

## 49. MIDDLE EOCENE TO OLIGOCENE PLANKTONIC DIATOM STRATIGRAPHY FROM DEEP SEA DRILLING SITES IN THE SOUTH ATLANTIC, EQUATORIAL PACIFIC, AND INDIAN OCEANS<sup>1 2</sup>

Juliane Fenner, Geologisch-Paläontologisches Institut der Universität Kiel, Olshausenstrasse 40-60, D 2300, Kiel, Federal Republic of Germany

### ABSTRACT

The relative abundance of Paleogene diatom species was determined at DSDP Sites 356 and 357 (southwest Atlantic), 64, 65, 69, 71A, 72, 73, 77B, 161, 163, 167, 289, and 292 in the equatorial Pacific, and 216, 217, and 220 in the Indian Ocean. Biostratigraphy and paleoceanographic implications of the differences in assemblage compositions are discussed.

The assemblage analysis for the middle and late Eocene at Sites 356 and 357 in the mid-latitude southwest Atlantic provides insight into the paleolatitudinal distribution of diatom species.

In the middle Eocene the diatom assemblages at these sites are composed of low-latitude and cosmopolitan species, whereas during the late Oligocene high-latitude species are present, reflecting an extension toward the equator of the circum-Antarctic assemblage that can be related to climatic cooling and probably intensified meridional wind and surface water circulation.

In addition, the Eocene-Oligocene planktonic diatom zonation developed in the low-latitude Atlantic and the Caribbean (Fenner, in press) is tested against the moderately to well-preserved early Oligocene diatom assemblages of the Pacific sites (except for Site 292, at which preservation of diatoms was too poor), and those of middle and late Eocene age at DSDP Site 167. The age assignments obtained by applying this stratigraphic zonation are in accordance with those obtained using other planktonic microfossil groups, thus proving the applicability of this zonation.

The wide occurrence of the same species through the equatorial Atlantic and Pacific oceans and the identical sequence of first appearances have both to be seen as a result of the homogenizing effect of unobstructed circum-equatorial circulation in Tethys.

In the diatomaceous Eocene-Oligocene section of Site 167 in the equatorial Pacific, the change in assemblage composition toward an assemblage dominated by *Cestodiscus* spp. in the early Oligocene occurs at about the Eocene/Oligocene boundary, as it also does at DSDP Site 366 in the equatorial Atlantic. The value of this change in assemblage composition as a paleoclimatic indicator and stratigraphic marker is suggested.

The only Indian Ocean sites (Sites 216, 217, 220) which contain Eocene-Oligocene diatoms were located just south of the equator during the Eocene. But preservation of diatoms is too poor to allow stratigraphic assignments or to discuss assemblage compositions in relation to other known sections.

### INTRODUCTION

Stratigraphic zonation of the Paleogene using planktonic diatoms has been substantially developed during the last ten years. Continuing a long tradition of Russian work on Paleogene diatomaceous deposits, Jousé (1973, 1979) compiled information on the stratigraphic occurrences of Paleogene planktonic diatom species from land outcroppings and deep sea cores. Much new information has also been obtained, especially from diatomaceous sections drilled by *Glomar Challenger*. Dzino-ridze et al. (1976, 1979) and Fenner, in Schrader and Fenner (1976), developed a stratigraphic scheme for the Paleogene of the Norwegian Sea. For the low latitudes, Fenner (1982; in press) described ranges of planktonic diatom species through the Eocene and Oligocene from DSDP Sites 13, 366, 366A, and 369A off Northwest Africa and Site 149 in the Venezuela Basin; planktonic diatom zones were also established. For the late Eocene and Oligocene of the circum-Antarctic, Fenner (in press)

defined diatom zones, revising older zonal definitions proposed by McCollum (1975), Schrader (1976), Gombos (1977), Weaver and Gombos (1981), and Gombos and Ciesielski (1983).

All the results presented here are from DSDP sites not previously analyzed for Paleogene diatoms; they provide basic new stratigraphic data and an opportunity to test zonations proposed earlier. Site locations appear in Table 1 and Figure 1.

The planktonic diatom zonation used in this study is that defined by Fenner (in press). Zones are defined and correlated to the calcareous microfossil zones in Figure 2.

This study presents part of the data analyzed for a study of Eocene-Oligocene paleoceanography being undertaken jointly with other authors (B. H. Corliss, L. D. Keigwin, Jr., G. Keller, M.-P. Aubry, and W. A. Berggren). The sites were selected to give information on the paleogeographic distribution of species and changes in assemblage composition from the middle Eocene through early Oligocene.

### METHODS

All samples were prepared by boiling the sediment for 10 min. in an equal mixture of 10% HCl and 30% H<sub>2</sub>O<sub>2</sub> in order to dissolve the calcium carbonate and oxidize the organic matter. Clay minerals were

<sup>1</sup> Hay, W. W., Sibuet, J.-C., et al., *Init. Repts. DSDP*, 75: Washington (U.S. Govt. Printing Office).

<sup>2</sup> Moore, T. C., Rabinowitz, P. D., et al., *Init. Repts. DSDP*, 74: Washington (U.S. Govt. Printing Office).

Table 1. Present geographic location of the DSDP sites examined.

Site	Geographic Location	Latitude	Longitude	Water Depth (m)
64, 64.1	Ontong-Java Plateau	01°44, 56' N	158°36, 51' E	2052
65, 65.1	Central equatorial Pacific	04°21, 21' N	176°59, 16' E	6130
69, 69A		06°00, 00' N	152°51, 93' W	4978
71A		04°28, 28' N	140°18, 91' W	4419
72		00°26, 49' N	138°52, 02' W	4326
73	Ninetyeast Ridge	01°54, 58' S	137°28, 12' W	4387
77B		00°28, 90' N	133°13, 70' W	4291
161A		10°14, 25' N	139°57, 21' W	4939
163		11°14, 66' N	150°17, 52' W	5230
167	Southeast Arabian Basin	07°04, 10' N	176°49, 05' W	3176
216		01°27, 73' N	90°12, 48' E	2262
217	Ontong-Java Plateau	08°55, 57' N	90°32, 33' E	3030
220		06°30, 97' N	70°59, 02' E	4036
289	Ontong-Java Plateau	00°29, 92' S	158°30, 69' E	2206
292	Benham Rise	15°49, 11' N	124°39, 05' E	2943
356	São Paulo Plateau	28°17, 22' S	41°05, 28' W	3203
357	Rio Grande Rise	30°00, 25' S	35°33, 59' W	2086

separated from the insoluble residue by using their slower gravitational settling times: starting with a well-mixed and suspended sample residue, the upper 9 cm of the water column in a 400 ml beaker were siphoned off after 8 hr. of settling time. This process was repeated until, after 8 hours of settling time, the water column was clear. After the acid was washed out, a 0.5% sodium pyrophosphate solution in water was used in one washing to improve the suspension of clay minerals. For more details see Fenner (1982). This method effectively concentrates the equivalent quartz grain sizes larger than 2  $\mu$ m.

Aroclor 4465 (n.d. = 1.66, solvent: Xylene; Göke, 1958) was used as the mounting medium.

Depending on the abundance of diatoms in a sample, all or half of a 20  $\times$  20 mm slide was scanned under the light microscope at a magnification of 1000 $\times$  to determine the relative abundances of the diatom species.

### MATERIAL

During the late Eocene to early Oligocene, Pacific DSDP Sites 65, 69, 71, 72, 73, 77, 161, 163, and 167 were located in the equatorial belt of high accumulation

rates of biogenic silica (e.g., Boström et al., 1963, Leinen, 1981). Site 292 was located to the west of this zone of high productivity, possibly representing its western extension (Ingle et al., 1975). DSDP Sites 64 and 289, on the Ontong-Java Plateau, were  $\sim$ 10° of latitude further south than their present locations (Hammond et al., 1975), and DSDP Sites 216, 217, and 220, in the Indian Ocean, were also about 10° of latitude further south, just south of the equator (McElhinny, 1970; McKenzie and Sclater, 1971). At DSDP Site 357, on the Rio Grande Rise, which was always located outside of the equatorial and circum-Antarctic upwelling regions, only short intervals of diatom-bearing sediments occur, one in the lower middle Eocene, the other in the upper Oligocene. A similar pattern of restricted occurrence and preservation of siliceous microfossils in the lower middle Eocene and upper Oligocene also occurs at Site 356 on the São Paulo Plateau, at nearby DSDP Sites 22 and 516F on the western Rio Grande Rise, and in the southwestern Brazil Basin at Site 515 (Maxwell et al., 1970; Shipboard Scientific Party, Leg 73).

### DSDP Sites 356 and 357 (Southwest Atlantic)

In the Eocene of Sites 356 and 357 on the São Paulo Plateau and western Rio Grande Rise, diatoms are encountered only during a short interval within the upper part of Zone NP15 to the lower part of Zone NP16. At Site 357 diatoms are dissolved in the Eocene sediments above and below a short interval in Core 24 (Fenner, unpublished data). At Site 356, 75 m of diatomaceous sediments of middle Eocene age are unconformably overlain by early Miocene and underlain by middle and early Eocene sediments barren of diatoms. This short interval of increased productivity and biogenic silica preservation is related to a short phase of volcanic activity in this region, combined with uplift and the presence of volcanic islands

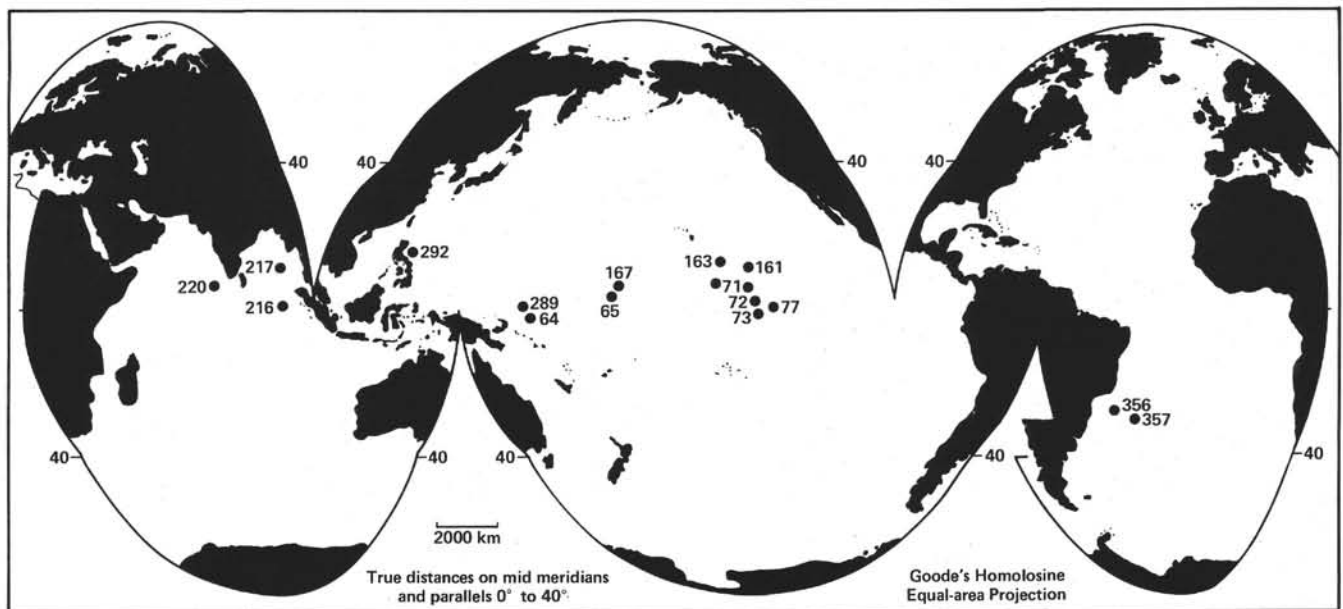


Figure 1. Geographic location of DSDP sites examined in this chapter.

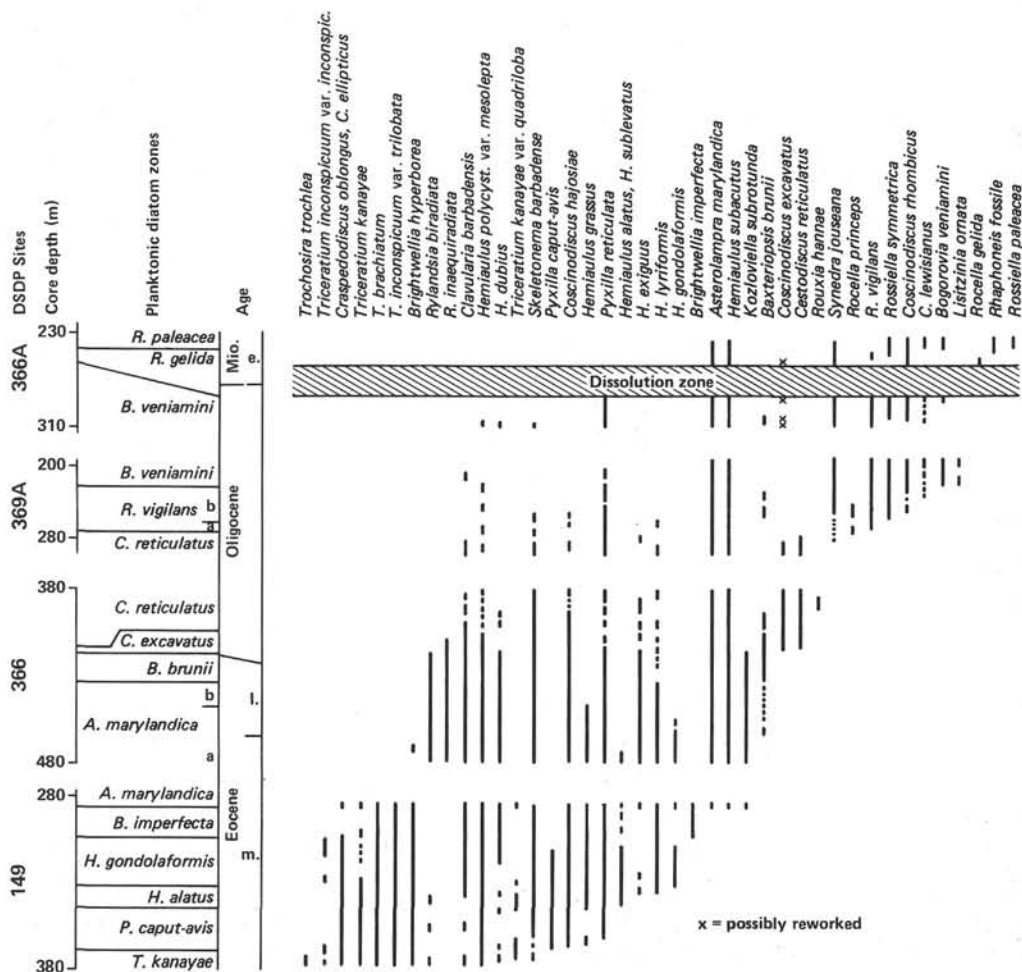


Figure 2. Eocene-Oligocene planktonic diatom zonation of Fenner (in press), as established for the low-latitude Atlantic and the Caribbean. Determination of other planktonic microfossil zones: Holes 366, 366A, 369A by Krashennikov and Pflaumann (1978), Cepek (1978), Johnson (1978), and Hole 149 by Hay and Beaudry (1973), Bukry (1973), and Riedel and Sanfilippo (1973). 1 = *T. bromia* and *P. goetheana* zones undifferentiated. Eocene/Oligocene boundary following Bukry (1978), who based it upon the LAD of *Discoaster barbadensis*.

(Fodor and Thiede, 1977; Barker et al., 1981; Tjalsma, in press); thus it might be due in part to an "island effect."

The preservation of diatoms is much better at Site 356 (Cores 6-9) than at Site 357 (Core 24; Table 2). The dominant and characteristic species at Site 356 (Fig. 3) are (1) cosmopolitan species such as *Asterolampra vulgaris*, *Brightwellia* spp., *Craspedodiscus oblongus*, *Hemiaulus polycystinorum* var. *mesolepta*, *Pyxilla reticulata*, and tri- and quadrilobate varieties of *Triceratium in conspicuum*; and (2) low-latitude species as *Clavularia barbadensis*, *H. alatus*, *H. altar*, *H. exiguus*, *H. polycystinorum* var. *dissona*, *P. caput-avis*, *P. gracilis*, *Skeletonema barbadense*, and *T. kanayae*. *H. grassus* and *H. gondolaformis* among the low-latitude stratigraphic marker species were not found. As both species are very robust and dissolution-resistant, their absence could either indicate that they were geographically restricted to the low latitudes or could be due to the greater age of the sediments. The composition of the diatom assem-

blages suggests that the first is the case. The succession of first and last occurrences of diatom species at Site 356 is the same as at Site 149 in the Caribbean, except for *C. barbadensis*, which seems to appear later at Site 356. Thus the planktonic diatom zonation established in the low-latitude Atlantic and Caribbean (Fenner, in press) applies at Site 356.

The first consistent occurrence of *Hemiaulus alatus* in Core 7 and the presence of *Pyxilla caput-avis*, common *Triceratium kanayae* var. *kanayae* and *T. kanayae* var. *quadrilobata* in Cores 8 and 9 place Core 7 to 9 in the *H. alatus* Zone and Cores 8-9 below in the *P. caput-avis* Zone. Because the low-latitude marker species *H. gondolaformis* is absent, Core 6 cannot be clearly placed into one of the low-latitude diatom zones. But the consistent presence of *Clavularia barbadensis* and the decrease in abundance of *T. kanayae* (both varieties) suggest that Core 6 has an age equivalent to that of the *H. gondolaformis* Zone of the low latitudes. The corre-

Table 2. Diatom species occurrence in Eocene and Oligocene samples from Site 357, Rio Grande Rise.

Planktonic diatom stratigraphy	Core-Section (level in cm)		Actinocyclus senarius	A. stella	Arachnoidiscus spp.	Asterolampra grevillei	A. marylandica	A. tela	A. vulgaris	Auliscus spp.	Biddulphia tridens	Brightwellia spp.	Bogorovia veniamini	Cestodiscus pulchellus	C. stokesianus	C. sp. 1 Fenner, 1982	Cladogramma conicum var. campanulatum	Coscinodiscus descrescens	C. extravagans	C. lewisianus	C. marginatus	C. payeri	C. rhombicus	C. symbolophorus	C. sp.	Craspedodiscus elegans	C. oblongus	Diploneis spp.	Endictya robustus						
	Planktonic diatom stratigraphy	Core-Section (level in cm)																																	
Planktonic diatom stratigraphy foraminiferal zones (Boersma, 1977) Calcareous nannoplankton zones (Perch-Nielsen, 1977)	R. gelida	N4	14 1 90.0																																
			14 2 90.0																																
			15 2 29.0	R	F																														
			15 2 119.0																																
			15 CC 0.0																																
	late Oligo.	P22	NP 25	16 1 90.0	R		P																												
				16 2 90.0																															
				17 1 78.0	P																														
				17 2 90.0																															
				17 3 88.0																															
		middle Eocene	P11	NP 15	17 4 88.0																														
					17 5 88.0																														
					17 6 96.0	F		P																											
					18 1 40.0	P																													
					24 4 54.0																														
middle Eocene	P11	NP 15	24 4 101.0																																
			24 5 8.0																																
			24 5 84.0	P																															
			24 5 104.0	R																															
			24 6 60.0	F																															

Note: The relative abundances are given as P = <0.1%, F = 0.1–1%, R = 1–10%, C = 10–30%, A = >30%. Core 357-19 to Section 357-24.4 was barren of diatoms as were Core 25 and below. In addition to the species listed, the following occurrences were noted: *Spermatogonia* spp., Sample 357-15, CC (P); *Macrora barbadiensis* (silicoflagellate), Samples 357-24-5, 8–9 cm (P), and 357-24-6, 60–61 cm (P); freshwater diatoms (*A. granulata*), Samples 357-16-1, 90–91 cm (F), 357-16-2, 90–91 cm (P), 357-17-6, 96–97 cm (P), and 357-18-1, 40–41 cm (P).

lation of the ranges of stratigraphically important diatom species and the planktonic diatom zones to the calcareous microfossil zones at this site is given in Figure 3.

At DSDP Site 357, further east on the western Rio Grande Rise, diatom preservation in the middle Eocene diatomaceous section is relatively poor and most of the low-latitude species such as *T. kanayae*, *Clavalaria barbadensis*, and *Skeletonema barbadense*, which are still present at DSDP Site 356, are not found. Only the very robust *P. caput-avis* is present. But as the also very robust *T. kanayae* is missing from the assemblage, the absence of these low-latitude species at this site during this interval is interpreted as being due to paleogeographic restriction (as Boersma [1977] reported also for the planktic foraminifers), rather than as being due to selective dissolution. Whether *H. alatus* is absent for stratigraphic or paleogeographic reasons cannot be decided. Further south, in the middle Eocene section of DSDP Site 512 on the Falkland Plateau (Gombos, 1983), all of the low-latitude species are definitely no longer present. Because most of the low-latitude marker species are absent, the occurrence of *P. caput-avis*, *Craspedodiscus oblongus*, and *T. inconspicuum* var. *inconspicuum* with *P. reticulata* allows us to place Core 24 of Site 357 into the middle Eocene only, with an age equivalent to some-

where within the *P. caput-avis*—*H. alatus*—*H. gondolaformis* low-latitude zones. This age determination is in agreement with the dating by calcareous nannofossils—upper part of Zone NP15 (*Discoaster bifax* Subzone) according to Perch-Nielsen (1977) and Bukry (1977)—and the planktonic foraminifers—Zone P11 (Boersma, 1977).

The second diatomaceous interval in the Paleogene of Site 357 (Cores 15–18) occurs in the upper Oligocene (Table 2, Fig. 4). The diatom assemblages are characterized by the frequent occurrence of *Synedra jouseana* and, in addition, *Asterolampra tela*, *Bogorovia veniamini*, *Coscinodiscus extravagans*, *C. lewisianus*, *C. rhombicus*, *Hemiaulus subacutus*, *Lisitzinia ornata*, *Rocella gelida*, *R. princeps*, *R. vigilans*, and *Rossiella symmetrica* species indicating a late Oligocene age. The first occurrence of *Rocella gelida* is used in the circum-Antarctic and in the low latitudes to define the base of the *R. gelida* Zone (Fenner, in press). The diatomaceous section does not extend beyond the earliest Oligocene, as is indicated by the presence of *Hemiaulus taurus* and *Rocella schraderi*. Neither species known to occur just above the Oligocene/Miocene boundary (e.g., *Rhaphoneis fossile* and *Rossiella paleacea*, typical in low-latitude sites; Fenner 1982) nor the cosmopolitan species



to be restricted to the low and middle latitudes (*Hemiaulus subacutus*) is present at this site. Other species, occurring at this site in the latest Oligocene, such as *H. taurus*, are typical high southern latitude species, thus making application of the circum-Antarctic planktonic diatom zonation more appropriate and reflecting an extension of "cool," high-latitude species toward the equator. A comparison with the Eocene diatom assemblages described from the Falkland Plateau (Gombos, 1976; Gombos and Ciesielski, 1983; Gombos, 1983; Fenner, in press) shows that on the Falkland Plateau in the middle Eocene (upper Lutetian; Gombos, 1983) the diatom assemblages were characterized by the absence of typical low-latitude species, and at least one indigenous circum-Antarctic species had already developed (*H. vitreus*). In the late Eocene and early Oligocene, the number of indigenous circum-Antarctic diatom species increases with the first appearances of *H. characteristicus*, *H. pacificus*, and *H. rectus* var. *twista*, which are common elements of the assemblages. But these species remained restricted to the circum-Antarctic region and were not found at the São Paulo Plateau or Rio Grande Rise. Typical high southern latitude species did not extend toward the equator before the latest Oligocene.

The good preservation of diatoms in the upper Oligocene sediments (Site 357) on the western Rio Grande Rise is correlated to increased sediment accumulation rates, from 5–7 m/m.y. in the diatom-barren sediments below to ~30 m/m.y. in the diatomaceous section (Perch-Nielsen et al., 1977). The calcium carbonate content of the sediment is constant at about 80% (Fenner, unpubl. data). In the diatomaceous interval traces of volcanic ash are found (Perch-Nielsen et al., 1977). Opal phytoliths, which are siliceous fillings of the epidermal cells of Gramineae and Equisetales, and thickly silicified valves of the freshwater diatom, *Aulacosira granulata*, occur consistently during this interval, whereas in the interval of increased preservation of siliceous skeletons during the middle Eocene no freshwater diatoms were found and only rare, single, opal phytoliths (Fenner, unpubl. data). The biosiliceous terrigenous components could be derived from nearby volcanic islands (for which there is no evidence in the late Oligocene) or from the South American hinterland. Their presence in marine sediments might be correlated to increased aridity and/or wind intensity around the time of the Oligocene/Miocene boundary. On the Sierra Leone Rise off Northwest Africa, an identical increase in the abundance of land-derived biosiliceous particles is observed (Fenner, 1982).

#### Equatorial Pacific Sites (Table 3)

In the equatorial Pacific sites, except for Site 167, preservation of diatoms in the Eocene is very poor because of dissolution and silica diagenesis, but in the early Oligocene it is moderate to good. This offers us the opportunity to study the paleogeographic distribution of the diatom species found to be characteristic of the low-latitude Atlantic Ocean (Fenner, 1982) and to test the planktonic diatom zonation established there (Fenner, in press).

At all sites, the same *Cestodiscus* spp.-dominated assemblage was found in the early Oligocene as is present in the equatorial Atlantic. Characteristic species were *C. gemmifer*, *C. convexus*, *C. reticulatus*, *C. trochus*, *C. parmula*, *Coscinodiscus excavatus*, *C. oligocenicus*. Furthermore, the late Eocene diatom assemblages found at Site 167 are characterized by the same species that dominated the low-latitude Atlantic diatom assemblages.

#### Site 64

This site on the Ontong-Java Plateau was spot-cored. Sample 64-10-1, 70–74 cm, at 847 m depth, has a typical early Oligocene diatom assemblage dominated by *Cestodiscus gemmifer* and *C. parmula*. Because the two stratigraphic guide species, *C. reticulatus* and *Coscinodiscus excavatus*, co-occur, this sample was assigned to the *Cestodiscus reticulatus* Zone. This age assignment is in accordance with the biostratigraphic results of Bukry (1971a), Martini and Worsley (1971), and Gartner (1971), who place Section 64-10-1 in Zone NP24 (*Helicosphaera reticulata* Zone). Deeper samples belong in the Eocene. Diatom preservation is poor.

#### Site 65 (Table 3)

This site in the central basin of the central equatorial Pacific was continuously cored. Thin chert layers and thin layers of turbidite sediments occur in the lower Oligocene and upper Eocene (Heath and Moberly, 1971a, b). The turbidites explain the presence of occasional well-preserved calcite tests, which must have originated above the contemporary calcite compensation depth. Throughout the sequence, reworked middle Eocene radiolaria are reported by Riedel and Sanfilippo (1971). However, reworking did not seem to be a major factor in the samples examined for this study. Only one evidently reworked *Hemiaulus* was found, in Sample 65-16-2, 82–86 cm. The presence of *Coscinodiscus excavatus* in Sample 65-14-1, 70–74 cm, together with the absence of *Cestodiscus reticulatus*, places this sample in the *C. excavatus* Zone, which is in accordance with the age determination by calcareous nannofossils (Bukry, 1971a) as *Helicosphaera reticulata* to *Discoaster barbadiensis* zones. The poor preservation of diatoms in samples from Cores 15 and 16, and from Hole 65.1 does not allow a more detailed age assignment than late Eocene, so that a test of the completeness of the upper Eocene section is impossible.

#### Site 69A

Planktonic diatoms place Sample 69A-8-1, 70–74 cm in the *Cestodiscus reticulatus* Zone, agreeing with the age given by calcareous nannofossils and planktonic foraminifers (*Helicopontosphaera reticulata* Zone or *Discoaster tani ornatus* Zone, respectively [Bukry, 1971b; Haq and Lipps, 1971] and Zone P20 to P18 [Beckmann, 1971]). There is a sharp change in lithology from the calcareous nannofossil ooze in Core 69A-8 to the radiolarian ooze below. Cores 69A-9 and 69A-10 are placed in the *Thyrsocyrtis bromia* Zone (Moore, 1971). The diatoms suggest an earliest Oligocene age in the *Coscinodiscus excavatus* Zone, because *Cestodiscus reticu-*

*latus* is absent and *Coscinodiscus excavatus* and *Thalassiosira bukryi* are present. There is no reason to believe that the occurrence of these species is due to downhole contamination, as was suggested for the radiolarians by Moore (1971). In Core 69A-11 only one species, *Riedelia pacifica*, was found. Radiolarians place this core in the middle Eocene *Thyrocyrtilis triacantha* Zone (Moore, 1971). Sample 69-6-1, 72-76 cm is also within the middle Eocene, based on the presence of *Hemiaulus polycystinorum* var. *asymmetrica* and *Odontella hastota*. Radiolarian stratigraphy assigns this sample to the middle Eocene *Podocyrtilis chalara* Zone (Moore, 1971). This suggests that the upper Eocene section is missing at this site.

#### Site 71A

The three spot cores studied at this site did not recover diatoms across the Eocene/Oligocene boundary. Core 71A-1 is assigned to the early Oligocene *Cestodiscus reticulatus* Zone, which is in agreement with the age determinations made on the basis of planktonic foraminifers (Zone P18-19), calcareous nannofossils, and radiolarians (*Thyrocyrtilis tuberosa* Zone) by Beckmann (1971), Haq and Lipps (1971), Bukry (1971b), Hay (1971), and Moore (1971). In Cores 71A-2 and 71A-3, which are probably of late Eocene age (*T. bromia* Zone; Moore, 1971), no diatoms were present.

#### Site 72

The lower Oligocene and upper Eocene were continuously cored, but the lower Oligocene section is incomplete and the Eocene section badly contaminated by younger material. Only one sample was examined from this site (Sample 72-9-1, 70-74 cm); it is placed in the earliest Oligocene.

#### DSDP Site 73 (Table 4)

At this continuously cored site, a short hiatus at the Eocene/Oligocene boundary is indicated by calcareous nannofossils (Bukry, 1971b). High abundances of down-mixed, well-preserved Neogene diatoms are seen in the uppermost section of each core. Eocene-Oligocene diatoms, by contrast, are poorly preserved and only the most dissolution-resistant species are present. The interval from Core 73-15 to Section 73-19-3 is assigned to the early Oligocene *Cestodiscus reticulatus* Zone based on the presence of *C. reticulatus*. *Coscinodiscus excavatus*, which is known from other equatorial sites to range below *Cestodiscus reticulatus*, is found only as far down as Section 73-18-5, although it is a very robust and also relatively dissolution-resistant species. There are two possibilities. *C. excavatus* may be absent from Core 73-19 because of dissolution. This point is supported by the high abundance of *Cestodiscus* spp. down to Section 73-19-3 that gives this section a typical early Oligocene character. Alternatively, the presence of *C. reticulatus* in Core 73-19 might be due to downhole contamination into a barely recognizable late Eocene assemblage. Such contamination is definitely evident in the presence of down-worked Neogene diatom species. Age determinations using planktonic foraminifers and calcareous nan-

nofossils (Bukry, 1971b; Haq and Lipps, 1971; Hay, 1971; Beckmann, 1971) place Core 73-19 in the late Eocene or later middle Eocene. Below Section 73-19-3, preservation of diatoms becomes very poor.

#### Site 77B

Diatom preservation in this continuously cored early Oligocene site is moderate to good, allowing determination of the *Cestodiscus reticulatus* and *Coscinodiscus excavatus* zones. The assemblages are dominated by species of the genus *Cestodiscus*. Diatoms are absent from Cores 52 and 53 (both Eocene).

#### Site 161A

The lithology changes from nannofossil chalk in the lower Oligocene (Cores 161A-2 to 161A-9) to radiolarian ooze in the upper and middle Eocene below. Cores 161A-2 to 161A-9 are assigned to the early Oligocene *Cestodiscus reticulatus* Zone because *C. reticulatus* co-occurs with *Coscinodiscus excavatus*. Preservation of diatoms is moderate. Below, in Cores 161A-10 to 161A-14 preservation of diatoms is extremely poor. The absence of the early Oligocene marker species and the presence of *Cestodiscus trochus* and *Kozloviella meniscosa* suggest a late Eocene age for Cores 161A-10 and 161A-11.

#### Site 163

The early Oligocene and Eocene at this site is almost barren of calcareous microfossils. The clayey diatomaceous ooze of Sample 163-4-1, 70-74 cm is placed in the *Cestodiscus reticulatus* Zone, which is in agreement with the age determination using radiolarians (*Thyrocyrtilis tuberosa* Zone, Dinkelman, 1973). In the Eocene radiolarian ooze below, thin chert layers are found and preservation of diatoms is poor. The assemblages are dominated by *Riedelia pacifica* and *Coscinodiscus marginatus*.

#### Site 167 (Fig. 5)

At this site on the Magellan Rise, the zonations of the planktonic calcareous microfossils (Douglas, 1973; Roth, 1973) show no hiatus at the Eocene/Oligocene boundary. Although diatom valves show definite dissolution, their preservation is moderate—enough to apply the planktonic diatom zonation of Fenner (in press). The Eocene/Oligocene boundary is not associated with a strong change in preservation. At this site the sequence of first appearances just below and just above the Eocene/Oligocene boundary is the same as in DSDP Site 366, in the equatorial Atlantic (Fenner, 1982). *Thalassiosira bukryi* appears first, followed by *Coscinodiscus excavatus* and then *Cestodiscus reticulatus*, placing the Eocene/Oligocene boundary between Samples 167-24-1, 48-53 cm and 167-25, CC. Large specimens of *C. pulchellus* var. *novaezealandica* are common during the interval of transition from the Eocene to the Oligocene. *Kozloviella subrotunda*, *Asterolampra punctifera*, *Coscinodiscus descrescens*, and *Hemiaulus polycystinorum* var. *mesolepta* last occur below the Eocene/Oligocene boundary. The decrease in abundance of valves of *Hemiaulus* spp.

Table 3. Diatom species occurrences in Eocene and Oligocene samples from DSDP sites in the central equatorial Pacific and Ontong-Java Plateau.

Age	Plankt. diatom stratigraphy	Core-Section (level in cm)				Actinocyclus octonarius	Actinocyclus intermedius	A. senarius	Arachnoidiscus sp.	Asterolampira affinis var. cellulosa	A. crenata	A. grevillei	A. aff. grevillei	A. marylandica	A. punctifera	A. tela	A. uraster	A. vulgaris	Asteromphaleus oligocenicus	Aulacodiscus spp.	Baxteriopsis brunii	Cestodiscus convexus	C. gemmifer	C. parvula	C. pulchellus	C. pulchellus var. novaezealandica	C. reticulatus	C. stokiesianus	C. trochus	C. sp. + C. sp. 3	Chaetoceros sp. (bristles)	C. sp. 3 Fenner, 1982	Coscinodiscus argus	C. asteromphalus	Thalassiosira bukryi	C. demergitus	C. descrescens	C. elegantulus	C. excavatus	C. grossheimii	C. marginatus	C. obscurus	C. oligocenicus	C. radiatus	C. sellatus	C. senarius var. parvula	C. hajosiae	C. symbolophorus	C. symbolophorus group	C. tuberculatus	C. vigilans		
e. Olig.	C. ret.	64	10	1	70.0																																																
Eoc.	Eoc.	64A	9	1	70.0					P	R								F			F	C	C																													
		64A	10	1	64.0																																																
Olig.	I. Olig.	65	13	1	68.0																	R		F																													
	C. exc.	65	14	1	70.0																	R		C																													
Eocene	Eoc.	65	15	1	108.0																P						F																										
	I. Eoc.	65	16	2	82.0																																																
	Eoc.	65A	4	1	66.0																																																
	Eoc.	65A	5	1	58.0																P																																
	m.Eoc.	69	6	1	72.0																																																
	C. ret.	69A	8	1	70.0					P																																											
e. Olig.	C. exc.	69A	9	1	70.0						R	F																																									
		69A	10	1	70.0																	P																															
	Eoc.	?	69A	11	1	70.0																P																															
e. Olig.	C. ret.	71A	1	1	62.0					P																																											
e. Olig.		72	9	1	70.0																																																
early Oligocene	C. reticulatus	77B	46	1	32.0					P																																											
		77B	46	2	32.0																																																
		77B	46	3	32.0																																																
		77B	46	4	32.0																																																
		77B	46	5	32.0																																																
		77B	46	6	32.0																																																
		77B	47	1	32.0																																																
		77B	47	2	32.0																																																
		77B	47	3	28.0																																																
		77B	47	4	26.0																																																
		77B	48	1	28.0																																																
		77B	48	2	28.0																																																
		77B	48	3	36.0																																																
		77B	48	4	28.0																																																
		77B	48	5	28.0																																																

is not so drastic as at Site 366, but the increase in valves of *Cestodiscus* spp. is as dramatic. Samples 167-25, CC to 167-27, CC are placed in the late Eocene *Baxteriopsis brunii* Zone, using the first appearance of *B. brunii*. Samples 167-28-1, 59-63 cm to 167-32-2, 59-63 cm belong in the *A. marylandica* Zone.

In Cores 33-to 35, chert is common and no diatoms are preserved.

#### Site 289 (Fig. 6)

At this site on the Ontong-Java Plateau, the preservation of the diatom valves is moderate to poor throughout the lower Oligocene and upper Eocene. Only in Core 106 (just above the chert) does preservation become very poor. The first occurrences of *Coscinodiscus excavatus* and *Cestodiscus reticulatus* place the Eocene/Oligocene boundary between Cores 101 and 102. The change in assemblage composition to an assemblage dominated by *Cestodiscus* spp. occurs slightly below, between Cores 102 and 103. The late Eocene preservation of diatoms is

poor. The identification of the planktonic diatom zones therefore has to be viewed with caution. The calcareous nannofossil indicate a short hiatus at the Eocene/Oligocene boundary (Shafik, 1975).

#### Site 292

At this site on the Benham Rise, a small hiatus at the Eocene/Oligocene boundary is indicated by calcareous nannofossils (Ellis, 1975). The preservation of diatom valves at this site is poor, with an interval of especially intense biogenic silica dissolution during the earliest Oligocene (Cores 33-35) that reaches its maximum in Sample 292-33-1, 10-14 cm, which is completely barren of diatoms. In the late Eocene, *Grammatophora* spp. are common in the diatom assemblages, indicating a shallow-water environment. The last occurrence of *Incertae Sedis*: Genus et species indet. (3) correlates with the nannofossil-determined Eocene/Oligocene boundary. Samples from Core 39, Section 2 are barren of diatoms.





















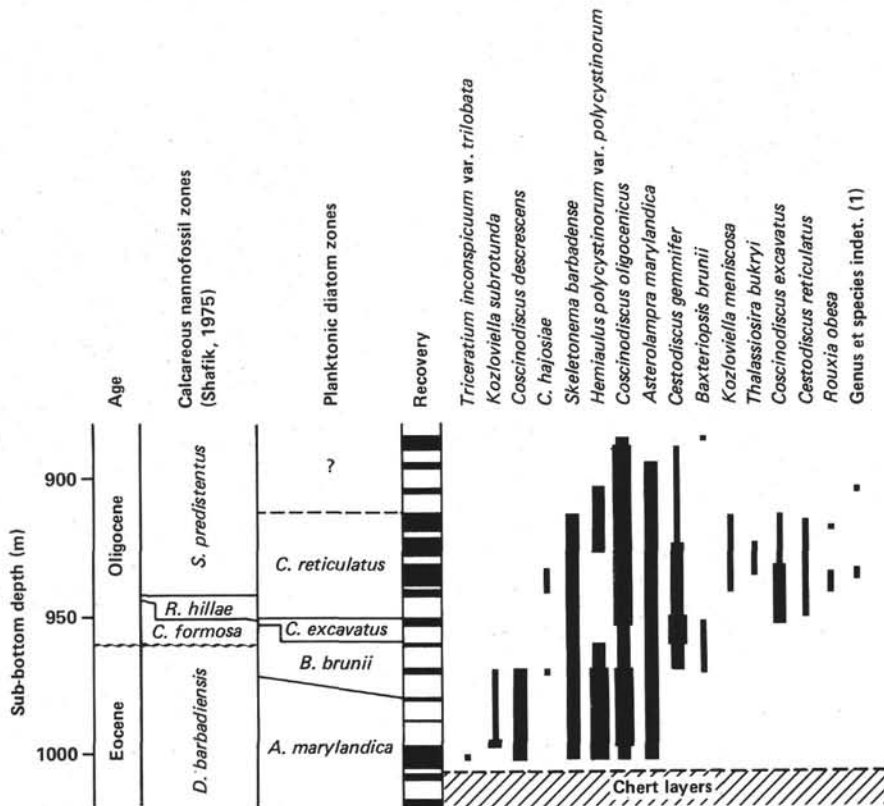


Figure 6. Ranges of stratigraphically important diatom species in late Eocene to early Oligocene cores of DSDP Site 289, Ontong-Java Plateau. Relative abundance as in Figure 3.

**Remarks.** Greville (1866) gave an accurate description of this species, but later misuse of the species name led to confusion. For a detailed description see Fenner, 1982, p. 86, pl. 15, figs. 1-4. Here the paratypes from slides of Greville's collection are illustrated.

*Cestodiscus pulchellus* Greville var. *novaezealandica* Grove, 1890, in A. Schmidt et al., 1874—. Synonyms: *Coscinodiscus novaezealandicus* Hanna, 1932, pp. 182-183, pl. 9, fig. 3; *Cestodiscus spinifer* Grove and Sturt sensu Fenner, 1982, p. 88, pl. 15, fig. 5. A. Schmidt et al. (1874—), pl. 148, fig. 7; pl. 163, figs. 8, 10?; Fenner, 1982, p. 87, pl. 12, figs. 5-7.

**Remarks.** Very large specimens with valve face slightly concentrically undulated are common around the Eocene/Oligocene boundary. *Cestodiscus reticulatus* Fenner, in press. Synonym: *Coscinodiscus superbus* Hardmann sensu Fenner, 1977, p. 516, pl. 14, figs. 2-3, not figs. 1, 4. Fenner, 1982, p. 87, pl. 14, figs. 1-2.

*Cestodiscus stokesianus* Greville, 1866. (Plate 1, Figs. 6-8.) Greville, 1866, p. 123, pl. 11, fig. 4; Fenner, 1982, p. 88, pl. 14, figs. 7-8.

**Description.** The valve outline is circular. The valve face is convex and densely areolated, with the areolae decreasing in size from the center (11 areolae in 10  $\mu$ m) to the margin (~20 areolae in 10  $\mu$ m). The areolae are arranged in 4-6 sectors, within which rows of areolae run parallel to the longest row of areolae in the fascicle, which is the middle row of each fascicle. The fascicles are separated from each other by a long radial row of areolae running from the centre of the valve face to the margin, where they end in a labiate process.

**Stratigraphic occurrence.** This species is found from the late Eocene to the middle Miocene.

*Cestodiscus trochus* Castracane, 1886. (Plate 1, Fig. 3-4.) Synonym: *Cestodiscus mukhinae* Jousé, 1973, pp. 344-345, pl. 1, figs. 1-5. Castracane, 1886, p. 123, pl. 7, figs. 1, 3; Fenner, 1982, p. 88, pl. 14, fig. 5.

*Cestodiscus* sp. 1 Fenner, 1982. Synonym: *Cestodiscus* aff. *pulchellus* Jousé, 1973, pl. 1, figs. 9-10, not fig. 11. Fenner, 1982, p. 88, pl. 14, fig. 6.

*Cestodiscus* sp. 3 Fenner, 1982. Fenner, 1982, p. 89, pl. 11, figs. 3-5.

#### Genus *CHAETOCEROS* Ehrenberg, 1844

*Chaetoceros* sp. (1) Fenner, 1982. Fenner, 1982, p. 89, pl. 32, figs. 15-16.

*Chaetoceros* sp. (3) Fenner, 1982. Fenner, 1982, p. 89, pl. 32, fig. 18.

*Chaetoceros* bristles.

**Remarks.** Under this category undifferentiated types of *Chaetoceros* bristles are listed.

#### Genus *CLADOGRAMMA* Ehrenberg, 1854

*Cladogramma conicum* Greville var. *campanulatum* Forti, in Tempère and Peragallo, 1907-1915. Forti, 1913, p. 1563, pl. 3, figs. 2, 4, 7.

#### Genus *CLAVULARIA* Greville, 1865

*Clavularia barbadensis* Greville, 1865. Synonyms: *Clavularia catenata* Brun, 1896, p. 236, pl. 20, figs. 12-13; *Cymatosira* sp. 1 Fenner, 1977, p. 518, pl. 32, figs. 2-5. Greville, 1865a, p. 24, pl. 3, figs. 1-3; Fenner, 1982, p. 90, pl. 28, figs. 9-12.

#### Genus *COCCONEIS* Ehrenberg, 1838

*Cocconeis* spp.

#### Genus *COSCINODISCUS* Ehrenberg, 1838

*Coscinodiscus argus* Ehrenberg, 1838. Hustedt, 1930, pp. 422-424, fig. 226.

*Coscinodiscus asteromphalus* Ehrenberg, 1844. Hustedt, 1930, pp. 452-454, fig. 250.

*Coscinodiscus demergitus* Fenner, 1977. Fenner, 1977, p. 514, pl. 4, Figs. 1-3; Fenner, 1982, p. 92.

*Coscinodiscus descrescens* Grunow, 1878, in A. Schmidt et al., 1874—. A. Schmidt et al. (1874—), pl. 61, figs. 7-9; Fenner, 1982, p. 92, pl. 9, fig. 7.

*Coscinodiscus elegantulus* Greville, 1861. Greville, 1861a, p. 42, pl. 4, fig. 8; Fenner, 1982, p. 92, pl. 9, fig. 4.



*Coscinodiscus excavatus* Greville, 1861. Synonym: *Coscinodiscus diophthalmus* Castracane, 1886, p. 163, pl. 16, fig. 4. Greville ms., Ralfs in Pritchard, 1861, p. 829, pl. 8, fig. 26; Grunow, 1884, p. 73; Fenner, 1982, p. 93.

*Coscinodiscus extravagans* A. Schmidt, 1878, in A. Schmidt et al., 1874—. Synonym: *Tripodiscus beringensis* Mann, 1907, p. 278, pl. 50, fig. 6. A. Schmidt et al., 1874—, pl. 58, fig. 33; Fenner, 1982, p. 93, pl. 16, fig. 6.

*Coscinodiscus grossheimii* Gleser, in Sheshukova-Poretzkaya and Gleser, 1962. Sheshukova-Poretzkaya and Gleser, 1962, p. 178, pl. 1, figs. 5a-b.

*Coscinodiscus hajosiae* Fenner, in press. Synonyms: *Podosira* aff. *maxima* Dzinoridze et al., 1978, pl. 4, figs. 6-7; *Hyalodiscus ambiguus* Grunow sensu Paramonora, 1964, pl. 2, fig. 2; *Coscinodiscus spiralis* Karsten, 1905, p. 81, pl. 5, figs. 5a-b. Fenner, in press, pl. 2, fig. 1; Fenner, 1982, p. 96, pl. 8, fig. 3.

*Coscinodiscus lewisianus* Greville, 1866. Greville, 1866b, p. 78, pl. 8, figs. 8-10.

*Coscinodiscus marginatus* Ehrenberg, 1841. Hustedt, 1930, p. 416, fig. 223.

*Coscinodiscus nodulifer* A. Schmidt, 1878, in A. Schmidt et al., 1874—. Hustedt, 1930, pp. 426-427, fig. 229.

*Coscinodiscus obscurus* A. Schmidt, 1878, in A. Schmidt et al., 1874—. A. Schmidt et al., 1874—, pl. 61, figs. 16-17.

*Coscinodiscus oligocenicus* Jousé, 1973. Jousé, 1973, p. 348, pl. 1, figs. 6-8, 16; Fenner, 1977, pp. 515-516, pl. 4, figs. 5-10; Fenner, 1982, p. 95, pl. 9, fig. 8.

*Coscinodiscus payeri* Grunow, 1884. Grunow, 1884, p. 80, pl. 3(C), figs. 12-13.

*Coscinodiscus radiatus* Ehrenberg, 1839. Hustedt, 1930, pp. 420-421, fig. 225.

*Coscinodiscus rhombicus* Castracane, 1886. Synonyms: *Coscinodiscus lanceolatus* Castracane, 1886, p. 164, pl. 17, fig. 19; *Coscinodiscus? naviculoides* Truan y Luard and Witt, 1888, p. 14, pl. 2, fig. 10; *Coscinodiscus punctatus* Ehrenberg var. *rhombica* Rat-tray, 1889, p. 547. Castracane, 1886, p. 164, pl. 22, fig. 11.

*Coscinodiscus sellatus* Jousé, 1973. Jousé, 1973, pp. 348-349, pl. 2, figs. 2-4.

**Remarks.** Although I consider this "species" to be a variety of *C. excavatus*, it was treated separately to investigate possible differences in its stratigraphic range.

*Coscinodiscus senarius* var. *parvula* A. Schmidt, in Tempère and Peragallo, 1912. Synonym: *Coscinodiscus senarius* A. Schmidt sensu Dzinoridze et al., 1976, pp. 42-43, figs. 57-61. Tempère and Peragallo, 1912, p. 344, no. 701-726; Fenner, 1982, p. 96, pl. 5, fig. 3.

*Coscinodiscus symbolophorus* Group. Fenner, 1982, p. 96, pl. 4, fig. 2.

*Coscinodiscus tabularis* Grunow, 1884. Synonyms: *Coscinodiscus endoi* Kanaya, 1959, pp. 76-77, pl. 3, figs. 8-11; *Coscinodiscus nodulifer* sensu McCollum, 1975, p. 527, pl. 5, figs. 7-8. Hustedt, 1958, pp. 119-120, figs. 48-56; Fenner et al., 1976, p. 774, pl. 7, figs. 10-13; Fenner, 1977, p. 516.

*Coscinodiscus tuberculatus* Greville, 1861. Greville, 1861a, p. 42, pl. 4, fig. 6; Fenner, 1982, p. 96, pl. 9, figs. 1-3.

*Coscinodiscus vigilans* A. Schmidt, 1888, in A. Schmidt et al., 1874—. A. Schmidt et al., 1874—, pl. 114, fig. 11.

#### Genus CRASPEDODISCUS Ehrenberg, 1844

*Craspedodiscus elegans* Ehrenberg, 1844. Synonym: *Craspedodiscus coscinodiscus* Ehrenberg, 1844, p. 266. Ehrenberg, 1844, p. 266, fig. 12; Fenner, 1982, p. 97.

*Craspedodiscus oblongus* (Greville) A. Schmidt, 1886, in A. Schmidt et al., 1874—. Synonym: *Porodiscus oblongatus* Greville, 1863b, p. 65, pl. 4, fig. 5. Greville, 1866a, p. 4, pl. 1, figs. 9-10.

#### Genus CYMATOSIRA Grunow, 1862

*Cymatosira* aff. *cornuta* Schrader and Fenner, 1976. Schrader and Fenner, 1976, p. 976, pl. 8, fig. 6; pl. 22, fig. 14; Fenner, 1982, p. 99, pl. 31, fig. 8.

#### Genus DENTICULOPSIS Simonsen, 1979

*Denticulopsis hustedtii* (Simonsen and Kanaya) Simonsen, 1979. Synonym: *Denticula hustedtii* Simonsen and Kanaya, 1961, p. 501, pl.

1, figs. 19-25; pl. 2, figs. 36-47. Simonsen and Kanaya, 1961, p. 501, pl. 1, figs. 19-25; pl. 2, figs. 36-47.

#### Genus DIPLONEIS Ehrenberg, 1840

*Diploneis* spp.

**Remarks.** Species of this genus are of shallow-water origin.

#### Genus ENDICTYA Ehrenberg, 1845

*Endictya robustus* (Greville) Hanna and Grant, 1926. Hanna and Grant, 1926, p. 144, pl. 16, figs. 2-3.

#### Genus ETHMODISCUS Castracane, 1886

*Ethmodiscus* spp.

**Remarks.** Only fragments of specimens interpreted as belonging to the genus *Ethmodiscus* have been found.

#### Genus et species indet. 1. (Plate 2, Fig. 8.)

**Description.** The valve outline is quadrangular, with robust horns at each corner. The valve length is 50-55  $\mu$ m. One horn is always thinner and generally broken, the other three are of equal width (8-10  $\mu$ m) from base to top and end in a stout, triangular spine. Thin marginal ridges run along the valve margin and connect the horns. The valve face, mantle, and horns are equally coarsely areolated (4-5 areolae in 10  $\mu$ m).

**Stratigraphic occurrence.** This species is found in the middle Oligocene (*S. distentus* Zone) of Sites 292 and 289.

#### Genus et species indet. 2. (Plate 2, Fig. 5.)

**Description.** The valve outline is circular. The central part of the valve face is depressed and sharply offset from the outer part of the valve face by a ridge. The areolae are arranged in radial rows. Between the areolae on the outer and inner part of the valve face small nodules are common. The areolation of the inner part is finer (5 areolae in 10  $\mu$ m) than on the outer part of the valve face (2-3 areolae in 10  $\mu$ m).

**Stratigraphic occurrence.** This species was found in the middle Eocene of Site 220.

#### Genus GRAMMATOPHORA Ehrenberg, 1839

*Grammatophora* spp.

**Remarks.** Intercalary bands belonging to species of this genus were found sporadically. These intercalary bands are especially dissolution-resistant.

#### Genus HEMIAULUS Ehrenberg, 1844

*Hemiaulus affinis* Grunow, in Van Heurck, 1883. Van Heurck, 1883, pl. 106, figs. 10-11.

*Hemiaulus alatus* Greville, 1865. Greville, 1865b, p. 31, pl. 3, fig. 14; Fenner, 1977, p. 529, pl. 26, figs. 1-2.

*Hemiaulus altar* Brun, 1896. Brun, 1896, p. 238, pl. 20, fig. 19-20.

**Remarks.** In cores with poor preservation, so that only broken arms but no complete valves could be found, differentiation between *H. altar* and *H. longicornis* was not possible.

*Hemiaulus barbadiensis* Grunow, 1884. Grunow, 1884, p. 63; Fenner, 1982, p. 103, pl. 23, fig. 4.

*Hemiaulus capitatus* Greville, 1865. Greville, 1865, p. 54, pl. 6, fig. 24.

*Hemiaulus dubius* Grunow, 1884. Synonym: *Hemiaulus biharensis* Pantocsek, 1892, p. 57, pl. 38, figs. 528-529. Grunow, 1884, p. 61, pl. 5 (E), fig. 54; Fenner, 1982, pp. 103, 104, pl. 26, figs. 1-5.

*Hemiaulus exiguus* Greville, 1865. Greville, 1865a, p. 29, pl. 4, fig. 20.

*Hemiaulus incisus?* Hajós, 1976. Hajós, 1976, p. 829, pl. 23, figs. 4-9.

**Remarks.** Only fragments—parts of horns—were found. Thus the assignments of these fragments to this species stands on very weak grounds.

*Hemiaulus kljushnikovii* Gleser, in Sheshukova-Poretzkaya and Gleser, 1964. Sheshukova-Poretzkaya and Gleser, 1964, p. 87, pl. 3, fig. 8; Fenner, 1977, p. 521, pl. 25, figs. 12, 14-15.

*Hemiaulus longicornis* Greville, 1865. Synonym: *Riedelia longicornis* (Greville) Schrader and Fenner, 1976, p. 997. Greville, 1865a, p. 31, pl. 3, fig. 13.

*Hemiaulus* aff. *longicornis* Greville, 1865

**Remarks.** This species differs from *H. longicornis* by its smaller size, relatively wider horns, and less dense areolation. It is found in the lower Eocene and lower middle Eocene at Sites 149 and 220.

- Hemiaulus lyriformis* Greville, 1865. Synonym: *Riedelia lyriformis* (Greville) Schrader and Fenner, 1976, p. 997. Greville, 1865a, p. 30, pl. 3, fig. 11.
- Hemiaulus polycystinorum* Ehrenberg var. *polycystinorum* Grunow, 1884. Grunow, 1884, p. 65; Cleve-Euler, 1951, p. 125; A. Schmidt et al., 1874—, pl. 143, figs. 24?, 28; Fenner, 1982, p. 106, pl. 20, figs. 2-5.
- Hemiaulus polycystinorum* Ehrenberg var. *dissona* Fenner, 1977. Fenner, 1977, p. 521, pl. 22, figs. 14-16.
- Hemiaulus polycystinorum* Ehrenberg var. *mesolepta* Grunow, 1884. Grunow, 1884, p. 65, pl. 2 (B), fig. 43.
- Hemiaulus subacutus* Grunow, 1884. Grunow, 1884, p. 61, pl. 5 (E), fig. 55; Fenner, 1982, p. 107, pl. 18, figs. 2-10.
- Hemiaulus taurus* Gombos, in Gombos and Ciesielski, 1983. Gombos and Ciesielski, 1983, pl. 19, figs. 1-8.
- Hemiaulus* sp. 5 Fenner, 1982. Fenner, 1982, p. 108, pl. 23, fig. 5.

#### Genus *HEMIDISCUS* Wallich, 1860

- Hemidiscus cuneiformis* Wallich, 1860. Hustedt, 1930, p. 904, fig. 542; Fenner, 1977, p. 523, pl. 1, fig. 1.

#### Genus *HYALODISCUS* Ehrenberg, 1845

##### *Hyalodiscus* spp.

Remarks. Specimens belonging in this genus were found extremely rarely, and there was no attempt to determine the species.

#### Genus *KOZLOVIELLA* Jousé, 1973

- Kozloviella meniscosa* Fenner, 1982. Fenner, 1982, p. 112, pl. 17, figs. 3-4.
- Kozloviella subrotunda* Fenner, in press. Fenner, 1982, pp. 112-113, pl. 17, figs. 1-2.

*Liostephania* stage of *Asterolampra* spp. Hanna and Brigger, 1970, pp. 89-100.

#### Genus *LISITZINIA* Jousé, 1978

- Lisitzinia ornata* Jousé, 1978. Synonym: *Triceratium* aff. *zonulatum* (Greville), Sheshukova-Poretzkaya et al., 1967, pl. 37, fig. 2; *Triceratium cruciforme* (A.S.) sensu Schrader and Fenner, 1976, p. 1002, pl. 27, fig. 2. Jouse, 1978, pp. 47-48, pl. 10, figs. 1-6.

#### Genus *MELOSIRA* Agardh, 1824

- Melosira architecturalis* Brun, 1892. Synonym: *Cyclotella hanna* Kanyaya, 1957, pp. 82-84, pl. 3, figs. 10-14. Brun, in Schmidt et al., 1874—, pl. 177, fig. 45-50.

#### Genus *NAVICULA* Bory, 1822

##### *Navicula* spp.

Remarks. No species were determined for the single specimens belonging to this genus.

#### Genus *NITZSCHIA* Hassall, 1845

- Nitzschia jouseae* Burckle, 1972. Burckle, 1972, p. 240, pl. 2, figs. 17-21.
- Nitzschia marina* Grunow, in Cleve and Grunow, 1880. Cleve and Grunow, 1880, p. 70.
- Nitzschia porteri* Frenguelli, 1949. Frenguelli, 1949, p. 116, pl. 1, figs. 33-34.

#### Genus *ODONTELLA* Agardh, 1832

- Odontella hastata* (Greville) Fenner, 1982. Greville, 1865a, p. 31, pl. 3, fig. 15; Fenner, 1982, p. 115, pl. 23, figs. 6-7.

#### Genus *PARALLA* Heiberg, 1863

- Paralla sulcata* (Ehrenberg) Cleve, 1873. Synonym: *Melosira sulcata* (Ehrenberg) Kützing, 1844, p. 55. Hustedt, 1930, pp. 276-278, figs. 118-120.

#### Genus *PSEUDOEUNOTIA* Grunow, in Van Heurck, 1880

- Pseudoeunotia doliolus* (Wallich) Grunow, in Van Heurck, 1880. Hustedt, 1959, pp. 258-260, fig. 737.

#### Genus *PSEUDOPODOSIRA* Jousé, in Proshkina-Lavrenko, 1949

##### *Pseudopodosira* spp.

Remarks. No determination to the species level was possible in the few, poorly preserved specimens found.

#### Genus *PYXILLA* Greville, 1865

- Pyxilla caput-avis* Brun, 1896. Brun, 1896, p. 242, pl. 19, fig. 11.
- Pyxilla gracilis* Tempère and Forti, in Forti, 1909. Synonym: *Pyrgopyxis gracilis* (Tempère and Forti) Hendey, 1969, p. 5. Forti, 1909, p. 26, pl. 2, fig. 5.
- Pyxilla reticulata* Grove and Sturt, 1887. Synonyms: *Pyxilla gracilis* var. *saratoviana* Tempère and Forti, in Forti, 1909, pl. 2, figs. 7-8; not *Hemiaulus ?saratovianus* Pantocsek, 1889, pl. 13, fig. 235; *Pyxilla johnsoniana* Forti, 1909, pl. 2, fig. 2; not *P. johnsoniana* Greville, 1865a, p. 2, pl. 1, fig. 6; *P. johnsoniana* Greville var. *corniculatum* Brun, 1893-1896, p. 243, pl. 19, figs. 12-13; *P. prolongata* Brun, 1893, p. 176, pl. 24, fig. 7; *Pyrgopyxis prolongata* (Brun) Hendey, 1969, p. 5. Fenner, 1982, p. 119.

#### Genus *RHAPHONEIS* Ehrenberg, 1844

- Rhaphoneis ampiceros* Ehrenberg, 1844. Andrews, 1975, pp. 204-205, pl. 1, figs. 9-12.

#### Genus *RHIZOLENIA* Ehrenberg, 1841

- Rhizolenia hebetata* Group. Grunow, 1884, p. 44, 96, pl. 5, figs. 48-50.
- Rhizolenia interposita* Hajós, 1976. Synonym: *Rhizolenia praebarboi* Schrader sensu Schrader and Fenner, 1976, p. 997, pl. 7, fig. 10, not pl. 5, fig. 16. Hajós, 1976, p. 827, pl. 21, fig. 8.
- Rhizolenia prokovskajae* (Jousé) Strelnikova, 1974. Strelnikova, 1974, p. 80, pl. 28, figs. 1-9.
- Rhizolenia praebergonii* Muchina var. *robusta* Burckle and Trainer, 1979. Burckle and Trainer, 1979, Appendix, pl. 1, figs. 1-7.
- Rhizolenia* sp. 1 Fenner, 1982. Fenner, 1982, p. 122, pl. 3, figs. 10-12.

#### Genus *RIEDELIA* Jousé and Sheshukova-Poretzkaya, 1971

- Riedelia pacifica* Jousé, in Jousé and Sheshukova-Poretzkaya, 1971. Jousé and Sheshukova-Poretzkaya, 1971, p. 22, pl. 2, figs. 3-4; Gleser and Jousé, 1974, p. 60, pl. 3, fig. 11.

#### Genus *ROCELLA* Hanna, 1930

- Rocella gelida* (Mann) Bukry, 1978. Synonyms: *Stictodiscus gelidus* Mann, 1907, p. 268, pl. 50, fig. 5; *Rocella gemma* Hanna, 1930, in part, p. 415, pl. 40, figs. 1-2, 4-9. Bukry, 1978, p. 788, pl. 5, figs. 1-13.
- Rocella princeps* (Jousé) Fenner, 1982. Jousé, 1973, p. 350, pl. 3, figs. 8-12; Fenner, 1982, p. 123.
- Rocella schraderi* Bukry, 1978. Bukry, 1978, p. 788, pl. 6; figs. 1-10; pl. 7, fig. 1.
- Rocella vigilans* Fenner, in press. Fenner, 1982, p. 123, pl. 4, figs. 6-7; pl. 6, fig. 8.

#### Genus *ROSSIELLA* Desikachary and Maheshwari, 1958

- Rossiella paleacea* (Grunow) Desikachary and Maheshwari, 1958. Synonyms: *Stoschia*(?) *paleacea* Grunow, in Van Heurck, 1883, pl. 128, fig. 6; *Coscinodiscus paleaceus* (Grunow) Rattray, 1889, p. 597; *Cussia paleacea* (Grunow) Schrader, 1974, p. 543, pl. 1, figs. 11-14. Desikachary and Maheshwari, 1958, p. 28, fig. 1; Fenner, 1982, p. 124, pl. 31, figs. 1-2.
- Rossiella symmetrica* Fenner, in press. Synonyms: *Bogorovia veniamini* Jousé sensu Gombos, 1976, p. 593, pl. 1, figs. 6-7, pl. 12, figs. 1, 2, 4; *Rossiella* sp. Gombos and Ciesielski, 1983, pl. 24, figs. 1-2. Fenner, in press, pl. 1, figs. 2-4; Fenner, 1982, p. 124, pl. 31, figs. 3-7 (as *Rossiella* sp. A Gombos (in prep.)).

#### Genus *ROUXIA* Brun and Héribaud, in Héribaud, 1893

- Rouxia hanna* Jousé, 1973. Jousé, 1973, pp. 349-350, pl. 2, fig. 13.
- Rouxia obesa* Schrader, in Schrader and Fenner, 1976. Schrader and Fenner, 1976, p. 997, pl. 24, figs. 5-6.

Genus *RUTILARIA* Greville, 1863

*Rutilaria* sp. (Plate 2, Fig. 6.)

**Remarks.** Only the specimen illustrated on Plate 2 was found. More observations are necessary to decide whether its asymmetrical shape is an abnormality or of taxonomic value.

Genus *SCEPTRONEIS* Ehrenberg, 1844

*Sceptroneis pesplanus* Fenner and Schrader, in Schrader and Fenner, 1976. Schrader and Fenner, 1976, p. 998, pl. 22, figs. 30-31, pl. 25, figs. 10-11.

*Sceptroneis pupa* Schrader and Fenner, 1976. Schrader and Fenner, 1976, p. 999, pl. 22, figs. 17-21, pl. 24, figs. 11-13.

Genus *SKELETONEMA* Greville, 1865

*Skeletonema barbadense* Greville, 1865. Greville, 1865c, p. 43, pl. 5, fig. 1.

*Skeletonema utriculosum* Brun, 1891. Brun, 1891, p. 44, pl. 11, fig. 1a-b.

Genus *STEPHANOPYXIS* Ehrenberg, 1844

*Stephanopyxis aculeata* (Ehrenberg) Grunow var. Fenner, 1982, p. 128, pl. 1, figs. 1-4.

*Stephanopyxis grunowii* Grove and Sturt, 1888, in A. Schmidt et al. 1874—. A. Schmidt et al., 1974—, pl. 130, figs. 1-6.

*Stephanopyxis minuta* Greville, 1865. Synonyms: *Creswellia minuta* Greville, 1865a, p. 4, pl. 1, fig. 13, not *Stephanopyxis minuta* (Grunow) A. Cleve, in Cleve-Euler, 1941, pl. 1, fig. 12f. Greville, 1865a, p. 4, pl. 1, fig. 13.

*Stephanopyxis superba* (Greville) Grunow, 1884. Greville, 1861d, p. 68, pl. 8, figs. 3-5.

*Stephanopyxis turris* (Greville and Arnott) Ralfs, in Pritchard, 1861. Hustedt, 1930, p. 304, fig. 140; Grunow, 1884, p. 87.

*Stephanopyxis turris* (Greville and Arnott) Ralfs, in Pritchard var. *cylindrus* Grunow, 1884. Grunow, 1884, p. 87, pl. 5(E), fig. 7-14.

Genus *STICTODISCUS* Greville, 1861

*Stictodiscus* spp.

**Remarks.** Single specimens belonging to this genus were found only very sporadically, and species-level determinations were not attempted. Species of this genus seem to be predominantly restricted to the littoral zone.

Genus *SYNEDRA* Ehrenberg, 1830

*Synedra jouseana* Sheshukova-Poretzkaya, 1962. Sheshukova-Poretzkaya, 1962, p. 208, fig. 4; Schrader, 1973, p. 710, pl. 23, figs. 21-23, 25, 38.

*Synedra* aff. *miocenica* Schrader, 1976. Schrader, 1976, p. 94, pl. 1, fig. 1.

**Remarks.** This species differs from the species described by Schrader (1976) in that it does not have the narrowed ends. In the shorter specimens the sides are not parallel, but the valve outline is narrowly elliptical.

Genus *THALASSIONEMA* Grunow, in Van Heurck, 1881

*Thalassionema nitzschioides* Grunow, in Van Heurck, 1881. Hustedt, 1959, pp. 244-246, fig. 725; Hasle and Mendiola, 1967, p. 111, figs. 5, 27-34, 39-44.

*Thalassionema nitzschioides* Grunow var. *parva* Heiden, in Heiden and Kolbe, 1928. Heiden and Kolbe, 1928, p. 564, fig. 118.

Genus *THALASSIOSIRA* Cleve, 1873

*Thalassiosira hukryi* Barron, 1983. Synonyms: *Coscinodiscus* sp. 1 Fenner, 1977, p. 517, pl. 6, figs. 7-8; *Coscinodiscus* sp. 5 Fenner, 1977, p. 517, pl. 6, fig. 6. Barron, 1983, p. 511, pl. 4, figs. 1-2, pl. 6, fig. 9.

*Thalassiosira eccentrica* (group) (Ehrenberg) Cleve, 1904. Hustedt, 1930, p. 388, fig. 201. Simonsen, 1974, p. 9, pl. 2, figs. 1-3.

*Thalassiosira fraga* Schrader, in Schrader and Fenner, 1976. Schrader and Fenner, 1976, p. 1001, pl. 16, figs. 9-12.

*Thalassiosira leptopus* (Grunow) Hasle and Fryxell, 1977. Hasle and Fryxell, 1977, pp. 15-18, pl. 1-4.

*Thalassiosira mediaconvexa* Schrader, in Schrader and Fenner, 1976.

Synonyms: *Thalassiosira dubiosa* Schrader, in Schrader and Fenner, 1976, p. 1001, pl. 35, fig. 6, not figs. 4-5. *Thalassiosira?* sp. 1 Fenner, 1977, p. 533, pl. 3, figs. 7-8. Schrader and Fenner, 1976, p. 1002, pl. 36, fig. 1.

Genus *THALASSIOTHRIX* Cleve and Grunow, 1880

*Thalassiothrix longissima* Cleve and Grunow, 1880. Hasle and Mendiola, 1967, p. 114, fig. 20.

**Remarks.** As generally only fragments of *T. longissima* and *Thalassionema nitzschioides* (*T. longissima* being heteropolar, *T. nitzschioides* being isopolar) were found, distinction between them was impossible in most cases, and they are listed together.

Genus *TRICERATIUM* Ehrenberg, 1839

*Triceratium americanum* Ralfs, in Pritchard, 1861. A. Schmidt et al., 1874—, p. 76, fig. 27 (pl. 76, fig. 28 is in error, see Boyer, 1900, p. 721).

*Triceratium cinnamomeum* Greville, 1863. Van Heurck, 1880, pl. 126, fig. 1; Kolbe, 1954, p. 47, pl. 2, fig. 18.

*Triceratium inconspicuum* Greville, 1861 var. *inconspicuum*. Greville, 1861a, p. 45, pl. 8, fig. 10.

*Triceratium inconspicuum* Greville var. *trilobata* Fenner, 1977. Synonym: *Triceratium barbadense* Greville sensu Kanaya, 1957, pp. 100-101, pl. 7, figs. 1-4. Fenner, 1982, p. 132, pl. 17, figs. 5-6; pl. 27, figs. 5-6.

*Triceratium* aff. *zonulatum* Greville, 1865. Fenner, 1982, p. 132, pl. 17, fig. 9.

*Triceratium kanayae* Fenner, in press. Kanaya (1957), pp. 102-103, pl. 7, figs. 5-7 (as *Triceratium* sp. A); Fenner, in press, pl. 1, figs. 5-6.

**Remarks.** Three- and four-angled varieties were found to co-occur in samples from DSDP Site 220.

*Triceratium kanayae* var. *quadriloba* Fenner, in press. Fenner, in press, pl. 2.

*Triceratium* sp. 1. (Plate 2, Fig. 7.)

**Remarks.** This species, very similar to *Lisitzinia ornata* but differing in the lack of the deep folds between the central part and the angles, was found in the middle Eocene (P10) of DSDP Site 220.

Genus *TRINACRIA* Heiberg, 1863

*Trinacria excavata* Heiberg f. *tetragona* A. Schmidt, 1888, in A. Schmidt et al., 1874—. Illustration: A. Schmidt et al., 1874—, pl. 152, figs. 26-28; Fenner, 1977, pp. 535-536, pl. 27, figs. 9-11.

*Trinacria praetenuis* (Greville) Grunow, 1884. Synonym: *Triceratium perminutum* Greville, 1864b, p. 89, pl. 13, fig. 18. Greville, 1864b, p. 89, pl. 13, fig. 16; Fenner, 1982, p. 133, pl. 28, figs. 1-2.

*Trinacria subcapitata* (Greville) Grunow, 1884. Greville, 1863a, p. 244, pl. 10, fig. 20; Grunow, 1884, p. 69; Fenner, 1982, p. 133, pl. 28, figs. 3-8.

Genus *TROCHOSIRA* Kitton, 1871

*Trochosira spinosa* Kitton, 1871. Kitton, 1871, p. 170, pl. 14, figs. 6-7; A. Schmidt et al., 1874—, pl. 180, fig. 49; pl. 176, fig. 56.

Genus *XANTHIOPYXIS* Ehrenberg, 1844

*Xanthiopyxis acrolopha* Forti, 1912. Forti, 1912, p. 84; Forti, 1913, pp. 15-16, pl. 2, figs. 22, 24, 27-28, 30-37.

*Xanthiopyxis oblonga* Ehrenberg, 1844. Hanna, 1927, p. 124; Hanna, 1932, p. 226.

*Xanthiopyxis ovalis* Lohmann, 1938. Synonym: *Liradiscus rugulosus* Forti, 1913, p. 1559, pl. 12, fig. 23. Lohmann, 1938, p. 91, pl. 20, fig. 2; pl., 22, fig. 12; Lohmann, 1974, p. 25, pl. 5, fig. 11.

## Genera Incertae Sedis

*Genus et Species indet. (1)* Fenner, 1982. Illustration: Fenner, 1982, pl. 8, figs. 1-2.

*Genus et species indet. (3)*

**Remarks.** Only fragments of this species were found. The valves or skeletons are heavily silicified and consist of a central thickening extending laterally at each end into a narrow prolongation. Both the central part and the prolongations are coarsely areolated, the areolae being arranged in longitudinal rows with ribs between the rows.

**Stratigraphic occurrence:** This species is found in the late Eocene of DSDP Sites 292 and 217.

**Genus MACRORA Hanna, 1932**

*Macrora barbadiensis* (Deflandre) Bukry, 1978. Loeblich et al., 1968, p. 207.

*Macrora stella* (Aspetitia) Hanna, 1932. Hanna, 1932, p. 196, pl. 12, fig. 7.

**Genus SPERMATOGONIA Leuduger-Fortmorel, 1892**

*Spermatogonia* spp.

**Remarks.** As only fragments of species belonging to this genus have been found, no species determination was attempted.

**ACKNOWLEDGMENTS**

This research was financially supported by DFG Grant Fu-119/6 and NSF Grant WHOI-26987. I am grateful to D. Fütterer, M. Sarnthein, and U. Pflaumann for their interest in this study. I thank L. H. Burckle and C. Sancetta for helpful comments and for reviewing the manuscript. Miss Schmidtman helped type the manuscript.

**REFERENCES**

- Agardh, C. A., 1824. *Systema algarum*: Lund (Literis Berlingianis).
- , 1832. *Conspectus Criticus Diatomacearum* (Pt. 4): Lund (Literis Berlingianis), 48–66.
- Andrews, G. W., 1975. Taxonomy and stratigraphic occurrence of the marine diatom Genus *Rhaphoneis*. 3rd Symp. Rec. Fossil Mar. Diatoms, Kiel. Beih. Nova Hedwigia, 53:193–229.
- Barker, P. F., Carlson, R. L., Johnson, D. A., and Shipboard Scientific Party, 1981. Leg 72: Southwest Atlantic circulation and Rio Grande Rise tectonics. *Geol. Soc. Am. Bull.*, 92:294–309.
- Barron, J. A., 1983. Latest Oligocene through early middle Miocene diatom biostratigraphy of the eastern tropical Pacific. *Mar. Micropaleontol.*, 7:487–515.
- Beckmann, J. P., 1971. The foraminifera of Sites 68 to 75. In Tracey, J. I., Jr., Sutton, G. H., et al., *Init. Repts. DSDP*, 8: Washington (U.S. Govt. Printing Office), 713–726.
- Berggren, W. A., Lohman, G. P., and Poore, R. Z., 1974. Shore laboratory report on Cenozoic planktonic foraminifera: Leg 22. In von der Borch, C. C., Sclater, J. G., et al., *Init. Repts. DSDP*, 22: Washington (U.S. Govt. Printing Office), 635–656.
- Boersma, A., 1977. Cenozoic planktonic foraminifera—DSDP Leg 39 (South Atlantic). In Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP*, 39: Washington (U.S. Govt. Printing Office), 567–590.
- Bory de Saint-Vincent, J. B. M., 1831. Contributions to Dictionnaire classique d'Histoire naturelle (Vol. 17): Paris.
- Boström, K., Kraemer, T., and Gartner, S., 1973. Provenance and accumulation rates of opaline silica, Al, Ti, Fe, Mn, Cu, Ni and Co in Pacific pelagic sediments. *Chem. Geol.*, 11:123–148.
- Boyer, C. S., 1900. Biddulphoid forms of North American Diatomaceae. *Proc. Acad. Nat. Sci. Philadelphia*, Pt. 3:685–748.
- Brun, J., 1891. Diatomées. *Mém. Soc. Phys. Hist. nat. Genève*, 31: ———, 1892. Notes sur quelques espèces nouvelles. In Tempère, J. (Ed.), *Le Diatomiste* (Vol. 1): Paris (M. J. Tempère), 173–177, pl. 14.
- , 1896. Diatomées Miocènes. In Tempère, J. (Ed.), *Le Diatomiste* (Vol. 2) Paris (M. J. Tempère), 229–247, pl. 19–24.
- Bukry, D., 1971a. Coccolith stratigraphy Leg 7, Deep Sea Drilling Project. In Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7, Pt. 2: Washington (U.S. Govt. Printing Office), 1513–1528.
- , 1971b. Coccolith stratigraphy, Leg 8, Deep Sea Drilling Project. In Tracey, J. I., Jr., Sutton, G. H., et al., *Init. Repts. DSDP*, 8: Washington (U.S. Govt. Printing Office), 791–808.
- , 1974. Coccolith and silicoflagellate stratigraphy, eastern Indian Ocean, Deep Sea Drilling Project, Leg 22. In von der Borch, C. C., Sclater, J. G., et al., *Init. Repts. DSDP*, 22: Washington (U.S. Govt. Printing Office), 601–608.
- , 1977. Coccolith and silicoflagellate stratigraphy, South Atlantic Ocean, Deep Sea Drilling Project Leg 39. In Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP*, 39: Washington (U.S. Govt. Printing Office), 825–840.
- , 1978. Cenozoic silicoflagellate and coccolith stratigraphy, northwestern Atlantic Ocean, Deep Sea Drilling Project Leg 43. In Benson, W. E., Sheridan, R. E., et al., *Init. Repts. DSDP*, 44: Washington (U.S. Govt. Printing Office), 775–805.
- Burckle, L. H., 1972. Late Cenozoic planktonic diatom zones from the eastern Equatorial Pacific. 1st Symp. Rec. Fossil Mar. Diatoms, Bremerhaven. Beih. Nova Hedwigia, 39:217–250.
- Burckle, L. H., and Trainer, J., 1979. Middle and late Pliocene diatom datum levels from the central Pacific. *Micropaleontology*, 25: 281–293.
- Castracane, A. F., 1886. *Report on the Scientific Results of the Voyage of H.M.S. Challenger during the Years 1873–76: Botany* (Vol. 2): London (HMSO).
- Cleve, P. T., 1873. Examination of diatoms found on the surface of the sea of Java. *Bihang Svenska Vetenskaps Akad. Handl.* 1:1–13, Stockholm.
- , 1904. Plankton table for the North Sea. *Cons. Expl. Mer. Bull.*, 1903–1904.
- Cleve, P. T., and Grunow, A., 1879 [1880]. Beiträge zur Kenntnis der arktischen Diatomeen. *K. Svenska Vetenskapsakad. Handl.*, 17: 1215, (Referat, Botan. Centralblatt, 5:65–69, 1881).
- Cleve-Euler, A., 1941. Alteriaere Diatomeen und Silicoflagellaten im Inneren Schwedens. *Palaeontographica*, 92:165–209.
- , 1951. *Die Diatomeen von Schweden und Finnland. K. Svenska Vetenskaps Akad. Handl. Fjärde Serien*, 2 (Pt. I, Centricae: Stockholm (Almqvist and Wiksells Boktryckeri).
- McCollum, D. W., 1975. Diatom stratigraphy of the Southern Ocean. In Hayes, D. E., Frakes, L. A., et al., *Init. Repts. DSDP*, 28: Washington (U.S. Govt. Printing Office), 515–572.
- Desikachary, T. V., and Maheshwari, C. L., 1958. Fossil diatoms from Colebrook Island. *J. Ind. Bot. Soc.*, 38(no. 1):27–41.
- Dinkelman, M. G., 1973. Radiolarian stratigraphy: Leg 16, Deep Sea Drilling Project. In van Andel, T. H., Heath, G. R., et al., *Init. Repts. DSDP*, 16: Washington (U.S. Govt. Printing Office), 747–814.
- Douglas, R. G., 1973. Planktonic foraminiferal biostratigraphy in the central North Pacific Ocean. In Winterer, E. L., Ewing, J. I., et al., *Init. Repts. DSDP*, 17: Washington (U.S. Govt. Printing Office), 673–694.
- Douglas, R. G., and Savin, S. M., 1975. Oxygen and carbon isotope analyses of the Tertiary from Shatsky Rise and other sites in the North Pacific Ocean. In Larson, R. L., Moberly, R., et al., *Init. Repts. DSDP*, 32: Washington (U.S. Govt. Printing Office), 509–520.
- Dzinoridze, R. N., Jousé, A. P., Koroleva-Golikova, G. S., Kozlova, G. E., Nagaeva, G. S., Petrushevskaya, M. G., and Strelnikova, N. I., 1976. Diatom and radiolarian cenozoic stratigraphy, Norwegian Basin. DSDP Leg 38. In Talwani, M., Udintsev, G., et al., *Init. Repts. DSDP*, Suppl. to Vols. 38, 39, 40, and 41: Washington (U.S. Govt. Printing Office), 289–427.
- Dzinoridze, R. N., Jousé, A. P., and Strelnikova, N. I., 1979. Description of the diatoms. *The History of the Microplankton of the Norwegian Sea (on the Deep Sea Drilling Materials)*. Acad. Sci. U.S.S.R., *Zool. Inst., Explorations of the Faunas of the Seas*, 23(31): 32–71.
- Ehrenberg, C. G., 1830. Beiträge zur Kenntnis der Organisation der Infusorien und ihrer geographischen Verbreitung besonders in Sibirien. *Abh. K. Akad. Wiss. Berlin*, pp. 1–88.
- , 1837. Die fossilen Infusorien und die lebendige Dammerde. *Abh. K. Akad. Wiss. Berlin*.
- , 1838. Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *Abh. K. Akad. Wiss. Berlin*, pp. 59–147.
- , 1839. Über noch jetzt zahlreich lebende Thierarten der Kreidebildung und den Organismus der Polythalamien. *Anh. K. Akad. Wiss. Berlin*, pp. 81–174.
- , 1840. Über ausgezeichnete jetzt noch lebende peruanische und mexikanische Meeres-Infusorien, welche mit zur Erläuterung rätselhafter fossiler Formen der Kreidebildung dienen. *Ber. K. Preuss. Akad. Wiss. Berlin*, pp. 157–162.
- , 1841. Verbreitung und Einfluss des mikroskopischen Lebens in Süd- und Nordamerika. *Abh. K. Akad. Wiss. Berlin*, Pt. 1, 291–445.

- \_\_\_\_\_, 1843. Mitteilungen über zwei neue asiatische Lager fossiler Infusorien-Erden aus dem russischen Trans-Kaukasien (Grusien) und Sibirien. *Ber. K. Preuss. Akad. Wiss. Berlin*, pp. 43-49.
- \_\_\_\_\_, 1844. Mitteilung über zwei neue Lager von Gebirgsmassen aus Infusorien als Meeres-Absatz in Nordamerika und eine Vergleichung derselben mit den organischen Kreidegebilden in Europa und Afrika. *Ber. K. Preuss. Akad. Wiss. Berlin*, pp. 57-97. (Notice by J. W. Bailey, 1845. "Ehrenberg's observations on the fossil infusoria of Virginia and Maryland, and comparisons of the same with those found in the chalk formations of Europe and America". *Am. J. Sci.*, 48:201-204).
- \_\_\_\_\_, 1845. Neue Untersuchungen über das kleinste Leben als geologisches Moment...mit kurzer Charakteristik von 10 neuen Genera und 66 neuen Arten. *Ber. K. Preuss. Akad. Wiss. Berlin*, pp. 53-88.
- \_\_\_\_\_, 1854. *Mikrogeologie. Das Erden und Felsen schaffende Wirken des unsichtbar kleinen selbständigen Lebens auf der Erde*: Leipzig. (Leopold Voss).
- Ellis, C. H., 1975. Calcareous nannofossil biostratigraphy—DSDP Leg 31. In Karig, D. E., Ingle, J. C., Jr., et al. *Init. Repts. DSDP*, 31: Washington (U.S. Govt. Printing Office), 655-676.
- Fenner, J., 1977. Cenozoic diatom biostratigraphy of the equatorial and southern Atlantic ocean. In Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP*, Suppl. to Vols. 38, 39, 40, and 41: Washington (U.S. Govt. Printing Office), 491-623.
- \_\_\_\_\_, 1982. Diatoms in the Eocene and Oligocene sediments off NW Africa, their stratigraphic and paleogeographic occurrence [Ph.D. dissert.] University of Kiel.
- \_\_\_\_\_, in press. Eocene-Oligocene planktic diatom stratigraphy in the low latitudes and the high southern latitudes. *Micropaleontology*.
- Forti, A., 1909. Studi per una Monografia del genere *Pyxilla* (Diatomee) e dei generi affini. *Nuova Notarisa*, Ser. 20:5-24.
- \_\_\_\_\_, 1912. Primo elenco delle Diatomee fossili contenute nei calcari marmorati biancastri di Monte Gibbio (Sassuolo-Emilia). *Nuova Notarisa*, Ser. 23:79-87.
- \_\_\_\_\_, 1913. Contribuzioni diatomologiche. XIII. Diagnoses Diatomacearum quarundam fossilium italicarum. *Atti R. Inst. Veneto Sci. Lett. Arti*, 72:1567-1700.
- Fodor, R. V., and Thiede, J., 1977. Volcanic breccia from DSDP Site 357: implications for the composition and origin of the Rio Grande Rise. In Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP*, 39: Washington (U.S. Govt. Printing Office), 537-544.
- Frenguelli, J., 1949. Diatomeas fósiles de los Yacimientos Chilenos de Tiltit y Mejillones. *Darwiniana*, 9(no. 1):97-157.
- Gartner, S. Jr., 1971. Calcareous nannofossil age determinations: Leg 7, Deep Sea Drilling Project. In Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7, Pt. 2: Washington (U.S. Govt. Printing Office), 1509-1512.
- \_\_\_\_\_, 1974. Nannofossil biostratigraphy, Leg 22, Deep Sea Drilling Project. In von der Borch, C. C., Sclater, J. G., et al., *Init. Repts. DSDP*, 22: Washington (U.S. Govt. Printing Office), 577-600.
- Gleser, S. I., and Jousé, A. P., 1974. Diatoms and silicoflagellates in the Eocene of the equatorial Atlantic. In: Jousé, A. P. (Ed.), *Micropaleontology of Oceans and Seas*: Moscow: Acad. Nauk S.S.S.R) pp. 49-62.
- Göke, G., 1958. Einführung in die Präparation der fossilen Diatomeen. Pts. 1. und 2. *Der Aufschluss*, 9.
- Gombos, A. M., 1977. Paleogene and Neogene diatoms from the Falkland Plateau and Malvinas Outer Basin, Leg 36, Deep Sea Drilling Project. In Barker, P. F., Dalziel, I. W. D., et al., *Init. Repts. DSDP*, 36: Washington (U.S. Govt. Printing Office), 575-687.
- \_\_\_\_\_, 1980. The early history of the diatom family *Asterolampraceae*. *Bacillaria*, 3:227-272.
- \_\_\_\_\_, 1983. Middle Eocene diatoms from the South Atlantic. In Ludwig, W. J., Krashennnikov, V. A., et al., *Init. Repts. DSDP*, 71: Washington (U.S. Govt. Printing Office).
- Gombos, A. M., and Ciesielski, P. F., 1983. Late Eocene to early Miocene diatoms from the southwest Atlantic. In Ludwig, W. J., Krashennnikov, V. A., et al., *Init. Repts. DSDP*, 71: Washington (U.S. Govt. Printing Office).
- Gray, S. F., 1821. *A Natural Arrangement of British plants...* with an Introduction to Botany (Vols. 1 and 2): (Diatomaceae) London (Baldwin, Craddock and Joy), 293-295.
- Greville, R. K., 1860. A monograph of the genus *Asterolampra*, including *Asteromphalus* and *Spatangidium*. *Trans. Microsc. Soc. London*, N. S. 8:102-124.
- \_\_\_\_\_, 1861a. Descriptions of new and rare diatoms. Series I. *Trans. Microsc. Soc. London*, NS 9:39-47.
- \_\_\_\_\_, 1861b. Descriptions of new and rare diatoms. Series II. *Trans. Microsc. Soc. London*, NS 9:67-73.
- \_\_\_\_\_, 1861c. Descriptions of new and rare Diatoms. Series III. *Trans. Microsc. Soc. London*, NS 9:73-77.
- \_\_\_\_\_, 1861d. Descriptions of new and rare diatoms. Series IV. *Trans. Microsc. Soc. London*, NS 9:78-87.
- \_\_\_\_\_, 1862a. Descriptions of new and rare diatoms. Series V. *Trans. Microsc. Soc. London*, NS 10:18-29.
- \_\_\_\_\_, 1862b. Descriptions of new and rare diatoms. Series VI. *Trans. Microsc. Soc. London*, NS 10:89-96.
- \_\_\_\_\_, 1862c. Descriptions of new and rare diatoms. Series VII. *Q. J. Microsc. Sci.*, NS 2:231-237.
- \_\_\_\_\_, 1862d. On the *Asterolamprae* of the Barbados deposit. *Q. J. Microsc. Sci.*, NS 2:41-58.
- \_\_\_\_\_, 1863a. Descriptions of new and rare diatoms. Series VIII. *Q. J. Microsc. Sci.*, NS 3:13-22.
- \_\_\_\_\_, 1863b. Descriptions of new and rare diatoms. Series IX. *Trans. Microsc. Soc. London*, NS 11 p. 63-79.
- \_\_\_\_\_, 1863c. Descriptions of new and rare diatoms. Series X. *Q. J. Microsc. Sci.*, NS 3:227-240.
- \_\_\_\_\_, 1865a. Descriptions of new and rare diatoms. Series XIV. *Trans. Microsc. Soc. London*, NS 13:1-37.
- \_\_\_\_\_, 1865b. Descriptions of new and rare diatoms. Series XV. *Trans. Microsc. Soc. London*, NS 13:24-37.
- \_\_\_\_\_, 1865c. Descriptions of new and rare diatoms. Series XVI. *Trans. Microsc. Soc. London*, NS 13:43-60.
- \_\_\_\_\_, 1865d. Descriptions of new and rare diatoms. Series XVII. *Trans. Microsc. Soc. London*, NS 13:97-108.
- \_\_\_\_\_, 1866a. Descriptions of new and rare diatoms. Series XVIII. *Trans. Microsc. Soc. London*, NS 14:1-12.
- \_\_\_\_\_, 1866b. Descriptions of new and rare diatoms. Series XIX. *Trans. Microsc. Soc. London*, NS 14:77-88.
- \_\_\_\_\_, 1866c. Descriptions of new and rare diatoms. Series XX. *Trans. Microsc. Soc. London*, NS 14:121-130.
- Grove, E. and Sturt, G., 1886-1889. On a fossil marine diatomaceous deposit from Oamaru, Otago, New Zealand. *J. Quekett Microsc. Club*, Ser. 2. Part I, 2:321-332. Part II, 3:7-12. Part III, 3:63-78. Appendix, 3:131-148.
- Grunow, A., 1862. Die oesterreichischen Diatomaceen nebst Anschluss einiger neuer Arten von anderen Lokalitäten und einer kritischen Übersicht der bisher bekannten Gattungen und Arten. *Verh. Kaiserl-K. Zool. Bot. Ges. Wien*, 12:315-472, 545-585.
- \_\_\_\_\_, 1884. Diatomeen von Franz Josef-Land. *Denkschr. Kaiserl. Akad. Wiss.*, 48:53-112.
- Hajós, M., 1976. Upper Eocene and lower Oligocene Diatomaceae, Archaeomonadaceae, and Silicoflagellatae in southwestern Pacific sediments, DSDP Leg 29. In Hollister, C. D., Craddock, C., et al., *Init. Repts. DSDP*, 35: Washington (U.S. Govt. Printing Office), 817-884.
- Hammond, S. R., Kroenke, L. W., and Theyer, F., 1975. Northward motion of the Ontong-Java Plateau between -110 and -30 m.y.: a paleomagnetic investigation of DSDP Site 289. In Andrews, J. E., Packham, G., et al., *Init. Repts. DSDP*, 30: Washington (U.S. Govt. Printing Office), 415-418.
- Hanna, G. D., 1927. The lowest known Tertiary diatoms in California. *J. Paleontol.*, 1:103-126.
- \_\_\_\_\_, 1930. A new genus of silicoflagellata from the Miocene of Lower California. *J. Paleontol.*, 4:415-416.
- \_\_\_\_\_, 1932. The diatoms of Sharktooth Hill, Kern County, California. *Proc. Calif. Acad. Sci.*, Ser. IV, 20(no. 6):161-263.
- Hanna, G. D., and Brigger, A. L., 1970. Observations on *Liostephanina*. *Beih. Nova Hedwigia*, 31:89-101.
- Hanna, G. D., and Grant, W. M., 1926. Expedition to the Revilla Gigedo Islands, Mexico, in 1925. II. Miocene marine diatoms from

- Maria Madre Island, Mexico. *Proc. Calif. Acad. Sci.*, Ser. 4, 15: 115-193.
- Haq, B., and Lipps, J. H., 1971. Calcareous nannofossils. In: Tracey, J. I., Jr., Sutton, G. H., et al., *Init. Repts. DSDP*, 8: Washington (U.S. Govt. Printing Office), 777-790.
- Hasle, G. R., and Fryxell, G. A., 1977. The genus *Thalassiosira*: Some species with a linear areola array. In Simonsen, R. (Ed.), *Fourth Symp. Rec. Fossil Mar. Diatoms, Oslo: Proceedings. Beih. Nova Hedwigia*, 54:15-66.
- Hasle, G. R., and de Mendiola, B. R. E., 1967. The fine structure for some *Thalassionema* and *Thalassiothrix* species. *Phycologia*, 6:107-125.
- Hassall, A. H., 1845. *A History of the British Freshwater Algae (Including Descriptions of the Diatomaceae and Desmidiaceae)*: London (Taylor, Walton, and Maberly).
- Hay, W. W., 1971. Preliminary dating by fossil calcareous nannoplankton, Deep Sea Drilling Project, Leg 8. In Tracey, J. I., Jr., Sutton, G. H., et al., *Init. Repts. DSDP*, 8: Washington (U.S. Govt. Printing Office), 809-818.
- Heath, G. R., and Moberly, R., Jr., 1971a. Cherts from the western Pacific, Leg 7, Deep Sea Drilling Project. In Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7, Pt. 2: Washington (U.S. Govt. Printing Office), 991-1008.
- \_\_\_\_\_, 1971b. Deep-sea turbidites from the western Pacific: Leg 7, Deep Sea Drilling Project. In Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7, Pt. 2: Washington (U.S. Govt. Printing Office), 1009-1010.
- Heiberg, P. A. C., 1863. *Conspectus criticus Diatomacearum Danicarum*: Copenhagen (Wilh. Priors Førlag).
- Heiden, H., and Kolbe, R. W. M., 1928. *Die marinen Diatomeen der Deutschen Südpolar-Expedition 1901-1903*, 8(Bot. Heft 5): 447-745.
- Hendey, N. I., 1969. *Pyrgopyxis*, a new genus of diatoms from a south Atlantic Eocene core. *Occas. Pap. Calif. Acad. Sci.*, 72:1-5.
- Héribaud, J., 1893. *Les Diatomées d'Auvergne*: Paris (Librairie des Sci. Naturelles).
- Hustedt, F., 1930. *Die Kieselalgen Deutschlands, Österreichs und der Schweiz mit Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete*. In Rabenhorst, L. (Ed.), *Kryptogamenflora von Deutschland, Österreich und der Schweiz* (Vol. 7, Pt. 1): Leipzig (Akademische Gesellschaft).
- \_\_\_\_\_, 1958. Diatomeen aus der Antarktik und dem Südatlantik. *Deutsche Antarkt. Exped. 1938-1939*, 2:103-191.
- \_\_\_\_\_, 1959. Die Kieselalgen Deutschlands, Österreichs und der Schweiz. Pt. 2, Bremen. In Rabenhorst, L. (Ed.), *Kryptogamenflora von Deutschland, Österreich und der Schweiz* (Vol. 7, Pt. 2): Leipzig (Akademische Gesellschaft), 737-845.
- Ingle, J. C., Karig, D. E., et al., 1975. Site 292. In Karig, D. E., Ingle, J. C., Jr., et al., *Init. Repts. DSDP*, 31: Washington (U.S. Govt. Printing Office), 67-130.
- Johnson, D. A., in press. Paleocirculation of the southwestern Atlantic. In Barker, P. F., Carlson, R. L., Johnson, D. A., et al., *Init. Repts. DSDP*, 72: Washington (U.S. Govt. Printing Office).
- José, A. P., 1973. Diatoms in the Oligocene-Miocene Biostratigraphic Zones of the Tropical Areas of the Pacific Ocean. *2nd Symp. Rec. Fossil Mar. Diatoms, London. Beih. Nova Hedwigia*, 45:333-364.
- \_\_\_\_\_, 1978. Novii iskopaemii rod diatomei *Lisitzinia* (Bacillariophyta). *Morsk. mikropaleontol. Akad. Nauk, SSSR, Moscow*, pp. 47-48, plate 10. (In Russian)
- \_\_\_\_\_, (Ed.), 1977. *Atlas of Microorganisms in Bottom Sediments of the Oceans (Diatoms, Radiolaria, Silicoflagellates, and Coccoliths)*: Moscow (Nauka).
- José, A. P., and Sheshukova-Poretzkaya, V. S., 1971. Genus novum *Riedelia* José et Sheshukova-Poretzkaya (Bacillariophyta). *Nov. System. Plant. non Vascular.*, 8:19-25.
- Kanaya, T., 1957. Eocene diatom assemblages from the "Kellogg" and "Sidney" shales, Mt. Diablo Area, California. *Sci. Rep. Tohoku Univ.*, Ser. 2 (Geol.), 28:1-124.
- \_\_\_\_\_, 1959. Miocene diatom assemblages from the Onnagawa Formation and their distribution in the correlative formations in Northeast Japan. *Sci. Rep. Tohoku Univ.*, Ser. 2 (Geol.), 30: 1-130.
- \_\_\_\_\_, 1971. Some aspects of pre-Quaternary diatoms in the oceans. In Funnell, B. M., and Riedel, W. R. (Eds.), *The Micropaleontology of the Oceans: Proceedings of the Symposium held in Cambridge, Sept. 1967, "Micropaleontology of Marine Bottom Sediments."* pp. 545-562.
- Karsten, G., 1928. Abteilung Bacillariophyta (Diatomeae). In Engler, A., and Prantl, K. (Eds.) *Die natürlichen Pflanzenfamilien* (2nd ed.): Leipzig (Verlag W. Engelmann), 2:105-345.
- Keigwin, L. D., Jr., 1980. Paleocceanographic change in the Pacific at the Eocene-Oligocene boundary. *Nature*, 287:722-725.
- Kitton, F., 1871. Diatomaceous deposits from Juetland, Part 2. *J. Quekett Microsc. Club*, 2:168-171.
- Kolbe, R. W., 1954. Diatoms from equatorial Pacific cores. *Rept. Swedish Deep Sea Exped.*, 6:1-49.
- Kützing, F. F., 1844. *Die kieselschaligen Bacillarien oder Diatomeen*. (Nordhausen, 1865).
- Leinen, M., 1981. Biogenic silica accumulation in the central equatorial Pacific and its implications for Cenozoic paleoceanography. *Geol. Soc. Am. Bull.*, Pt. II, 90(no. 9):1310-1376.
- Leuduger-Fortmorel, G., 1892. Diatomées de la Malaisie. *Ann. Jard. Bot. Buitenzorg*, 11:1-60.
- Lohmann, K. E., 1938. Pliocene diatoms from the Kettleman Hills, California. *U.S. Geol. Surv., Prof. Pap.*, 189-C:81-102.
- \_\_\_\_\_, 1974. Lower middle Miocene marine diatoms from Trinidad. *Verh. Nat. Ges. Basel*, pp. 1-47
- McElhinny, M. W., 1970. Formation of the Indian Ocean. *Nature*, 228:977.
- McKenzie, D. P., and Sclater, J. G., 1971. The evolution of the Indian Ocean since the Late Cretaceous. *Geophys. J. R. Astronom. Soc.*, 25:437-528.
- Mann, A., 1907. Report on the diatoms of the *Albatross* voyages in the Pacific Ocean, 1888-1904. *Contr. U.S. Nat. Herbarium*, 10(Pt. 5):221-419.
- Martini, E., and Worsley, T., 1971. Tertiary calcareous nannoplankton from the western equatorial Pacific. In Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7, Pt. 2: Washington (U.S. Govt. Printing Office), 1471-1508.
- Maxwell, A. E., von Herzen, R. P., et al., 1970. Site 22. In Maxwell, A. E., von Herzen, R. P., et al., *Init. Repts. DSDP*, 3: Washington (U.S. Govt. Printing Office), 413-440.
- Mills, F. W., 1933-1935. *An Index to the Genera and Species of the Diatomaceae and Their Synonyms, 1816-1932*: London (Wheldon and Wesley).
- Moore, T. C., 1971. Radiolaria. In Tracey, J. I., Jr., Sutton, G. H., et al., *Init. Repts. DSDP*, 8: Washington (U.S. Govt. Printing Office), 727-776.
- Pantocsek, J., 1889. Beiträge zur Kenntnis der fossilen Bacillarien Ungarns (Vol. 2). Brackwasser Bacillarien und Anhang: Analyse der marinen Depots von Borny, *Bremia Vagy-Kürtös* in Ungarn, Ananino und Kusnetz in Russland.
- \_\_\_\_\_, 1892. Beiträge zur Kenntnis der fossilen Bacillarien Ungarns (Vol. 3) Süßwasser Bacillarien. Anhang: Analysen 15 neuer Depots von Bulgarien, Japan, Mahren, Russland und Ungarn: *Vagy-Tapolcsany* (Julius Platzko).
- Perch-Nielsen, K., 1977. Albian to Pleistocene calcareous nannofossils from the western South Atlantic, DSDP Leg 39. In Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP*, 39: Washington (U.S. Govt. Printing Office), 699-824.
- Perch-Nielsen, K., Supko, P. R., et al., 1977. Site 357: Rio Grande Rise. In Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP*, 39: Washington (U.S. Govt. Printing Office), 231-328.
- Pritchard, A., 1842-1852. *A History of Infusoria, Living and Fossil*: London (Whitaker).
- \_\_\_\_\_, 1861. *History of Infusoria, Including the Desmidiaceae and Diatomaceae, British and Foreign* (4th ed.): London
- Proshkina-Lavrenko, A. I., 1949-1951. *Diatomovyi analiz* (3 vols.). Moscow.
- Rattray, J., 1889. A revision of the genus *Coscinodiscus* and some allied genera. *Proc. R. Soc. Edinburgh*, 16:449-692.
- \_\_\_\_\_, 1890. A revision of the genus *Actinocyclus* Ehrenberg. *J. Quekett Microsc. Club*, Ser. 2, 4:137-212.
- Riedel, W. R., and Sanfilippo, A., 1971. Cenozoic radiolaria from the western tropical Pacific, Leg 7. In Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7, Pt. 2: Washington (U.S. Govt. Printing Office), 1529-1672.
- Roper, F. C. S., 1859. On the genus *Biddulphia* and its affinities. *Trans. Microsc. Soc. London*, 7:1-24.



- Roth, P. H., 1973. Calcareous nannofossils—Leg 17, Deep Sea Drilling Project. In Winterer, E. L., Ewing, J. I., et al., *Init. Repts. DSDP*, 17: Washington (U.S. Govt. Printing Office), 695–795.
- Schmidt, A., 1874—. *Atlas der Diatomeenkunde*. Begun by A. Schmidt, continued by Schmidt, M., Fricke, F., Heiden, H., Mueller, O., and Hustedt, F.: Leipzig, Berlin (O. R. Reissland).
- Schrader, H. J., 1973. Cenozoic diatoms from the northeast Pacific, Leg 18. In Kulm, L. D., von Huene, R., et al., *Init. Repts. DSDP*, 18: Washington (U.S. Govt. Printing Office), 673–797.
- , 1974. Cenozoic marine planktonic diatom stratigraphy of the tropical Indian Ocean. In Fisher, R. L., Bunce, E. T., et al., *Init. Repts. DSDP*, 24: Washington (U.S. Govt. Printing Office), 887–967.
- , 1976. Cenozoic marine planktonic diatom biostratigraphy of the Southern Pacific Ocean. In Hollister, C. D., Craddock, C., et al., *Init. Repts. DSDP*, 35: Washington (U.S. Govt. Printing Office), 605–672.
- Schrader, H. J., and Fenner, J., 1976. Norwegian Sea cenozoic diatom biostratigraphy and taxonomy. In Talwani, M., Udintsev, G., et al., *Init. Repts. DSDP*, 38: Washington (U.S. Govt. Printing Office), 921–1099.
- Shafik, S., 1975. Nannofossil biostratigraphy of the Southwest Pacific, Deep Sea Drilling Project, Leg 30. In Andrews, J. E., Packham, G., et al., *Init. Repts. DSDP*, 30: Washington (U.S. Govt. Printing Office), 549–598.
- Sheshukova-Poretzkaya, V. S., 1962. Novie i redkie Bacillariophyta iz diatomovoi suiti Sakhalina. *Uch. Zap. 1 gu, ser. Biol. Nauk (Leningrad Univ.)*, 49 (no. 313):203–211.
- , 1967. *Neogenovye Morskie Diatomovye Vodorsli Sakhalina i Kamchatki*, 8:1–432.
- Sheshukova-Poretzkaya, V. S., and Gleser, S. I., 1962. Bacillariophyta, Silicoflagellata and Ebridae from Maikop series deposits (River Shibik, Krasnodar Region). (Diatomovye vodorosli, silicoflagellatii ebridei iz maikopsikh otloznenii s. v. Shibik (Krasnodarski Krai). *Uch. Zap., Ser. Biol. Nauk (Leningrad Univ.)*, 49: 171–202.
- , 1964. Diatomaceae marinae novae e Paleogeno Ucraineae. *Acad. NAUK S.S.S.R., Nov. sist. nizschich rast. otdel bentii otisk, isdatelbstwo Nauka*, pp. 78–92.
- Simonsen, R., 1974. The diatom plankton of the Indian Ocean Expedition of R.V. *Meteor*, 1964–1965. *Meteor Forsch. Ergebn., Reihe D*, 19:1–65.
- , 1979. The diatom system. *Bacillaria*, 2:9–71.
- Simonsen, R., and Kanaya, T., 1961. Notes on the marine species of the diatom genus *Denticula* Kütz. *Int. Rev. Ges. Hydrobiol.*, 46: 498–513.
- Strelnikova, N. I., 1974. *Diatomei Pozdnego Mela* [Late Cretaceous diatoms of western Siberia]. *Acad. Nauk, S.S.S.R., Roy 8*.
- Tempère, J., and Peragallo, H., 1907–1915. *Diatomees du Monde Entier* (2nd ed.) (Privately published.)
- Thwaites, G. H. K., 1848. Further observations on the diatomaceae with descriptions of new genera and species. *Ann. Mag. Nat. Hist.*, 1 (ser. 2):161–172.
- Tjalsma, E., in press. Eocene to Miocene benthic foraminifers from DSDP Site 516, Rio Grande Rise, South Atlantic. In Barker, P. F., Carlsen, R. L., Johnson, D. A., et al., *Init. Repts. DSDP*, 72: Washington (U.S. Govt. Printing Office).
- Truan y Luard, A., and Witt, O. N., 1888. Diatomaceen der Polycystinen Kreide von Jeremie in Haiti, Westindia. *J. Micrograph. Ann.* (Berlin) 12.
- Van Heurck, H., 1880–1885. *Synopsis des diatomées de Belgique*. Atlas, pl. 1–30 (1880); pl. 31–77 (1881); pl. 78–103 (1882); pl. 104–132 (1883); pl. A, B, C (1885).:Anvers (Ducaju et Cie.)
- , 1896. *A Treatise on the Diatomaceae*: London
- Van Landingham, S. L., 1967–1979. *Catalogue of the Fossil and Recent Genera and Species of Diatoms and Their Synonyms*: Lehre (Cramer).
- Vergnaud Grazzini, C., and Rabussier-Lointier, D., 1980. Compositions isotopiques de l'oxygène et du carbone des foraminifères tertiaires en Atlantique équatorial (site 366 du DSDP). *Rev. Geol. Dynam. Geogr. Phys.*, 22:63–74.
- Wallich, G. C., 1860. On the siliceous organisms found in the digestive cavities of the Salpae and their relation to the flint nodules of the Chalk Formation. *Trans. Microsc. Soc. London*, NS 8:36–55.
- Weaver, F. M., and Gombos, A. M., Jr., 1981. Southern high-latitude diatom biostratigraphy. In Warme, T. C., Douglas, R. C., and Winterer, E. L. (Eds.), *The Deep Sea Drilling Project: A Decade of Progress*. Spec. Publ., 32:445–470.

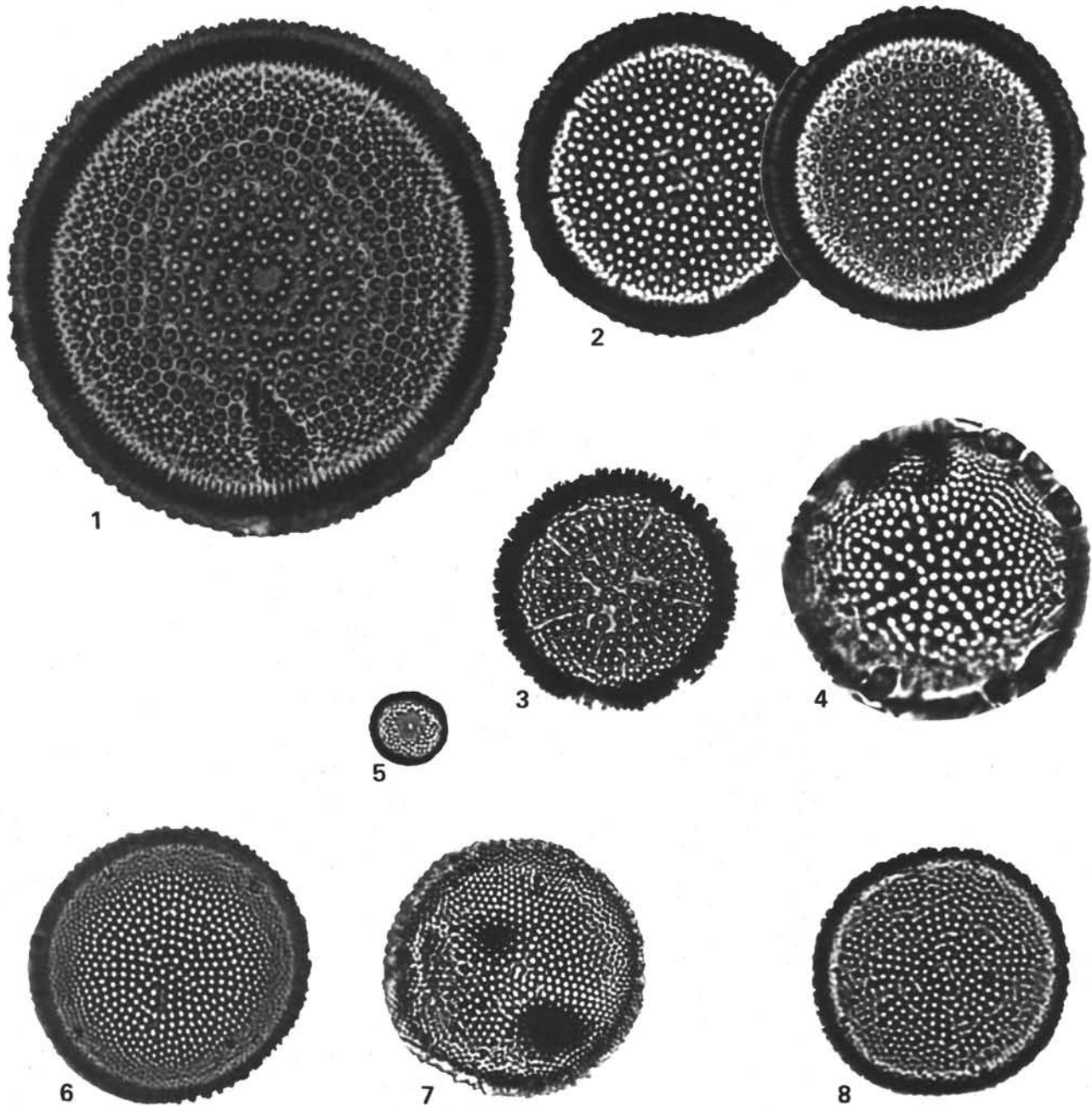


Plate 1. (All figures magnified 1500 $\times$ ). 1-2. *Cestodiscus pulchellus* Greville (paratype), Nankoori, Nicobar Islands, Coll. DEBY, B.M. slide 9896. 3. *Cestodiscus parmula* Castracane, DSDP Sample 357-17-6, 96-97 cm. 4. *Cestodiscus* aff. *trochus* Castracane, DSDP Sample 357-15-2, 29-30 cm. 5. *Trochosira?* sp., DSDP Sample 357-24-5, 84-85 cm. 6-8. *Cestodiscus stokesianus* Greville, (6) Paratype, Moron deposit, Coll. Greville (slide obtained from Ref. Stokes), B.M. slide 3235, (7) DSDP Sample 289-97-4, 122-126 cm, (8) Moron deposit, Coll. Tulk, B.M. slide 53516.

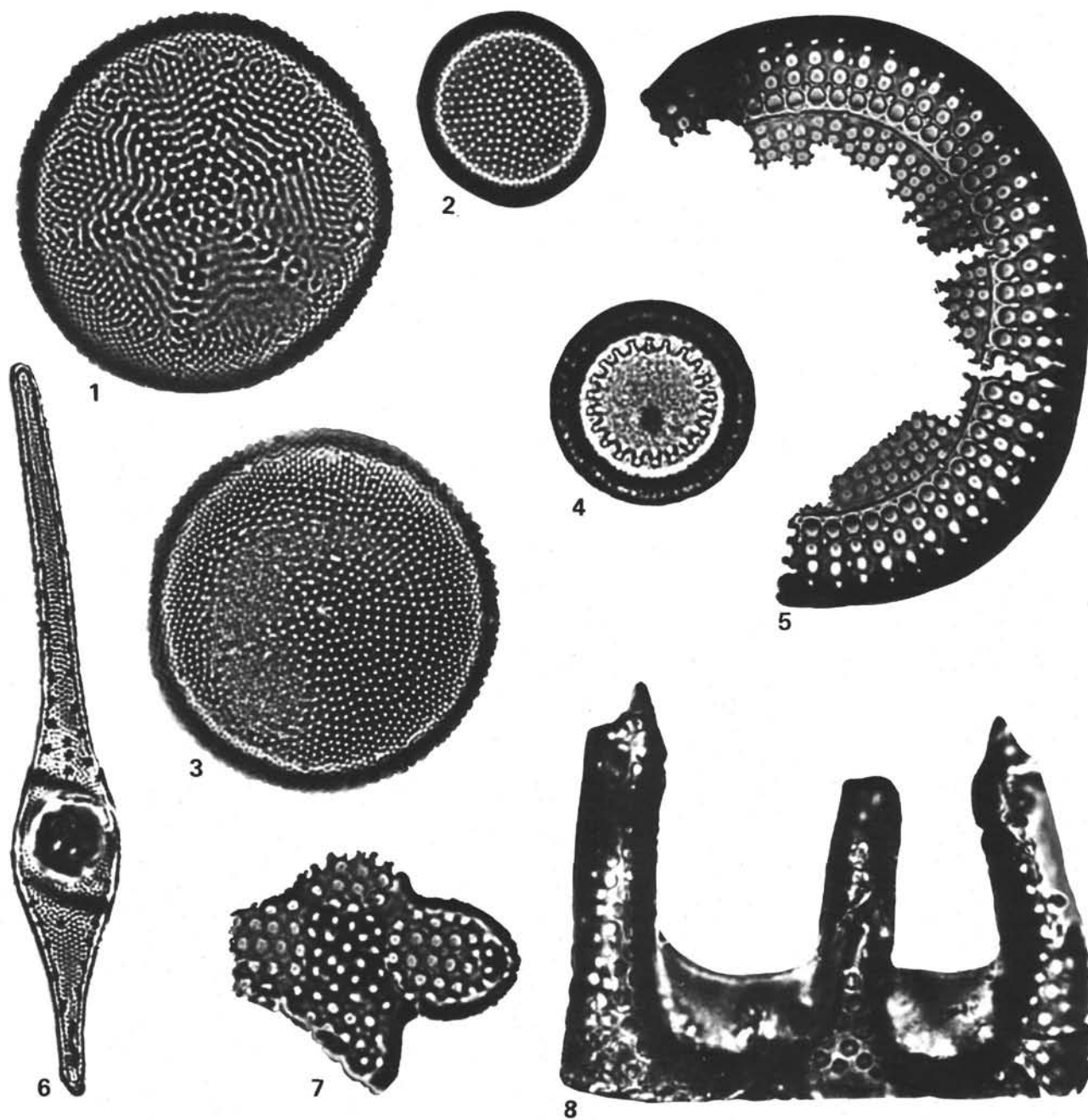


Plate 2. (All figures magnified  $1500\times$ .) 1-3. *Actinocyclus ehrenbergii* var. *tenella* (Bréb.) Hustedt, (1) Moron deposit, Coll. Greville, B.M. slide 3235, (2) Coll. Greville, B.M. slide 3396, (3) Coll. Tulk, B.M. slide 53516. 4. *Paralia* sp., DSDP Sample 112-9-2, 70-71 cm. 5. Genus et species indet. 2, DSDP Sample 220-14-3, 121-126 cm. 6. *Rutilaria* sp., DSDP 357-24-5, 84-85 cm. 7. *Triceratium* sp. 1, DSDP Sample 220-14-3, 121-126 cm. 8. Genus et species indet. 1, DSDP Sample 289-99-2, 62-67 cm.