	+	M,p						X				Upper-Eocene, - ?
<i>Archaeomonas</i>												
<i>californica</i> Defl.	+	M,p	X						X	X		Miocene
<i>inconspicua</i> Defl.	+	M,p	X							X		Upp.-Cretaceous-Pliocene
<i>japonica</i> Defl.	+	M,p	X	X						X		Miocene
<i>mangini</i> Defl.	+	M,p								X		Upp.-Cret.-Miocene?
<i>melo</i> Defl.	+	M,p		X						X		Miocene
sp.	+	M,p								X		
? <i>Micrampulla</i> sp.	+	M,p								X		
<b>SILICOFLAGELLALES:</b>												
<i>Cannopilus</i> cfr. <i>sphaericus</i> Gemein.	+	M,p						X				Miocene - ?
<i>Dictyocha</i>												
<i>fibula</i> Ehr.		M,p		X	X	X	X	X				Upp.-Cret. - Recent
<i>speculum</i> Ehr.		M,p	X	X	X	X	X		X			Eocene - Recent
<i>Mesocena binonaria</i> Ehr.	+	M,p						X				Fossil Guano (Chile)
<i>Mesocena</i>												
<i>elliptica</i> (Ehr.) Ehr. var. <i>pentagona</i> Bachm. & Tch.	+	M,p	X									Miocene
<i>elliptica</i> (Ehr.) Ehr. var. <i>quadrangula</i> Bachm. & Tch.	+	M,p					X	X				Miocene - ?
<i>polymorpha</i> Lemm. var. <i>bioctonaria</i> (Ehr.) Lemm.		M,p							X			Miocene - Recent
<b>EBRIIDALES:</b>												
<i>Hermesinum</i> cfr. <i>adriaticum</i> Zach.		M,p	X	X								Miocene - Recent
<b>BACILLARIOPHYTA:</b>												
<i>Achnanthes</i>												
<i>brevipes</i> Ag.		B,e,l,s	⊗									Miocene - Recent
<i>fimbriata</i> (Grun.) Ross		M,B		X								Miocene - Recent, Med.
sp.				X								Recent?
<i>Actinocyclus</i>												
<i>octonarius</i> Ehr.		M,B,n,l,p		X		X						Miocene - Recent
<i>octonarius</i> Ehr. var. <i>crassa</i> (W. Sm.) Hust.		M,B,p,n,l			X							Miocene - Recent
<i>octonarius</i> Ehr. var. <i>minuta</i> (Pant.) Hajós		M,B,l,p,eu.		X								Miocene - Recent, Med.
<i>octonarius</i> Ehr. var. <i>tenella</i> (Bréb.) Hajós		M,B,p,l,eu			X	X	X					Miocene - Recent, Med.
<i>Actinoptychus</i>												
<i>reinholdii</i> Hajós	+	M,p				X						Neogene - ?
<i>senarius</i> (Ehr.) Ehr.		M,n,l,p,st	X					X				Upp.-Eocene - Recent, Med.
<i>senarius</i> (Ehr.) Ehr. var. <i>minor</i> (A. Cl.) Hajós	+	M,n,l,p,st						X				Upp.-Eocene - Pleistocene
<i>Amphora</i>												
cfr. <i>angusta</i> (Greg.) Cl.		M	X									Miocene - Recent
<i>holsatica</i> Pant.		B								⊗		Miocene - Recent
<i>minuta</i> Pant. var. <i>interrupta</i> Hajós	+	B								⊗	⊗	Miocene - ?
<i>proteus</i> Greg.		M,l,b			X							Miocene - Recent, Med.
sp.					X							
<i>Asterionella</i> sp.		M	X									
<i>Asteromphalus robustus</i> Castr.		M,o,p,sh			X		X		X			Miocene - Recent, Med.
<i>Bacteriastrum</i>												
<i>comosum</i> Pavillard		M,p,n,st			X							Fossil ? - Recent, Med.
sp.		M,p				X			X			
<i>Campylodiscus</i>												
<i>clypeus</i> Ehr. var. <i>bicostata</i> (W. Sm.) Hust.		M,B,l,s,b	⊗	⊗								Fossil ? - Recent
<i>echeensis</i> Ehr.		B,l,s,b	⊗									Pliocene - Recent
<i>Campylosira</i> sp.		M,p							X			

1

2

3

Diatom Zone

TABLE 1 – Continued

Species	Extinct Species	Ecologies <sup>a</sup>	Locality						Ages <sup>b</sup>					
			124-13-2; 89-90 cm	124-13-2; 127-129 cm	127-5-6; 136-139 cm	127-14-4; 144-147 cm	128-3-6; 97-100 cm	128-10-3; 5-8 cm		128-10-3; 59-62 cm	128-11-3; 148-150 cm	130-3 CC	130-4 CC	
<i>Chaetoceros</i>														
<i>gastridium</i> Ehr.		M,p,st			X									Fossil Guana (Peru) – Recent
<i>lauderi</i> Ralfs		M,p,n					X							Pleistocene – Recent
sp. I		M,p									X			
sp. II		M,p						X			X			
sp. III		M,p						X			X			
sp. IV		M,p						X			X			
sp. V		M,p	X											
sp. VI		M,p	X											
<i>Cocconeis</i>														
<i>britannica</i> Naeg.		M,l,e			X									Miocene – Recent, Med.
<i>costata</i> Greg.		M,l,e,b	X											Miocene – Recent, Med.
<i>ornata</i> Greg. var. <i>signata</i> Perag.		M,l,e,b,st.			X									Fossil ? Recent
<i>pediculus</i> Ehr.		B,t,e,l,s		⊗										Fossil ? Recent
<i>placentula</i> Ehr. var. <i>klinoraphis</i> Geitl.		F,e									■			Pliocene – Recent
<i>pseudomarginata</i> Greg.		M,l,e,b			X									Miocene – Recent
<i>scutellum</i> Ehr.		M,B,e,s,b,n			X	X								Lower Miocene – Recent
sp. I		e	X											
sp. II		e	X											
? <i>Cocconeis</i> sp.		e	X											
<i>Coscinodiscus apiculatus</i> Ehr. var. <i>ambigua</i> Grun.		M,p						X		X				Miocene – Recent
<i>curvatus</i> Grun.		M,o,n,p					X							Miocene – Recent
<i>curvatus</i> Grun. var. <i>arcuata</i> Hajós	+	M,p						X		X				Miocene – ?
<i>curvatus</i> Grun. var. <i>macropunctata</i> Hajós	+	M,p					X	X						Miocene – ?
<i>curvatus</i> Grun. var. <i>minor</i> (Ehr.) Grun.		M,p					X	X						Miocene – Recent
<i>divisus</i> Grun.		M,o,n,l,p			X									Miocene – Recent
<i>excentricus</i> Ehr.		B,B,p,r				X	X	X		⊗	⊗			Miocene – Recent
<i>excentricus</i> Ehr. var. <i>macropora</i> Grun.		M,B,p,r				X								Miocene – Recent
<i>globosus</i> Hajós	+	M,p						X						Miocene – ?
<i>hustedtii</i> Jousé	+	M,p						X						Paleocene-Miocene – ?
<i>kützingii</i> A. Schm.		M,p,l				X	X	X		X	X			Miocene – Recent
? <i>lineatus</i> Ehr.		M,o,n,p,r						X						Miocene – Recent
<i>marginatus</i> Ehr.		M,o,p,sh						X						Eocene – Recent
<i>nitidus</i> Greg.		M,o,n,l,p				X	X			X				Upp.-Eocene – Recent
<i>oculus-iridis</i> Ehr.		M,o,sh,p				X				X				Upp.-Eocene – Recent
sp.		M,p								X				
<i>Cyclotella</i>														
<i>comta</i> (Ehr.) Kütz		F,p									■			Fossil ? – Recent
sp.		F,p												
<i>Denticulata hustedtii</i> Simonsen et Kanaya	+	M,p		X										Miocene
<i>Diatomella balfouriana</i> Grev.		F,e									■			Miocene – Recent
<i>Dimerogramma marinum</i> (Greg.) Ralfs		M,p,l					X							Miocene – Recent, Med.
<i>Diploneis</i>														
<i>bombus</i> Ehr.		M,l,b				X								Miocene – Recent, Med.
<i>coffaeiformis</i> (A. Schm.) Cl.		M,l,b									X			Miocene – Recent, Med.
<i>didyma</i> Ehr.		M,B,l,eu,b			⊗									Miocene – Recent
<i>gorjanovichi</i> (Pant.) Hust.		B,b			⊗									Miocene
<i>lineata</i> (Donk) Cl. var.?	+	M,l			X									Recent, Med.
<i>notabilis</i> (Grev.) Cl.		M,l				X								Recent, Med.
<i>ovalis</i> (Hilse) Cl.		F,B			⊗									Miocene – Recent
<i>smithii</i> (Bréb.) Cl.		M,B,l,b,s,r										X		Lower-Miocene – Recent
sp. I						X								
sp. II						X								

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TABLE 1 – Continued

Species	Extinct Species	Ecologies <sup>a</sup>	Locality			Ages <sup>b</sup>
			124-13-2; 89-90 cm 124-13-2; 127-129 cm 127-5-6; 136-139 cm	127-14-4; 144-147 cm 128-3-6; 97-100 cm 128-10-3; 5-8 cm	128-10-3; 59-62 cm 128-11-3; 148-150 cm 130-3 CC 130-4 CC	
<i>Epithemia</i> <i>sorex</i> Kütz. <i>turgida</i> (Ehr.) Kütz. <i>zebra</i> (Ehr.) Kütz. var. <i>saxonica</i> (Kütz.) Grun.		F,B,l,sw,e F,B,eu,e F,e	⊗ ⊗ ■			Pleistocene – Recent Pleistocene – Recent Miocene – Recent
<i>Eunotia pectinalis</i> (Kütz.) Rabh.		F			■	Pleistocene – Recent
<i>Fragilaria</i> <i>construens</i> (Ehr.) Grun. <i>hirosakiensis</i> Kanaya <i>inflata</i> (Heid.) Hust. <i>inflata</i> (Heid.) Hust. var. <i>istrányi</i> (Pant.) Hust. <i>leptostauron</i> (Ehr.) Hust. <i>leptostauron</i> (Ehr.) Hust. var. <i>dubia</i> Grun.	+	F,l,sw. M F F F,b F,b			■ X ■ ■ ■ ■	Miocene – Recent Miocene – ? Fossil ? – Recent Fossil ? – Recent Miocene – Recent Miocene – Recent
<i>Fragilariopsis pliocena</i> (Brun) Sheshuk	+	M		X X X		Pliocene – ?
<i>Glyphodesmis williamsonii</i> (W. Sm.) Grun.		M,l,b			X	Recent, Med.
<i>Gomphonema</i> sp.			X			
<i>Grammatophora angulosa</i> Ehr. <i>angulosa</i> Ehr. var. <i>islandica</i> (Ehr.) Grun. <i>marina</i> (Lyngb.) Kütz. var. <i>adriatica</i> Grun. <i>maxima</i> Grun. <i>oceanica</i> (Ehr.) Grun. var. <i>macilentata</i> (W. Sm.) Grun. sp. I sp. II sp. III cfr. <i>stricta</i> Ehr. var. <i>fossilis</i> Grun. <i>undulata</i> Ehr.		M,l,e,r M,l,e,r M,l,b,r M,l,b M,l,b M,b M,b M,b M,b M,b M,l,b	X	X X X X X X X		Miocene – Recent, Med. Miocene – Recent, Med. Recent, Med. Recent Miocene – Recent
<i>Hyalodiscus</i> <i>scoticus</i> (Kütz.) Grun. sp.		M,B,l,p M,p		X	X	Miocene – Recent
<i>Isthmia</i> sp.		M			X	
<i>Liradiscus ovalis</i> Grev.	+	M			X	Eocene-Miocene – ?
? <i>Liradiscus</i> sp.		M			X	
<i>Mastogloia</i> <i>brauni</i> Grun. cfr. <i>elegans</i> Lewis <i>elliptica</i> (Ag.) Cl. var. <i>dansei</i> (Thw.) Cl. sp. I sp. II sp. III		M,B,l,e M,l,e B,s,e e e e	⊗ X ⊗ ⊗ X X X			Recent Recent, Med. Pleistocene – Recent
<i>Melosira</i> <i>ambigua</i> (Grun.) O. Müll. <i>granulata</i> (Ehr.) Ralfs <i>granulata</i> (Ehr.) Ralfs var. <i>angustissima</i> O. Müll. <i>westii</i> W. Sm.		F,eu,p F,eu,p F,eu,p M,n,l,p	■ ■		■ ■ ■ ■	Miocene – Recent Miocene – Recent Miocene – Recent Miocene – Recent
<i>Navicula</i> <i>comoides</i> (Ag.?) Perag. <i>humerosa</i> Bréb. <i>impercepta</i> Hust. <i>pseudotuscula</i> Hust. <i>radiosa</i> Kütz.		M,l,p M,l,eu,r M,o,p F F	X X	X	■	Fossil ? – Recent Miocene – Recent Fossil ? – Recent Recent Miocene – Recent
? <i>Navicula</i> sp.				X		

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TABLE 1 – Continued

Species	Extinct Species	Ecologies <sup>a</sup>	Locality			Ages <sup>b</sup>
			124-13-2; 89-90 cm 124-13-2; 127-129 cm	127-5-6; 136-139 cm 127-14-4; 144-147 cm	128-3-6; 97-100 cm 128-10-3; 5-8 cm 128-10-3; 59-62 cm 128-11-3; 148-150 cm	
<i>Nitzschia</i> <i>granulata</i> Grun. <i>parvula</i> Lewis sp. I sp. II sp. III		M,B,b B	⊗ ⊗		X X	Pliocene – Recent Recent ?
<i>Paralia</i> <i>sulcata</i> (Ehr.) Cl. <i>sulcata</i> (Ehr.) Cl. var. <i>biseriata</i> Grun. <i>sulcata</i> (Ehr.) Cl. var. <i>crenulata</i> Grun. fa. <i>radiata</i> Grun.		M,l,p,n M,l,n,p M,l,n,p		X X X	X	Upp.-Eocene – Recent Upp.-Cret. – Recent Miocene – Recent
<i>Pinnularia eburnea</i> (Carlson) Zanon		F	■			Recent ?
<i>Plagiogramma staurophorum</i> (Greg.) Heib.		M,l,b			X	Miocene-Recent, Med.
<i>Podosira</i> sp.		M,b	X X			
<i>Rhaphoneis nitida</i> (Greg.) Grun.		M,n,l,b,st			X	Miocene-Recent, Med.
<i>Rhaphoneis surirella</i> (Ehr.) Grun. var. <i>australis</i> Petit		M,b,l,r,e,b		X X		Recent, Med.
<i>Rhisosolenia</i> <i>berganii</i> Perag. sp. I sp. II sp. III sp. IV		M,p,st M,p M,p M,p M,p			X X X	X Recent, Med.
<i>Rhoicosphenia curvata</i> (Kütz.) Grun.		F,B	⊗			Pleistocene – Recent
<i>Rhopalodia</i> <i>gibba</i> (Ehr.) O. Müll. <i>gibba</i> (Ehr.) O. Müll. var. <i>ventricosa</i> (Ehr.) Grun. <i>gibberula</i> (Ehr.) O. Müll. Van Heurchii O. Müll. <i>musculus</i> (Kütz.) O. Müll.		F F B,l,s B,l,eu,r	■ ■ ■ ⊗ ⊗			■ Miocene – Recent Miocene – Recent Miocene – Recent Miocene – Recent
<i>Sceptroneis caducea</i> Ehr.		M,l,p	X		X	Eocene – Recent, Med.
<i>Stauroneis</i> sp.					X	
<i>Stephanodiscus</i> <i>astrea</i> (Ehr.) Grun. <i>astrea</i> (Ehr.) Grun. var. <i>minutula</i> Kütz.) Grun. sp. I sp. II		F,B,p,eu F,B,p,eu F,p F,p			■ ■ ■ ■ ■ ■ ■ ■	Pleistocene – Recent Pleistocene – Recent
<i>Stephanopyxis turris</i> (Grev. et Arn.) Ralfs		M,n,p,st			X	Upper-Cret. – Recent
<i>Stictodiscus paralellus</i> (Ehr.) Grev. var. <i>balearica</i> Grun.		M,p			X	Miocene – Recent
<i>Surirella</i> <i>striatula</i> Turp. sp.		F,B	⊗ X			Upp.-Miocene – Recent
<i>Synedra Van Heuckii</i> Brun.		M,p			X	Miocene – Recent ?
<i>Thalassionema nitzschioides</i> Grun.		M,n,l,eu,p	X X	X X	X X	Miocene – Recent
<i>Thalassionema</i> sp.		M,p		X		
<i>Thalassiosira</i> <i>decipiens</i> (Grun.) Joerg. <i>oestrupi</i> (Ostf.) Prosh.-Lavr. sp.		M,o,n,l,p M,p M,p		X	X X X X	Miocene - Recent, Med.
<i>Thalassiotrix</i> sp.		M,p		X		

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Diatom Zone

TABLE 1 – Continued

Species <sup>a</sup>	Extinct Species	Ecologies <sup>a</sup>	Locality				Ages <sup>b</sup>
			124-13-2; 89-90 cm 124-13-2; 127-129 cm	127-5-6; 136-139 cm 127-14-4; 144-147 cm 128-3-6; 97-100 cm	128-10-3; 5-8 cm 128-10-3; 59-62 cm 128-11-3; 148-150 cm	130-3 CC 130-4 CC	
<i>Triceratium balearicum</i> Cl. et Grun. fa. <i>biquadrata</i> (Janisch) Hust.		M,I,b			X		Miocene – Recent, Med.
<i>Xanthiopyxis</i> sp. I		M			X		
sp. II		M			X		
sp. III		M	X				
<i>Forma indeterminata</i>					X		
PHYTOLITHARIA		F	■ ■	X		■ ■	Miocene – Recent
INCERTAE SEDIS: (ACRITARCHA)							
<i>Cymatiosphaera</i> cfr. <i>miocaenica</i> Hajós	+	M,p			X X X	X	Miocene – ?
RADIOLARIA		M,p		X	X		
PORIFERA:							
<i>Monaxon; oxea</i>		M	X	X X	X	X	
<i>Monaxon; acanthostyl</i>		M	X	X X	X	X	

1 2 3 Diatom Zone

<sup>a</sup>Explanation of Ecological Remarks: M = Marine species X; B = Brackish water species ⊗; F = Fresh water species ■; o = Oceanic; n - Neritic; l = Littoral; r = River mouths; sw = Stagnant water; s = Salina; p = Planktonic; e = Epiphytic; b = Benthonic; eu - Euryhaline; st - Stenothermal; sh = Stenohaline

<sup>b</sup>Med. = Mediterranean

#### *Cyclotella* sp.

*Diatomella balfouriana* (epiphytic)

*Fragilaria leptostaurota* (benthonic)

*Fragilaria leptostaurota* (planktonic euryhaline)

*Pinnularia eburnea*

*Rhicosphenia curvata*

*Rhopalodia gibba*

*Rhopalodia gibba* var. *ventricosa*.

Autochthonous brackish-water and freshwater forms indicate the presence of a shallow-water, land-locked, littoral area which did not undergo a significant change in water depth before the advent of later geological events. On the basis of a few extinct fossil species such as *Archaeomonas californica*, *A. japonica*, *A. melo*, *Mesocena elliptica* var. *pentagona*, *Denticula hustedtii*, *Diploneis gorjanovicii*, which have so far been recorded from Miocene (Tortonian-Sarmatian) deposits only, the sediment can be dated as late Miocene.

#### Division 2 – Sapropels from the Hellenic Trench

On the basis of the floral assemblage, sediments of the samples from Sites 127 and 128 (127-5-6, 136-139 cm; 127-14-4, 144-147 cm; 128-3-6, 97-100 cm; 128-10-3, 5-8 cm; 128-10-3, 59-62 cm; 128-11-3, 148-150 cm) were formed approximately contemporaneously and under the same environmental conditions. The samples of these two

sites can be correlated. The floral spectrum consists of (1) purely marine assemblages, showing the predominance of Silicoflagellata which require an open sea environment of normal salinity, and (2) neritic, littoral planktonic diatoms. The number of oceanic and stenohaline planktonic forms is also considerable. The species *Cannopilus sphaericus* indicates a salinity higher than 30‰. Subtropical and tropical stenothermal species favoring warm waters are abundant. The species *Triceratium balearicum* var. *biquadrata*, *Stictodiscus parallelus* var. *balearica* and *Bacteriastrium comosum* are known in Europe to occur exclusively in the region of the Balearic Islands.

#### Oceanic warm-water forms:

*Asteromphalus robustus* (stenohaline)

*Coscinodiscus curvatulus*

*Coscinodiscus divisus*

*Coscinodiscus lineatus*

*Coscinodiscus marginatus* (stenohaline)

*Coscinodiscus nitidus*

*Coscinodiscus oculus-iridis* (stenohaline)

*Rhisosolenia bergonii*

*Thalassiosira decipiens*

*Bacteriastrium comosum* is a marine, neritic (stenohaline) species. As implied by the known salinity ranges of the species, the salinity of the environment must have been higher than 20 to 30‰ and 30‰, respectively.



*Stenothermal warm-water forms*, indicating a warm to temperate sedimentary environment, include the following:

*Actinoptychus senarius*  
*Cocconeis ornata* var. *signata*  
*Rhaphoneis nitida*  
*Rhisosolenia bergonii*  
*Stephanopyxis turris*

Besides the warm-to-temperate-water-favoring species of *Rhisosolenia*, *Bacteriastrum* and *Coscinodiscus*, the representatives of Acritarchs, Radiolaria and Silicospongia are characteristic.

On the basis of the floral assemblage the age of the sediment is early Quaternary.

### Division 3 – Blue to Black Clays from the Mediterranean Ridge

The floral assemblages of Samples 130-3-CC and 130-4-CC of Site 13 are the same and indicate that the sediment is marine. However, along with marine and littoral planktonic forms, considerable numbers of fresh to brackish water, euryhaline planktonic forms are found. Among the marine planktonic forms the species *Coscinodiscus excentricus* and its varieties, which frequently occur in river mouths, are characteristic. The fresh and brackish water planktonic forms are presumably allochthonous and most likely have been introduced into the Mediterranean with the sediment of the Nile River delta. Most of the identified species of well-known stratigraphic range are still-living forms. The age of the sediment seems to be Quaternary.

On the basis of the studied samples, the paleogeographic distribution of the species has also been examined. The extinct species were found to show very little affinity, if any, with the forms occurring in the Miocene-Pliocene sediments of the peri-Mediterranean countries. A considerable number of the species presently live in the Mediterranean Sea. Many of the oceanic neritic and littoral species are known to occur on the Atlantic coast of Europe and on the Pacific coastal zones of America and Asia, as well as in the subtropical and tropical areas of the southern seas. Least affinity is shown with the known taxa of the Indian Ocean by both the fossil and recent species. At any rate, in Pliocene and Quaternary times the region of the Mediterranean Sea must have had a westward connection with the open ocean.

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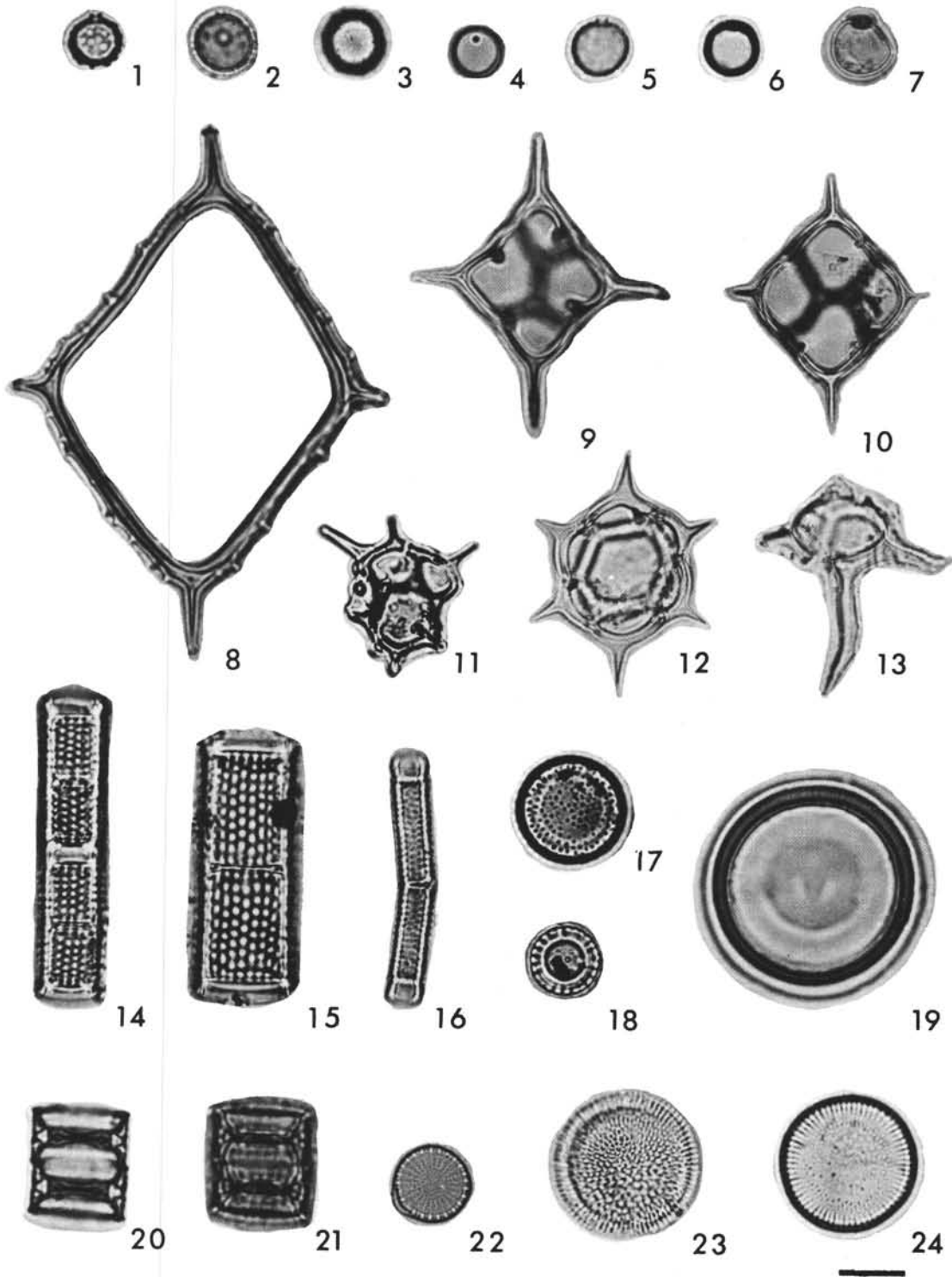
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PLATE 1  
Magnifications × 1000  
Scale bar represents 10 microns

- Figure 1      *Archaeomonas mangini* Deflandre
- Figures 2, 3, 5      *Archaeomonas japonica* Deflandre
- Figures 4, 6      *Archaeomonas inconspicua* Deflandre
- Figure 7      *Archaeomonas melo* Deflandre
- Figure 8      *Mesocena elliptica* (Ehrenberg) Ehrenberg var. *quadrangula* Bachmann & Ichikawa.
- Figures 9, 10      *Dictyocha fibula* Ehrenberg
- Figures 11, 12      *Dictyocha speculum* Ehrenberg
- Figure 13      *Hermesinum* cfr. *adriaticum* Zach.
- Figures 14, 15      *Melosira granulata* (Ehrenberg) Ralfs
- Figure 16      *Melosira granulata* (Ehrenberg) Ralfs var. *angustissima* O. Müller.
- Figures 17, 18      *Melosira granulata* (Ehrenberg) Ralfs
- Figure 19      *Melosira westii* W. Smith
- Figures 20, 21      *Paralia sulcata* (Ehrenberg) Cleve
- Figure 22      *Cyclotella comta* (Ehrenberg) Kützing
- Figures 23, 24      *Cyclotella* sp.

## PLATE 1



## PLATE 2

Magnifications × 1000  
Scale bar represents 10 microns

- Figure 1 *Paralia sulcata* (Ehrenberg) Cl. var. *biseriata* Grunow
- Figures 2, 3 *Podosira* sp.
- Figure 4 *Hyalodiscus scoticus* (Kützing) Grunow
- Figure 5 *Hyalodiscus* sp.
- Figure 6 *Stephanopyxis turris* (Greville Arnott) Ralfs
- Figures 7, 8 *Thalassiosira oestrupi* (Ostenfeld) Proskina-Lavrenko
- Figures 9, 10 *Thalassiosira decipiens* (Grunow) Joergensen
- Figures 11, 12, 19 *Stephanodiscus astrea* (Ehrenberg) Grunow
- Figures 13, 14 *Stephanodiscus astrea* (Ehrenberg) Grunow var. *minutula* (Kützing) Grunow
- Figures 15, 16 *Coscinodiscus excentricus* Ehrenberg var. *micropora* Grunow
- Figure 17, 18 *Coscinodiscus curvatulus* Grunow var. *macropunctata* Hajós

PLATE 2

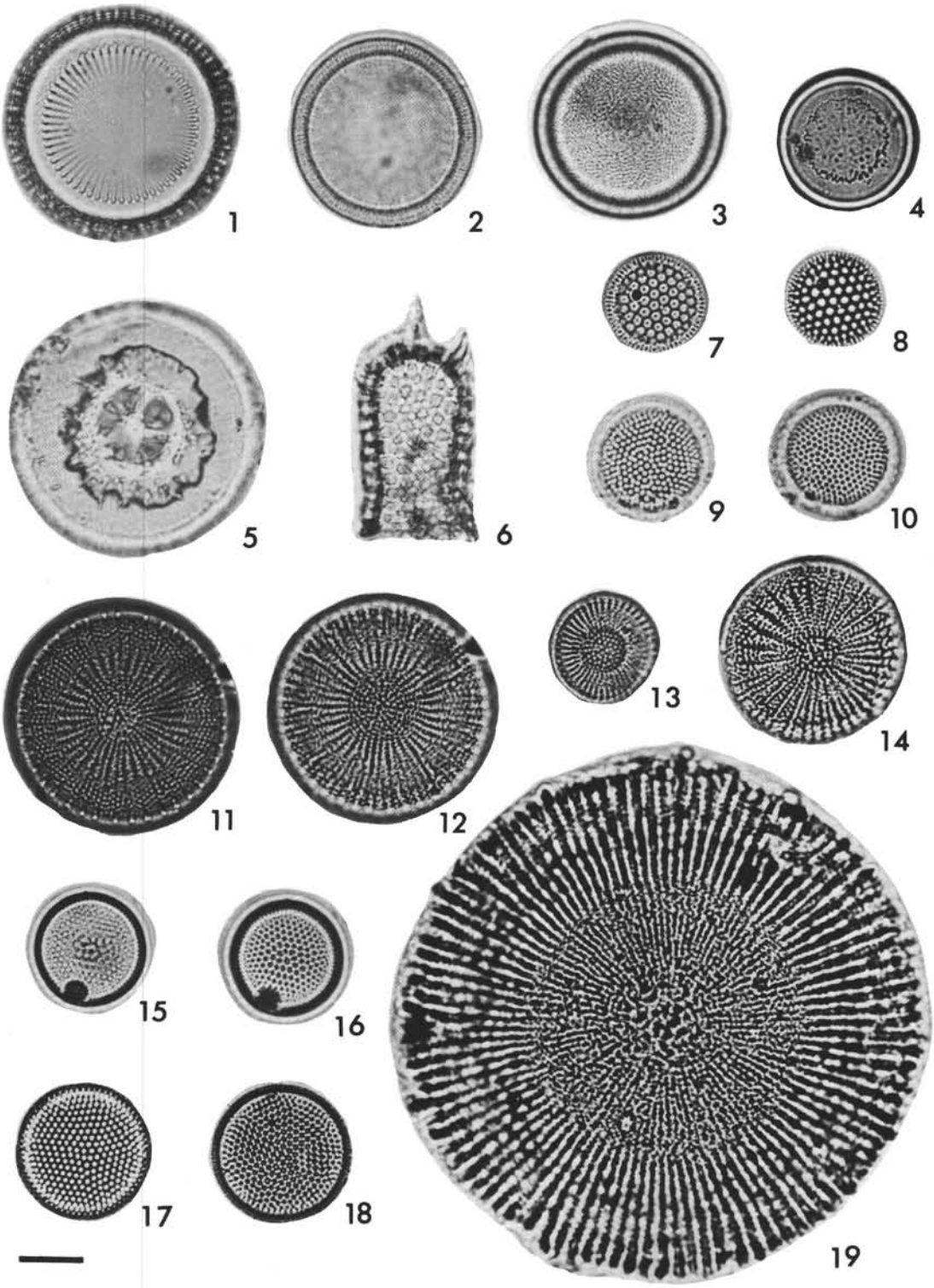


PLATE 3

Magnifications  $\times 1000$   
Scale bar represents 10 microns

- |                  |  |
|------------------|--|
| Figures 1, 2, 5  | <i>Coscinodiscus oculus-iridis</i> Ehrenberg |
| Figures 3, 4, 10 | <i>Coscinodiscus excentricus</i> Ehrenberg   |
| Figure 6         | <i>Coscinodiscus nitidus</i> Gregory         |
| Figure 7         | <i>Coscinodiscus marginatus</i> Ehrenberg    |
| Figures 8, 9     | <i>Coscinodiscus hustedtii</i> Jousé         |



## PLATE 3

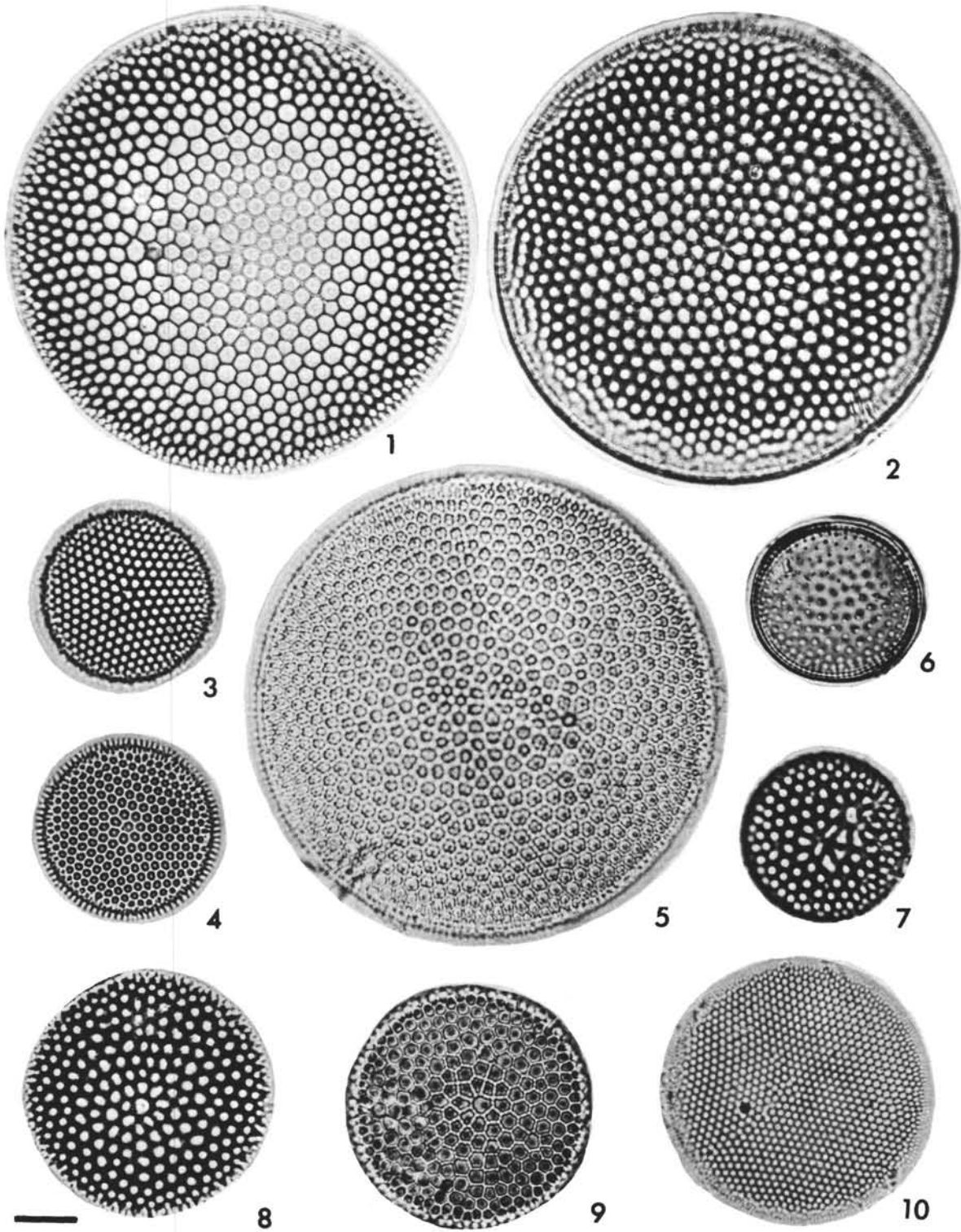


PLATE 4

Magnifications  $\times 1000$   
Scale bar represents 10 microns

- Figures 1, 2, 4, *Coscinodiscus excentricus* Ehrenberg  
Figures 3, 5 *Coscinodiscus kützingii* A. Schmidt  
Figures 6, 7 *Coscinodiscus divisus* Grunow  
Figures 8, 9 *Coscinodiscus curvatulus* Grunow var. *arcuata* Hajós  
Figure 10 *Stictodiscus paralellus* (Ehrenberg) Greville var. *balearica* Grunow  
Figure 11 *Actinoptychus reinholdii* Hajós

PLATE 4

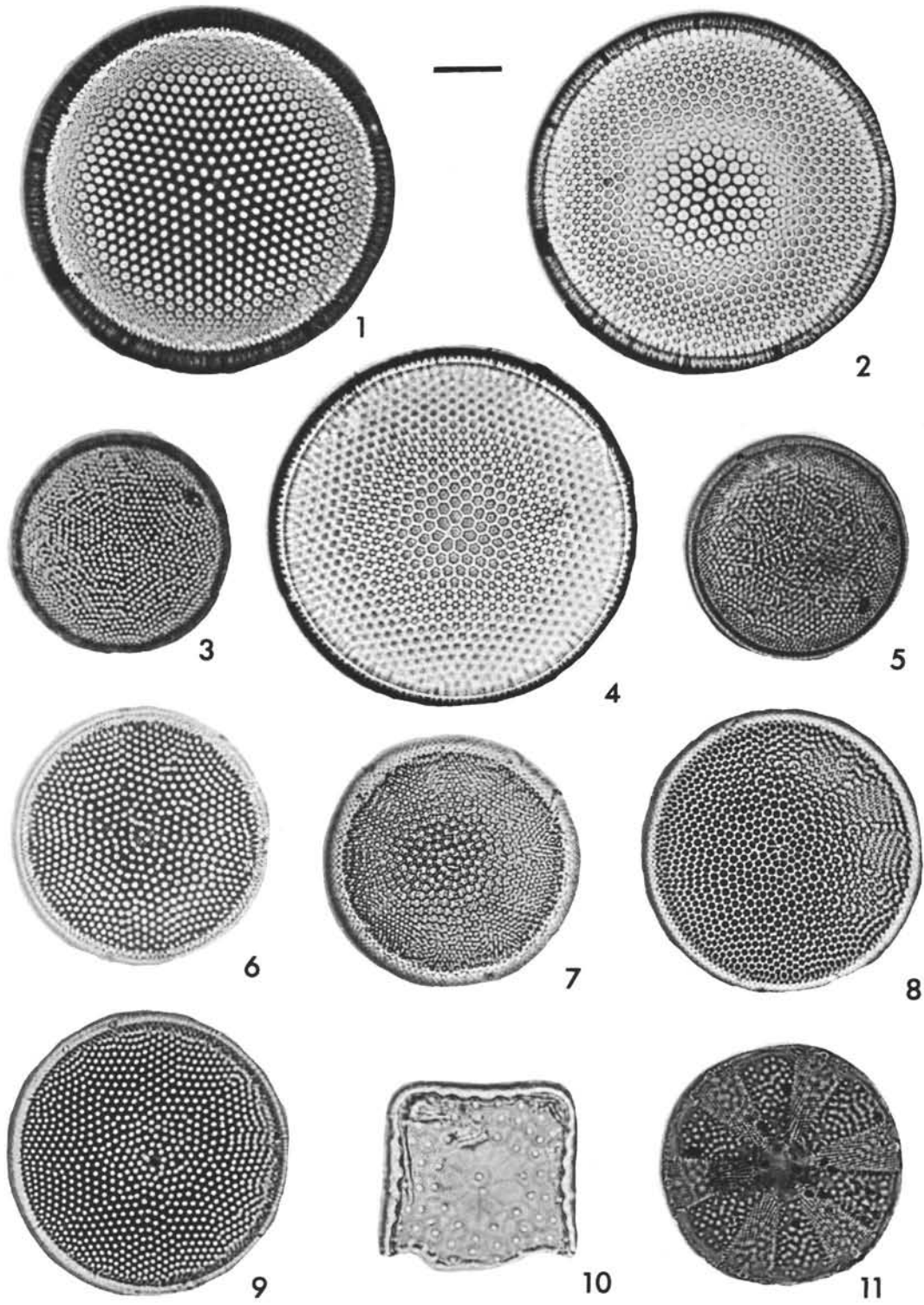
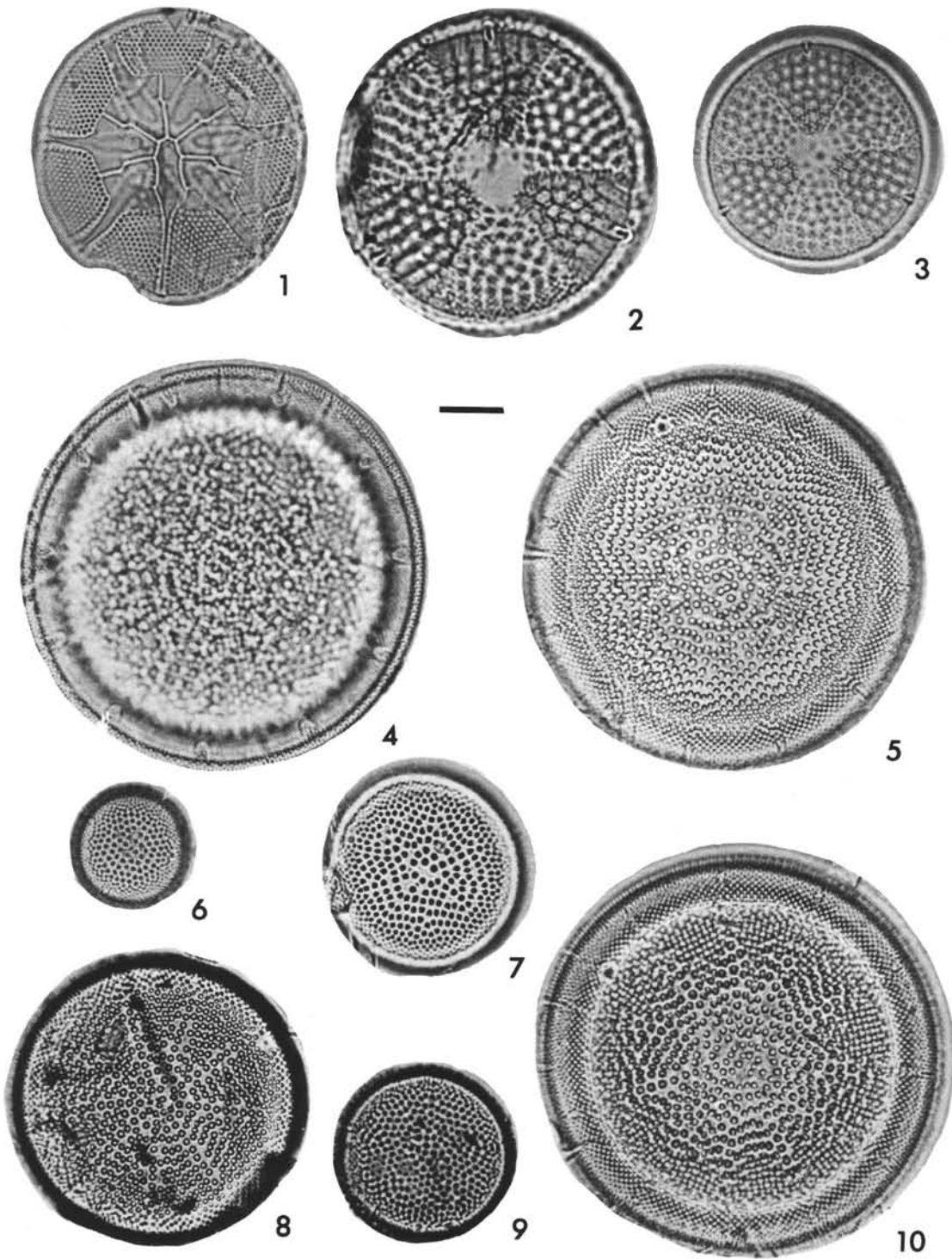


PLATE 5

Magnifications  $\times 1000$   
Scale bar represents 10 microns

- Figure 1      *Asteromphalus robustus* Castracane  
Figures 2, 3      *Actinoptychus senarius* (Ehrenberg) Ehrenberg  
Figures 4, 5, 10      *Actinocyclus octonarius* Ehrenberg var. *crassa* (W. Smith) Hustedt  
Figure 6      *Actinocyclus octonarius* Ehrenberg var. *minuta* (Pantocsek) Hajóš  
Figures 7, 9      *Actinocyclus octonarius* Ehrenberg var. *tenella* (Brebisson) Hajóš  
Figure 8      *Actinocyclus octonarius* Ehrenberg

PLATE 5



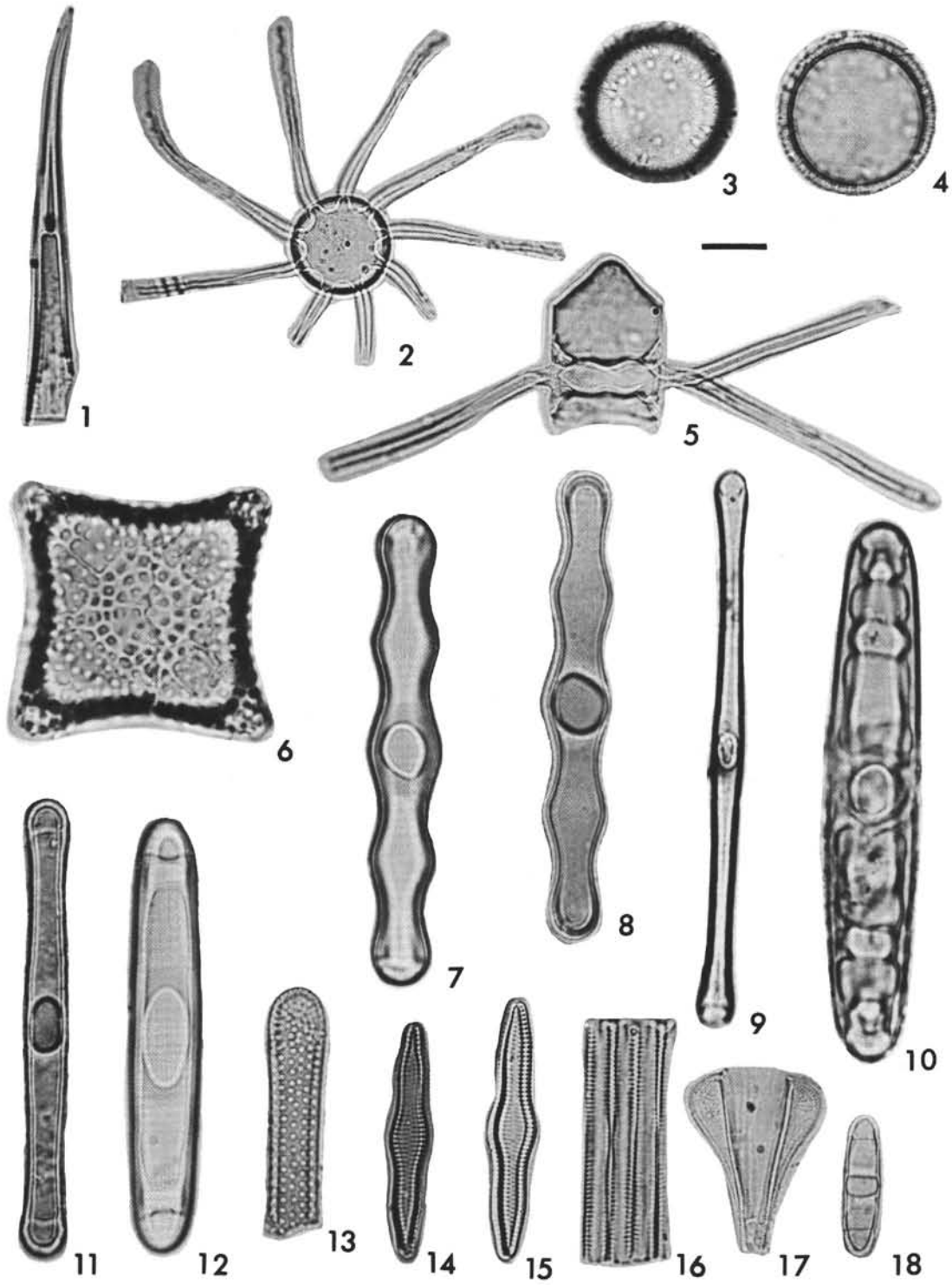


## PLATE 6

Magnifications  $\times 1000$   
Scale bar represents 10 microns

- |               |  |
|---------------|--|
| Figure 1      | <i>Rhososolenia</i> sp. IV   |
| Figure 2      | <i>Bacteriastrum comosum</i> Pavillard   |
| Figures 3, 4  | <i>Chaetoceros</i> sp. VI.   |
| Figure 5      | <i>Chaetoceros gastridium</i> Ehrenberg  |
| Figure 6      | <i>Triceratium balearicum</i> Cleve and Grunow var. <i>biquadrata</i> (Janisch) Hustedt  |
| Figures 7, 8  | <i>Grammatophora undulata</i> Ehrenberg  |
| Figures 9, 11 | <i>Grammatophora oceanica</i> (Ehrenberg) Grunow var. <i>macilenta</i> (W. Smith) Grunow |
| Figure 10     | <i>Grammatophora angulosa</i> Ehrenberg var. <i>islandica</i> (Ehrenberg) Grunow         |
| Figure 12     | <i>Grammatophora</i> sp. I.  |
| Figure 13     | <i>Sceptroneis caducea</i> Ehrenberg   |
| Figures 14-16 | <i>fragilaria inflata</i> (Heiden) Hustedt var. <i>istvánffy</i> (Pantocsek) Hustedt     |
| Figure 17     | <i>Asterionella</i> sp.  |
| Figure 18     | <i>Plagiogramma staurophorum</i> (Gregory) Heiberg                                       |

## PLATE 6

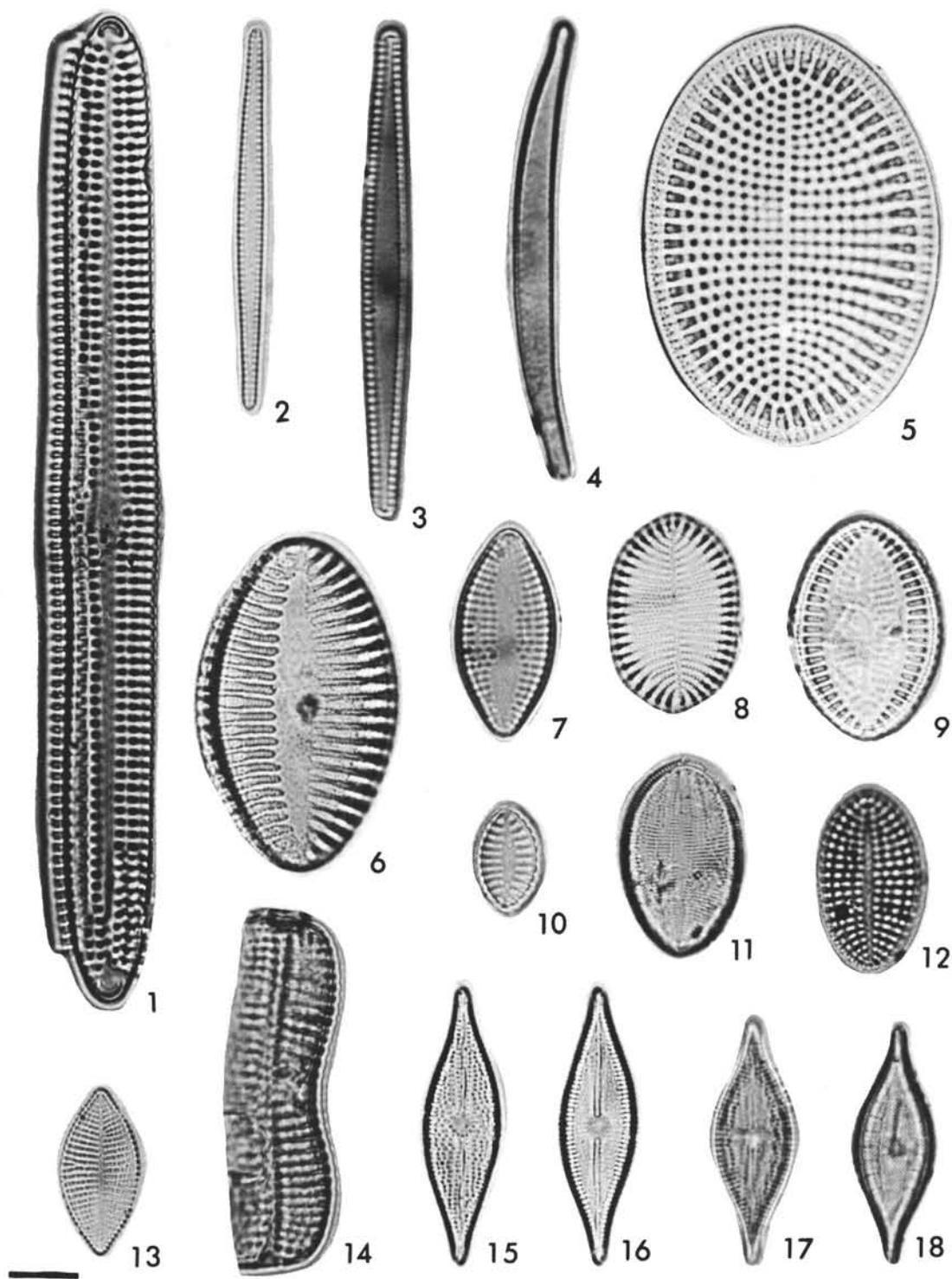


## PLATE 7

Magnifications  $\times 1000$   
Scale bar represents 10 microns

- Figure 1 *Dimerogramma marinum* (Gregory) Ralfs  
Figure 2 *Thalassionema nitzschioides* Grunow  
Figure 3 *Fragilaria hirosakiensis* Kanaya  
Figure 4 *Campylosira* sp.  
Figure 5 *Cocconeis scutellum* Ehrenberg  
Figure 6 *Cocconeis* sp. I  
Figure 7 *Rhaphoneis surirella* (Ehrenberg) Grunow  
Figure 8 *Cocconeis britannica* Naegeli  
Figure 9 *Cocconeis ornata* Gregory var. *signata* Peragallo  
Figure 10 *Cocconeis costata* Gregory  
Figure 11 *Cocconeis pediculus* Ehrenberg  
Figure 12 *Cocconeis scutellum* Ehrenberg  
Figure 13 *Achnanthes fimbriata* (Grunow) Ross  
Figure 14 *Achnanthes brevipes* Agardh  
Figures 15-18 *Mastogloia* sp. II.

PLATE 7



## PLATE 8

Magnifications × 1000  
Scale bar represents 10 microns

- Figures 1, 2, 5 *Mastogloia brauni* Grunow  
Figures 3, 4 *Mastogloia* sp. II.  
Figure 6 *Diploneis gorjanovichi* (Pantocsek) Hustedt  
Figure 7 *Diploneis ovalis* (Hilse) Cleve  
Figure 8 *Diploneis bombus* Ehrenberg  
Figure 9 *Diploneis notabilis* (Greville) Cleve  
Figure 10 *Navicula comoides* (Agardh) Peragallo  
Figure 11 *Navicula pseudotuscula* Hustedt  
Figure 12 *Navicula impercepta* Hustedt  
Figures 13, 14 *Denticula hustedtii* Simonsen et Kanaya  
Figure 15 *Amphora minuta* Pantocsek var. *interrupta* Hajós  
Figure 16 *Pinnularia eburnea* (Carlson) Zanon  
Figure 17 *Amphora holsatica* Hustedt  
Figure 18 *Navicula humerosa* Brébisson



## PLATE 8

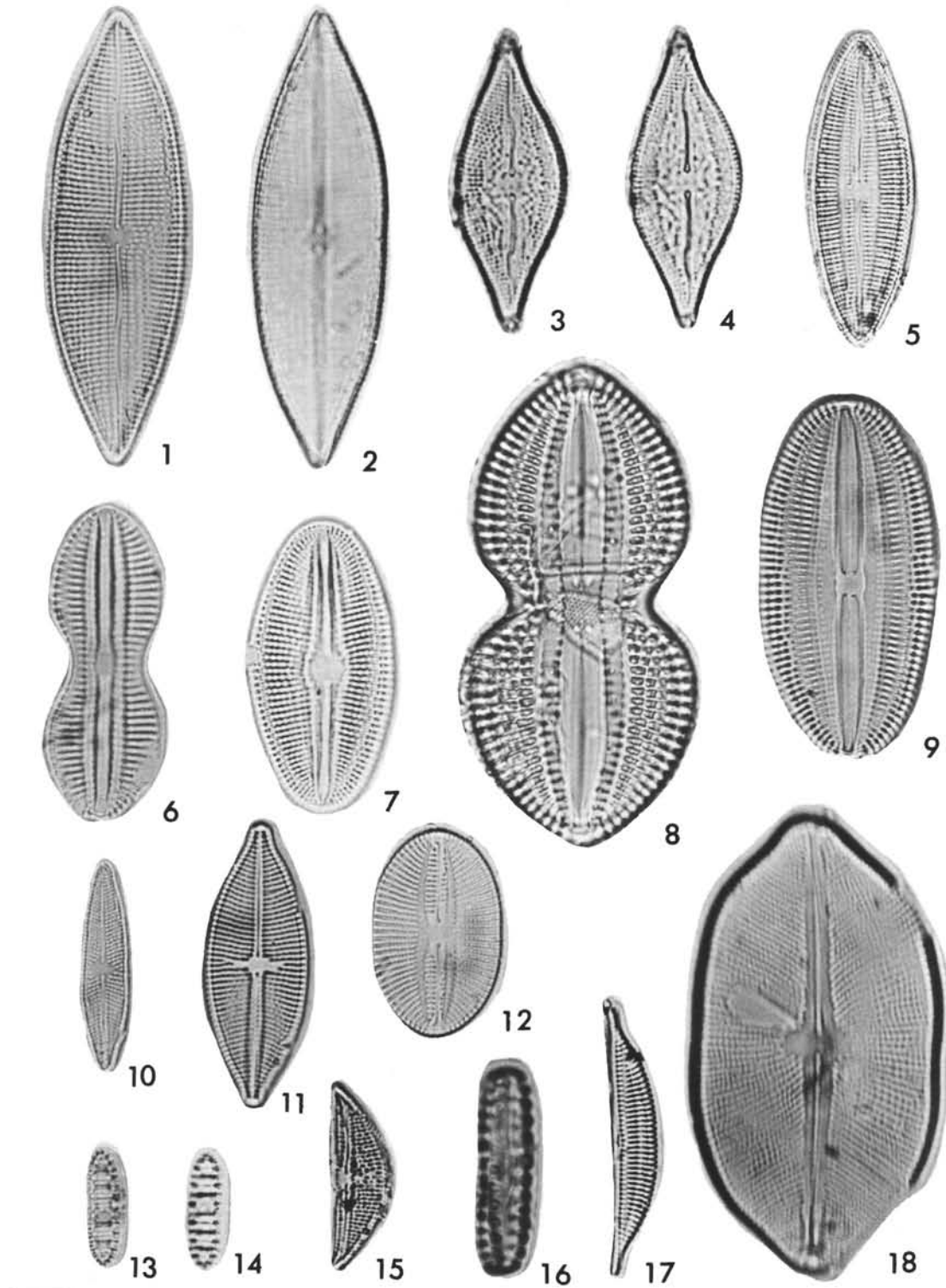


PLATE 9

Magnifications X 1000  
Scale bar represents 10 microns

- Figure 1 *Epithemia zebra* (Ehrenberg) Kützing var. *saxonica* (Kützing) Grunow
- Figure 2 *Amphora* sp.
- Figure 3 *Rhopalodia gibba* (Ehrenberg) O. Müller. var. *ventricosa* (Ehrenberg) Grunow
- Figure 4 *Epithemia sorex* Kützing
- Figure 5 *Epithemia turgida* (Ehrenberg) Kützing
- Figure 6 *Rhopalodia gibba* (Ehrenberg) O. Müller
- Figure 7, 8 *Porifera*
- Figure 9 *Pseudoeunotia doliolus* (Wallich) Grunow
- Figure 10 *Fragilariopsis pliocena* (Brun) Sheshukova-Poretzskaya
- Figure 11 *Nitzschia granulata* Grunow
- Figure 12 *Campylodiscus clypeus* Ehrenberg var. *bicostata* (W. Smith) Hustedt
- Figure 13 *Cymatiosphaera* cfr. *miocaenica* Hajós
- Figures 14-17 *Phytolitharia*

## PLATE 9

