

11. NEOGENE AND QUATERNARY SILICOFLLAGELLATES FROM THE CENTRAL PACIFIC OCEAN (DSDP LEG 33)

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INTRODUCTION

During Leg 33 of the Deep Sea Drilling Project five sites (314 to 318) were occupied and eight holes drilled between Hawaii and Tahiti in the Central Pacific Ocean. Material from two sites (315 and 316) yielded silicoflagellates and diatoms sufficient for detailed investigation, whereas the recovered sediments from Sites 314, 317, and 318 are barren of silicoflagellates.

Increased interest in silicoflagellate biostratigraphy and systematics in the last few years is indicated by a large number of papers dealing with this subject, most of them based on material recovered by the Deep Sea Drilling Project. Since the first investigation of continuous deep-sea sequences (Martini, 1971a, b), the knowledge of the distribution and diversity of silicoflagellate assemblages has been considerably broadened, especially through the studies of Bukry (1973a-d, 1974a, b); Dumitrica (1973a, b); and Ling (1970, 1972, 1973) on the basis of deep-sea material, and Bachmann (1970, 1971a, b) and Martini (1972a, b, 1974) on the basis of land sections and localities. The systematics of silicoflagellates, on the other hand, shows little improvement. This is indicated by the use of a variety of names for the same taxa as a result of badly figured species, overemphasis of aberrant forms, and unknown or insufficient data on localities and their stratigraphic position. Fortunately, the Ehrenberg collection, which encompasses a large number of silicoflagellates, survived the last war and is now housed in the Museum für Naturkunde der Humboldt-Universität in Berlin. An investigation and documentation of the type material have been completed and will be published in the near future by Locker. It is hoped that the paper by Locker will clear up many of the misinterpretations and uncertainties in the silicoflagellate field.

LOCALITIES AND ASSEMBLAGES RECOVERED

Geographical positions of the DSDP sites drilled during Leg 33 are as follows (see also Figure 1):

Site 314	lat 15°54.76'N, long 168°28.07'W, water depth 5213 meters
Holes 315, 315A	lat 4°10.26'N, long 158°31.52'W, and 158°31.54'W, water depth 4152 meters
Site 316	lat 0°05.44'N, long 157°07.71'W, water depth 4451 meters
Holes 317, 317A, 317B	lat 11°00.09'S, long 162°15.78'W, water depth 2598 meters
Site 318	lat 14°49.63'S, long 146°51.51'W, water depth 2641 meters

As noted above, only the equatorial Sites 315 and 316 yielded silicoflagellates in the upper part of the drilled sections.

In Hole 315 silicoflagellates occur in varying numbers in all cores, indicating the presence of the *Dictyocha*

aculeata Zone (Core 1), *Mesocena quadrangula* Zone (Cores 2 and 3), and *Dictyocha fibula* Zone (Core 4). In Hole 315A silicoflagellates were encountered down to Core 5, with the *Dictyocha fibula* Zone present in Cores 1 and 2, the *Dictyocha rhombica* Zone in Core 3 and possibly in Core 4, and the *Dictyocha triacantha* Zone (?) in Core 5. With the decrease of the diatom population in Core 4 and below Core 5, silicoflagellates become extremely rare or disappear. The population in samples from Core 5 is rather small and monotonous, and the tentative placement in the *Dictyocha triacantha* Zone is deduced from the nannoplankton Zone NN 5 (*Sphenolithus heteromorphus* Zone), which is present at this interval.

At Site 316 silicoflagellates occur commonly only in Cores 1 to 3, and as usual, are associated with diatoms (Plate 2, Figures 7, 8). The assemblages are of low diversity owing to the equatorial position of Site 316. The *Dictyocha aculeata* Zone and *Mesocena quadrangula* Zone are present in Core 1, and the *Dictyocha rhombica* Zone has been identified in Core 2 and the upper part of Core 3. In Core 3 an unconformity with several nannoplankton zones missing marks the lowest common occurrence of silicoflagellates. Below, only a single specimen of *Dictyocha* cf. *rhombica* was found in Core 3, Section 2 at 30-31 cm, and probably belongs in the *Dictyocha triacantha* Zone as indicated by the nannoplankton of this particular sample. Correlation of Sites 315 and 316 and silicoflagellates identified in samples from these sites are shown in Figure 2 and Tables 1 and 2.

NEOGENE AND QUATERNARY SILICOFLLAGELLATE ZONATION AND COMPARISON WITH ZONATIONS OF OTHER FOSSILS GROUPS IN THE PRESENT MATERIAL

The silicoflagellate zonation used during Leg 33 has been described in detail by Martini (1971a, b, 1972a, b) with the additional *Dictyocha aculeata* Zone described by Dumitrica, 1973, and includes the following zones from top to bottom:

- Dictyocha aculeata* Zone (base = last *M. quadrangula*)
- Mesocena quadrangula* Zone (base = first *M. quadrangula*)
- Dictyocha fibula* Zone (base = change in frequency of *D. rhombica* and *D. fibula*; *D.f.* > *D.r.*)
- Dictyocha rhombica* Zone (base = last *D. triacantha*)
- Dictyocha triacantha* Zone (base = last *N. quadrata*)

As shown in Figure 3, a number of silicoflagellate zonations have been applied in different areas by various authors, indicating somewhat better time resolution in the Northern Pacific (Ling, 1973) and Eastern

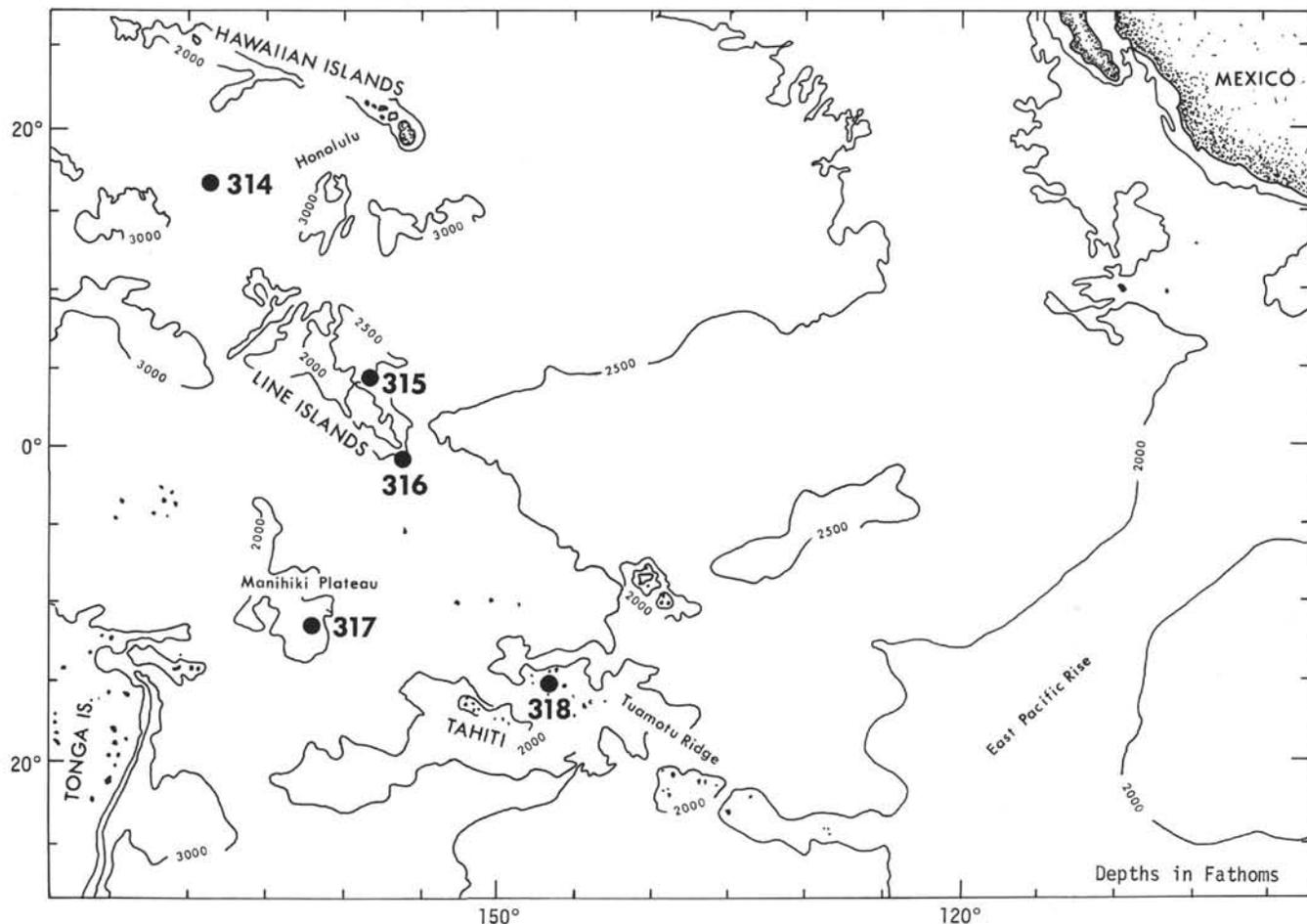


Figure 1. Sites occupied during Leg 33 in the Central Pacific Ocean. Silicoflagellates were encountered only at Sites 315 and 316.

Pacific (Bukry and Foster, 1973) than in the Central Pacific (Martini, 1971a, b, present paper) or Europe (Sanfilippo et al., 1973). However, all silicoflagellate zonations show a surprisingly low resolution in the upper Miocene, as does the nannoplankton zonation, in which the *Discoaster quinqueramus* Zone (NN 11) encompasses a time interval of approximately 4.5 m.y., and in which only recently some additional species suitable for a further subdivision have been found in certain areas. Also, the reported occurrences of some species (e.g., *D. pseudofibula*) in deep-sea cores lead to the suspicion that they have a wedge-shaped occurrence in a time/space model.

Although the silicoflagellate occurrences at Sites 315 and 316 cover only the late Miocene to Quaternary interval, and cores are irregularly spaced, some correlations with other fossil groups are possible in the present material. According to revised shipboard identifications and Schrader (this volume), the base of the *Dictyocha aculeata* Zone is in the higher part of Zone NN 19 (*Pseudoemiliana lacunosa* Zone) of the standard nannoplankton zonation (Martini, 1971a, b) and in the upper part of the diatom *Nitzschia reinholdii* Zone (Burckle, 1972). The base of the *Mesocena quadrangula* Zone is within an uncored interval, and no correlations are available. The base of the *Dictyocha fibula* Zone (*D.*

rhombica/*D. fibula datum*) was found to be within standard nannoplankton Zone NN 11 (*Discoaster quinqueramus* Zone), within the foraminiferal *Globorotalia acostaensis* Zone (N16), within the radiolarian *Ommatartus antepenultimus* Zone, and in the lower part of the diatom *Nitzschia porteri* Zone. Earlier correlation of the base of the *D. fibula* Zone (Martini, 1971a, b) to the nannoplankton zonation was based on samples from the Swedish Deep Sea Expedition Station 76. However, reexamination of Sample 509-509.5 cm revealed rare specimens of *Discoaster quinqueramus* and early forms of *Ceratolithus tricorniculatus*, indicating that this sample belongs in Zone NN 11 (*Discoaster quinqueramus* Zone) rather than Zone NN 10 (*Discoaster calcaris* Zone). Therefore, the old correlations have to be corrected inasmuch as the base of the *Dictyocha fibula* Zone is in the lower part of nannoplankton Zone NN 11 (*Discoaster quinqueramus* Zone). The base of the *Dictyocha rhombica* Zone in Hole 315A is within an uncored interval and at Site 316 is obscured by an unconformity with several nannoplankton zones missing.

SILICOFLAGELLATE SURFACE ORNAMENTATION

Surface ornamentation of Neogene and Quaternary silicoflagellates has been described by several authors

TABLE 1
Distribution of Silicoflagellates at Site 315

Sample (Interval in cm)	<i>Dictyocha aculeata</i>	<i>Dictyocha ausonia</i>	<i>Dictyocha cf. ausonia</i>	<i>Dictyocha crux</i>	<i>Dictyocha fibula</i>	<i>Dictyocha medusa</i>	<i>Dictyocha messanensis</i>	<i>Dictyocha rhombica</i>	<i>Dictyocha speculum</i>	<i>Mesocena quadrangula</i>	Silicoflagellate Zones
1-2, 24-25	17				5		3	1			<i>Dictyocha aculeata</i>
1-4, 2-3	7				3		1				
1-6, 100-101	1										
1, CC	4						4				
2, CC					10		3				<i>Mesocena quadrangula</i>
3, CC					7				1		
4-1, 140-141					21						<i>Dictyocha fibula</i>
4-2, 1-2					10						
4-3, 30-31					20			1			
1A-1, 136-137		1			6						
1A-2, 70-71		1			22			1	2		
1A, CC					3						
2A-1, 80-81					46	2		4	1		
2A, CC	1				7				1		
3A-1, 35-36								10			<i>Dictyocha rhombica</i>
3A-2, 140-141							1	43			
3A, CC							1	8	2		
4A-1, 100-101								2			
5A-1, 45-46	28	2						3			<i>Dictyocha triacantha</i>
5A-2, 120-121	2						1	6			
5A, CC							1	8			

Note: Numbers refer to specimens found in 10 rows of approximately 30mm length on a routine smear slide viewed with an ocular 12.5X and an objective 25X.

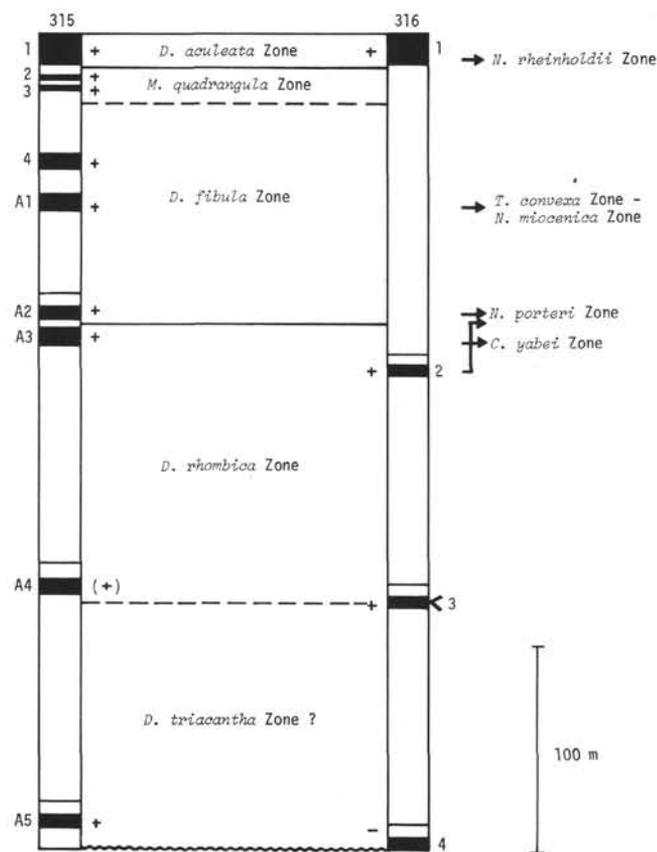


Figure 2. Correlation of Sites 315, 315A, and 316 based on silicoflagellates, indication of silicoflagellate zones (Martini, 1971) and position of certain samples in the East Pacific diatom zonation (Burckle, 1972). + = silicoflagellates common, (+) = rare, - = missing, < = unconformity.

(e.g., Deflandre, 1950; Jerković, 1969; Bachmann and Keck, 1969) as being a network of crests and depressions in most species investigated. Some are shown to lack surface ornamentation like some specimens in the aberrant genus *Deflandryocha* (Jerković, 1969) or have only knots on the surface of the skeleton like in *Dictyocha* (= *Distephanus*) *speculum* (Wornardt, 1971). Neogene and Quaternary silicoflagellates recovered during Legs 7 and 33 in the equatorial Pacific in nearly all specimens examined under the scanning electron microscope show no signs of crests and depressions, but exhibit small knots on an otherwise smooth surface, and include the following species: *Dictyocha aculeata* (Plate 2, Figures 3a, b); *Dictyocha messanensis* (Plate 2, Figures 2a, b); *Dictyocha fibula* (Plate 2, Figure 4); *Dictyocha rhombica* (Plate 2, Figure 6); and *Mesocena quadrangula* (Plate 2, Figures 5a, b). Only a single specimen of *Dictyocha fibula* shows faint surface ornamentation of crests and depressions (Plate 2, Figures 1a, b). Comparative material from Sepulveda (Los Angeles, California) shows the netlike surface ornamentation in *Dictyocha fibula* and ornamentation by small knots in *Dictyocha speculum*, *Dictyocha pseudofibula*, and *Mesocena circulus*. Bachmann and Keck (1969, p. 206) discussed the problems of origin of the surface ornamentation and seem to favor the idea that skeletons of adult

silicoflagellate cells show well-developed surface ornamentation whereas juvenile skeletons only show weak ornamentation or lack the netlike ornamentation, an opinion which is also expressed in Jerković (1969). Applied to the equatorial Pacific populations, this would mean that only a few skeletons are from adult cells, whereas the bulk of the former populations was built up by juvenile cells. However, observations in the equatorial Pacific, California, and the Norwegian Sea indicate a dependence of the presence of surface structures in isolated skeletons on temperature, presence of calcareous ingredients in the bottom sediments, and, most importantly, on solution. Details will be published elsewhere.

SYSTEMATIC PALEONTOLOGY

The systematic paleontology of silicoflagellates is in a rather chaotic state, as there is considerable confusion about species names owing to poor illustration and description by early authors as well as to insufficient data on the stratigraphic position of samples from which silicoflagellates were described. Fortunately the famous Ehrenberg collection survived the war. Most of Ehrenberg's silicoflagellate species are recognizable and are photographed, redrawn, and redescribed by Locker (personal communication). It seems that originals of quite a few species do not correspond to the common use of names in the more recent literature (Locker, personal communication). To avoid further confusion, species names and concepts

TABLE 2
Distribution of Silicoflagellates at Site 316

Sample (Interval in cm)	Silicoflagellate Zones									
	<i>Dictyocha aculeata</i>	<i>Dictyocha cf. aculeata</i>	<i>Dictyocha ausonia</i>	<i>Dictyocha cf. crux</i>	<i>Dictyocha fibula</i>	<i>Dictyocha medusa</i>	<i>Dictyocha messanensis</i>	<i>Dictyocha rhombica</i>	<i>Dictyocha speculum</i>	<i>Mesocena quadrangula</i>
1-1, 120-121	48				3		5			<i>Dictyocha aculeata</i>
1-2, 33-34	34				1		22			
1-4, 5-6	25	1			7		34			
1-4, 70-71	13						8			
1-6, 75-76	30				2		21			
1, CC	4	1					2		1	<i>Mesocena quadrangula</i>
2-1, 70-71			3		14	2	93	5		<i>Dictyocha rhombica</i>
2-1, 135-136			5		2		29	3		
2-2, 30-31					5	1	47	1		
2-2, 125-126				1	1		34	2		
2, CC					5	2	115	6		
3-1, 120-121							19			<i>Dictyocha triacantha</i>
3-2, 30-31							1			

Note: See footnote in Table 1 for explanation of numbers.

used in this paper (e.g., *D. fibula*, *D. rhombica*) are the same as those in Martini, 1971, but some will probably have to be changed after the redescription of the Ehrenberg material is available.

References to the original descriptions and possible synonyms, or to more recent descriptions or illustrations of particular species are limited to a minimum, and only some remarks or short discussions are given.

Genus DICTYOCHA Ehrenberg, 1839

Dictyocha aculeata (Lemmermann) (Plate 1, Figure 2; Plate 2, Figures 3a, b)

Dictyocha fibula var. *aculeata* Lemmermann, 1901, p. 261, pl. 11, fig. 1, 2.

Dictyocha fibula "var." *aculeata* Lemmermann, in Ling, 1970, p. 91, pl. 18, fig. 11-13.

Dictyocha fibula Ehrenberg s.l., pro parte in Martini, 1971b, p. 1696, pl. 1, fig. 5.

Dictyocha epidodon Ehrenberg, in Bukry and Foster, 1973, p. 826, pl. 2, fig. 7, 8.

Remarks: In the equatorial Pacific this species has its lowest occurrence in the upper part of the *Mesocena quadrangula* Zone and in standard nannoplankton Zone NN19, which is in good agreement with the range published by Ling, 1972, as occurring in the foraminifer Zone N 22 to Recent. It is the most common form in the late Pleistocene to Recent samples.

Dictyocha cf. aculeata (Lemmermann) (Plate 1, Figure 3)

Remarks: A single specimen showing eight short secondary spines pointing outwards instead of four on the basal ring was found in Sample 316-1-4, 5-6 cm (*D. aculeata* Zone). It represents most likely an aberrant specimen of *D. aculeata*.

Dictyocha ausonia Deflandre (Plate 1, Figures 15-18)

Dictyocha ausonia Deflandre, 1941, p. 101, fig. 8-11, 13.

Dictyocha rhombica (Schulz) s.l., in Martini, 1971b, p. 1697, pl. 1, fig. 9, 10.

Dictyocha ausonia Deflandre, in Ling, 1972, p. 159, pl. 25, fig. 1-10.

Remarks: *D. ausonia* Deflandre and *D. mutabilis* Deflandre seem to occur in similar strata, and according to Deflandre can be differen-

tiated by their size and surface ornamentation. However, the great variation of *D. ausonia* leading to navicular forms discussed as *D. cf. ausonia* below, and the similar trend in *D. mutabilis* seem to indicate the identity of the two species. In *D. ausonia* the apical bar is longer than the connecting rods to the basal ring, whereas in *D. rhombica* both are of approximately equal length. Present in the *D. triacantha* Zone (?) of Hole 315A, in the *D. rhombica* Zone of Site 316, and in the *D. fibula* Zone (one specimen) of Hole 315A. An intermediate form between *D. rhombica* and *D. ausonia* was encountered in Sample 316-1, CC (*M. quadrangula* Zone) and is tentatively included here.

Dictyocha cf. ausonia Deflandre (Plate 1, Figures 19-20)

Remarks: Navicular forms which are within the range of *D. ausonia* and *D. mutabilis* according to Deflandre (1950) were found in two specimens in the *D. fibula* Zone of Hole 315A, but are not associated with good *D. ausonia* specimens, the last of which was found some 50 meters below the occurrences of the navicular forms (Table 2 and Figure 2).

Dictyocha crux Ehrenberg (Plate 1, Figure 7)

Dictyocha crux Ehrenberg, 1840, p. 207.

Distephanus crux (Ehrenberg), in Ling, 1972, p. 164, pl. 26, fig. 9-16.

Remarks: Only two specimens with relatively long radial spines along the major axis were observed in Sample 315A-5-1, 45-46 cm in the possible *D. triacantha* Zone. The calcareous nannoplankton indicate Zone NN 5 (*Sphenolithus heteromorphus* Zone) for this particular sample. Identical specimens are present in the Luisian and Lower Mohnian of California and in the Experimental Mohole (Ling, 1972; Martini, 1972a).

Dictyocha cf. crux Ehrenberg (Plate 1, Figure 4)

Remarks: In Sample 316-2-2, 125-126 cm a single specimen similar to *D. crux* was encountered in a population which is dominated by *Dictyocha rhombica*. As the apical ring is extremely small, the outline of the basal ring and length of spines are identical with the *D. rhombica* specimens present in the same sample; this specimen is only tentatively included in *D. crux*.

Dictyocha fibula Ehrenberg (Plate 1, Figures 9, 10, 12; Plate 2, Figures 1, 4)

Dictyocha fibula Ehrenberg, 1840, p. 129

Dictyocha fibula Ehrenberg s.l., pro parte in Martini, 1971b, p. 1696, pl. 1, fig. 4, 6-7.

Dictyocha fibula Ehrenberg, in Ling, 1972, p. 160, pl. 25, fig. 11-15.

Remarks: Typical specimens of this species are common in the *D. fibula* Zone and are also present to lesser extent in the *D. rhombica* Zone and in the *M. quadrangula* Zone. Larger specimens (Plate 1, Figure 12) occur occasionally in the *D. fibula* population, and show no difference other than in size as compared with the "normal" forms. However, most *fibula*-like specimens encountered in the overlying *M. quadrangula* Zone and *D. aculeata* Zone tend to have a more quadrate basal ring (pl. 1, fig. 9), and radial spines of equal length, thus being similar to forms called *D. fibula* var. *messanensis* (Haeckel) by Ling, 1972 (p. 161, pl. 25, fig. 18, 19) and are included in *Dictyocha messanensis*.

Dictyocha medusa Haeckel (Plate 1, Figures 5, 6)

Dictyocha medusa Haeckel, 1887, p. 1560, pl. 101, fig. 13, 14.

Dictyocha medusa Haeckel, in Martini, 1971b, p. 1696, pl. 1, fig. 3.

Dictyocha medusa Haeckel, in Bukry and Foster, 1973, p. 827, pl. 3, fig. 4, 5.

Remarks: Rare specimens corresponding to that figured on Plate 1, Figure 6 occur in the *D. rhombica* Zone at Hole 315A and Site 316, but were also found in the lower part of the *D. fibula* Zone and in the *D. triacantha* Zone (?) of Hole 315A. The cf.-specimen (Plate 1, Figure 5) from Sample 316-2-2, 30-31 cm (*D. rhombica* Zone) has a more rectangular outline and the supporting spines on the basal ring are more prominent than in the common form.

		Equatorial Pacific (Martini 1971)	Europe (Martini 1973 and Sanfilippo et al. 1973)	Eastern Pacific (Bukry & Foster 1973)	Eastern North Pacific (Bukry 1973)
Quat.	NN21	Mesocena quadrangula Zone		<i>D. epidon</i> Zone	<i>C. octangulatus</i> Zone
	NN20 NN19			<i>M. elliptica</i> Zone	
Pliocene	Upper			<i>D. boliviensis</i> Zone	<i>D. speculum</i> Zone
	NN18 NN17 NN16			<i>C. major</i> Zone	
	Lower			NN15 NN14 NN13	
Miocene	Upper	<i>Dictyocha fibula</i> Zone	<i>D. fibula</i> Zone	<i>D. cruz</i> Zone	<i>D. pseudofibula</i> Zone
	NN11	<i>Dictyocha pseudofibula</i> Horizon			
	Middle	<i>Dictyocha rhombica</i> Zone	<i>D. rhombica</i> Zone	<i>D. longispinus</i> Zone	<i>D. longispinus</i> Zone
	NN10 NN9 NN8 NN7	<i>Dictyocha octacantha</i> Horizon			
	Lower	<i>Corbisema triacantha</i> Zone	<i>C. triacantha</i> Zone	<i>C. triacantha</i> Zone	<i>C. triacantha</i> Zone
	NN6 NN5				
	Lower	NN4 NN3 NN2	<i>N. navicula</i> Zone		
	01igoc.	NN1	<i>N. lata</i> Zone		

Figure 3. Correlation of silicoflagellate zonations used in different parts of the Pacific Ocean and in Europe, and indication of equivalent nannoplankton zones.

Dictyocha messanensis Haeckel
(Plate 1, Figure 9; Plate 2, Figures 2a, b)

Dictyocha messanensis Haeckel in Peters, 1860, p. 799 (pl. 12, fig. 3-6 in Haeckel, 1862, fide Loeblich et al., 1968).
Dictyocha fibula var. *messanensis* (Haeckel), in Ling, 1972, p. 161, pl. 25, fig. 18, 19.

Remarks: A single specimen was found during scanning electron microscope examination of Sample 316-1-4, 5-6 cm (*D. aculeata* Zone), showing the broken base of a spine on the apical bar (Plate 2, Figures 2a, b). As mentioned under *D. fibula*, most specimens in the *M. quadrangula* Zone and *D. aculeata* Zone differ from *D. fibula* in having a more quadrate basal ring and radial spines of equal length (Plate 1, Figure 9), and are included here, although only in a very few specimens a spine on the apical bar seemed to be present when studied with the light microscope.

Dictyocha rhombica (Schulz)
(Plate 1, Figures 11, 13, 14; Plate 2, Figure 6)

Dictyocha rhombica (Schulz), in Deflandre, 1941, p. 101, fig. 1-7.
Dictyocha rhombica (Schulz), in Martini, 1971b, p. 1696, pl. 1, fig. 8.

Remarks: Although common in the *D. rhombica* Zone and also present to a lesser extent in the *D. triacantha* Zone and *D. fibula* Zone, this species with a horizontal apical bar is among the most disputed forms, and it seems to be identical with *D. aspera* of some authors. Data from the original material of the Ehrenberg collection even indicate that the type of *D. fibula* has a horizontal bar and not a vertical bar as commonly accepted (Locker, personal communication). In the present paper specimens with a horizontal apical bar approximately equivalent in length to the lateral rods are included in "*D. rhombica*."

Specimens encountered in Hole 315A, Core 5 (*D. triacantha* Zone ?) are generally larger than those from the *D. rhombica* Zone. A single aberrant specimen (Plate 1, Figure 11) similar to *D. triacantha* Ehrenberg was found among 93 counted specimens on a smear slide of Sample 316-2-1, 70-71 cm.

Dictyocha speculum Ehrenberg
(Plate 1, Figure 8)

Dictyocha speculum Ehrenberg, 1839, p. 129, pl. 4, fig. Xn.
Dictyocha speculum Ehrenberg, in Martini, 1971b, p. 1696, pl. 1, fig. 13, 14.
Distephanus speculum (Ehrenberg), in Ling, 1972, p. 166, pl. 26, fig. 23, 24, pl. 27, fig. 1, 2.

Remarks: Specimens found in small numbers in the *D. rhombica* Zone of Hole 315A and Site 316 and in the *D. fibula* Zone of Hole 315A show a relatively large apical ring and two opposite basal spines much longer than the remaining ones.

Genus MESOCENA Ehrenberg 1843

Mesocena quadrangula Haeckel
(Plate 1, Figure 1; Plate 2, Figures 5a, b)

Mesocena quadrangula Haeckel, 1887, p. 1556.
Mesocena polymorpha var. *quadrangula* Haeckel, in Lemmermann, 1901, pl. 10, fig. 5-7.
Mesocena cf. *elliptica* Ehrenberg, pro parte in Ling, 1970, p. 100, pl. 20, fig. 13, 14.
Mesocena quadrangula Ehrenberg ex Haeckel, in Martini, 1971b, p. 1969, pl. 1, fig. 2.

		Northern Pacific (Ling 1973)	Southwestern Pacific (Dumitrica 1973)	Central Pacific (Martini 1975)		
Quat.	NN21	<i>D. ootanguatus</i> Zone	<i>D. aculeata</i> Zone	<i>D. aculeata</i> Zone		
	NN20	<i>D. otonarius</i> Zone				
	NN19	<i>D. subarcticus</i> Zone				
Pliocene	Upper	NN18	<i>M. cf. elliptica</i> Zone	<i>M. quadrangula</i> Zone		
		NN17				
		NN16				
	Lower	NN15		<i>D. perlaevis</i> Zone	<i>D. fibula</i> Zone	
		NN14				
		NN13				
Miocene	Upper	NN12	<i>D. f. aspera</i> Zone			<i>D. rhombica</i> Zone
		NN11				
		NN10				
	Middle	NN9	<i>C. triacantha</i> Zone	<i>D. triacantha</i> Zone		
		NN8				
		NN7				
Lower	NN6	<i>D. schauinslandii</i> Zone				
	NN5					
	NN4					
0119oc.	NN3	<i>Mesocena circulus</i> <i>apiculata</i> Zone	<i>D. f. aspera</i> Zone	<i>D. rhombica</i> Zone		
	NN2					
	NN1					

Figure 3. (Continued).

"*Mesocena*" cf. *elliptica* Ehrenberg, in Dumitrica, 1973b, p. 850, pl. 6, fig. 1.

?*Mesocena elliptica* Ehrenberg, pro parte in Bukry and Foster, 1973, p. 828, tab. 3.

Remarks: The "*Mesocena elliptica* complex" of various authors obviously contains quite different forms and needs further study and proper differentiation. Specimens considered here show a rounded to quadrate ring with irregularly scattered knots on the surface (Plate 2, Figures 5a, b) clearly seen in the light microscope, and four prominent spines of equal length, arranged along the long and short axis. Further, it seems to be a stratigraphically useful species with a range restricted to the late Pliocene and most of the Pleistocene. Its last occurrence seems to be in the upper part of standard nannoplankton Zone NN19 (*Pseudoemiliana lacunosa* Zone) and in the upper part of the diatom *Nitzschia reinholdii* Zone in the Central Pacific. It was also noted by Dumitrica (1973b) in the early Pleistocene of the southwest Pacific and is present in the Western Indian Ocean (DSDP 241) in the basal *Gephyrocapsa oceanica* Zone (NN 20).

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PLATE 1

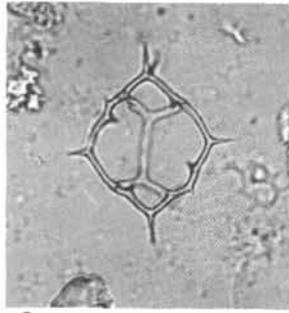
All specimens approximately $\times 450$

- Figure 1 *Mesocena quadrangula* Haeckel.
Sample 315-3, CC, *M. quadrangula* Zone.
- Figure 2 *Dictyocha aculeata* (Lemmermann).
Sample 316-1-4, 70-71 cm, *D. aculeata* Zone.
- Figure 3 *Dictyocha* cf. *aculeata* (Lemmermann).
Sample 316-1-4, 5-6 cm, *D. aculeata* Zone.
- Figure 4 *Dictyocha* cf. *crux* Ehrenberg.
Sample 316-2-2, 125-126 cm, *D. rhombica* Zone.
- Figure 5 *Dictyocha* cf. *medusa* Haeckel.
Sample 316-2-2, 30-31 cm, *D. rhombica* Zone.
- Figure 6 *Dictyocha medusa* Haeckel.
Sample 316-2-1, 70-71 cm, *D. rhombica* Zone.
- Figure 7 *Dictyocha crux* Ehrenberg.
Sample 315A-5-1, 45-46 cm, *D. triacantha* Zone
(?).
- Figure 8 *Dictyocha speculum* Ehrenberg.
Sample 316-2-1, 135-136 cm, *D. rhombica* Zone.
- Figure 9 *Dictyocha messanensis* Haeckel.
Sample 316-1-4, 5-6 cm, *D. aculeata* Zone.
- Figure 10 *Dictyocha fibula* Ehrenberg.
Sample 315A-2, CC, *D. fibula* Zone.
- Figure 11 *Dictyocha rhombica* (Schulz), aberrant specimen.
Sample 316-2-1, 70-71 cm, *D. rhombica* Zone.
- Figure 12 *Dictyocha fibula* Ehrenberg, large form.
Sample 315-3, CC, *M. quadrangula* Zone.
- Figures 13, 14 *Dictyocha rhombica* (Schulz).
13. Sample 316-2-1, 70-71 cm, *D. rhombica* Zone.
14. Sample 315A-3-1, 35-36 cm, *D. rhombica* Zone.
- Figures 15-18 *Dictyocha ausonia* Deflandre.
15. Sample 316-1, CC, *M. quadrangula* Zone.
16. Sample 316-2-1, 135-136 cm, *D. rhombica* Zone.
17, 18. Sample 315A-5-1, 45-46 cm, *D. triacantha* Zone
(?).
- Figures 19, 20 *Dictyocha* cf. *ausonia* Deflandre.
19. Sample 315A-1-1, 136-137 cm, *D. fibula* Zone.
20. Sample 315A-1-2, 70-71 cm, *D. fibula* Zone.

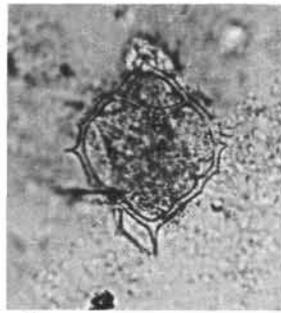
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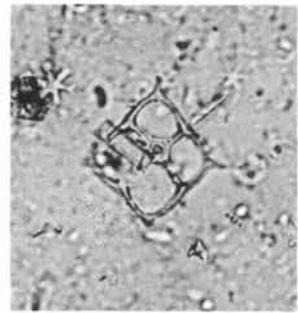
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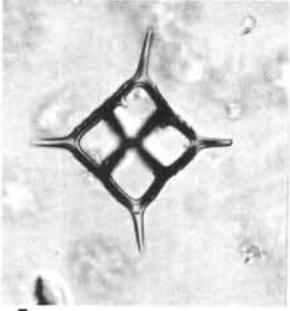
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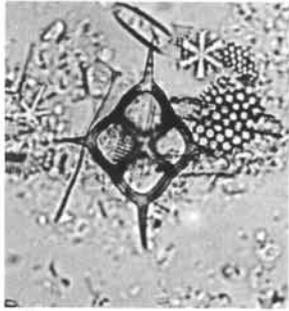
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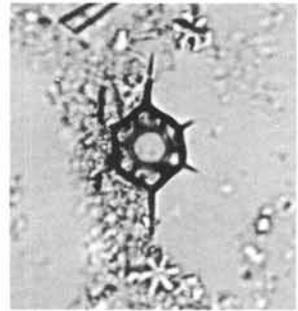
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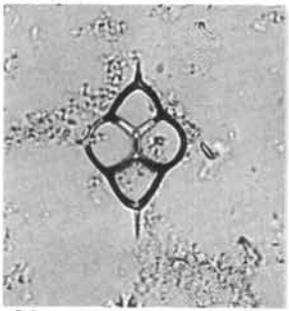
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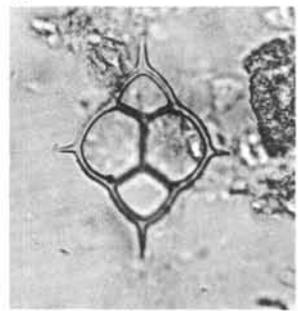
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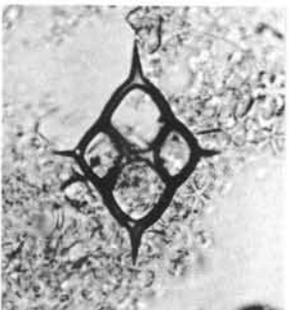
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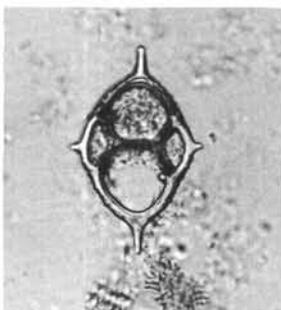
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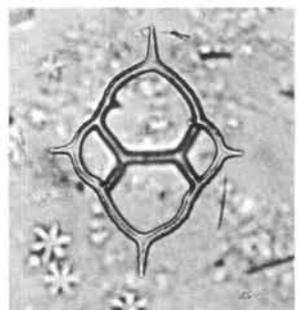
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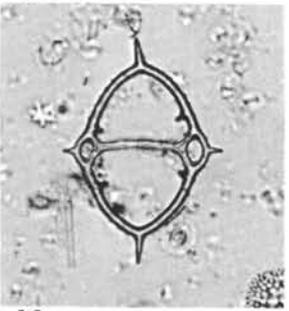
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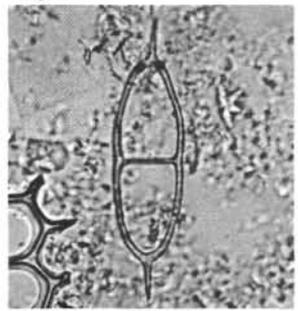
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18



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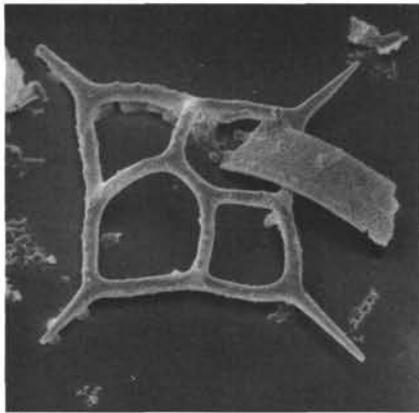


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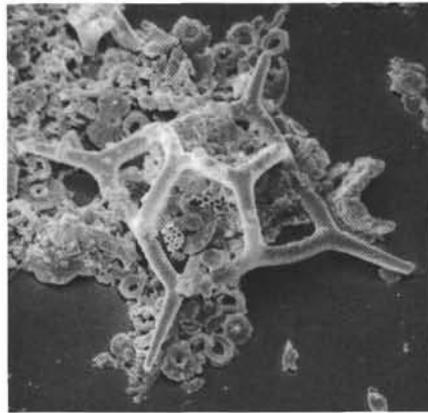
PLATE 2

- Figure 1 *Dictyocha fibula* Ehrenberg.
Sample 315A-2-1, 80-81 cm, *D. fibula* Zone.
1a. SEM 1300×, 1b. SEM 3250×.
- Figure 2 *Dictyocha messanensis* Haeckel.
Sample 316-1-4, 5-6 cm, *D. aculeata* Zone.
2a. SEM 1300×. 2b. SEM 6500×.
- Figure 3 *Dictyocha aculeata* (Lemmermann).
Sample 316-1-4, 5-6 cm, *D. aculeata* Zone.
3a. SEM 1300×. 3b. SEM 6500×.
- Figure 4 *Dictyocha fibula* Ehrenberg. SEM 1300×.
Sample 316-1-4, 5-6 cm, *D. aculeata* Zone.
- Figure 5 *Mesocena quadrangula* Haeckel.
Sample 66-A1-2, top, *M. quadrangula* Zone.
5a. SEM 1300×. 5b. SEM 3250×.
- Figure 6 *Dictyocha rhombica* (Schulz). SEM 1200×.
Sample 66-2-2, 140-141 cm, *D. rhombica* Zone.
- Figure 7 *Coscinodiscus* sp. SEM 1080×.
Sample 315A-2-1, 80-81 cm, *D. fibula* Zone.
- Figure 8 *Roperia tessellata* (Roper). SEM 650×.
Sample 316-1-4, 5-6 cm, *D. aculeata* Zone.

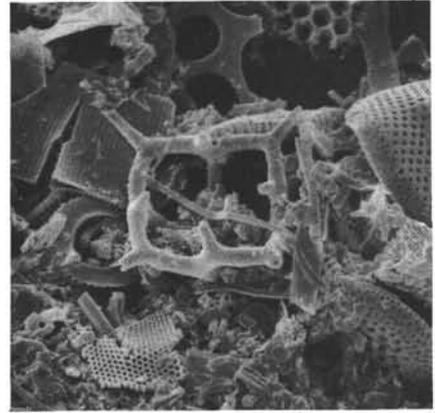
PLATE 2



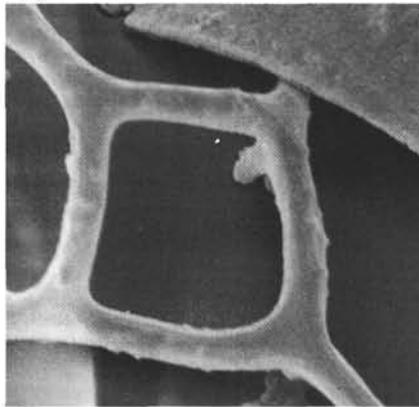
1a



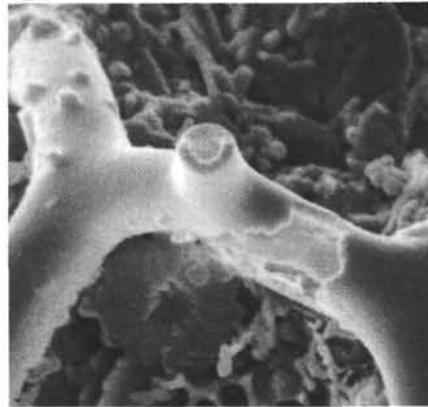
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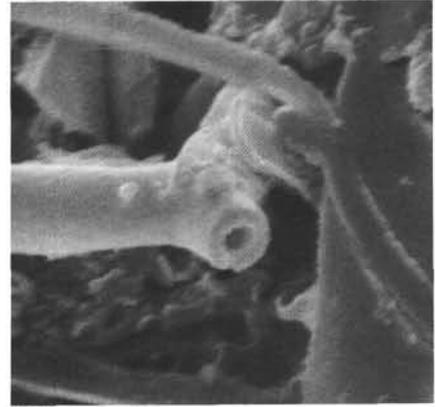
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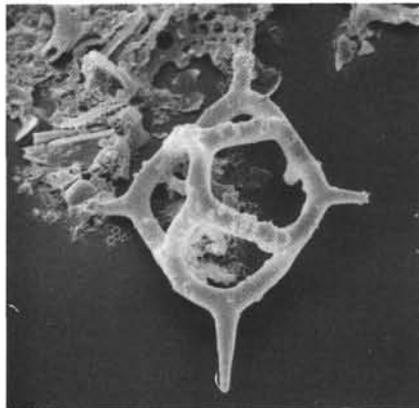
1b



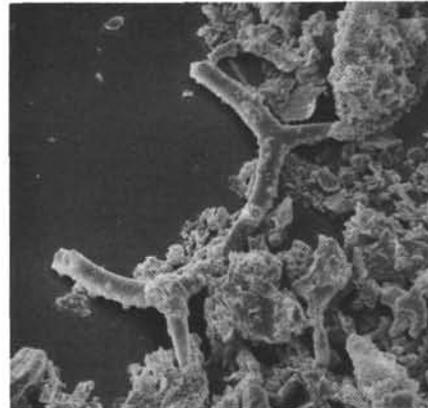
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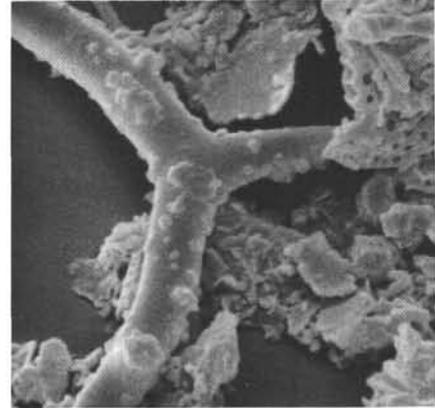
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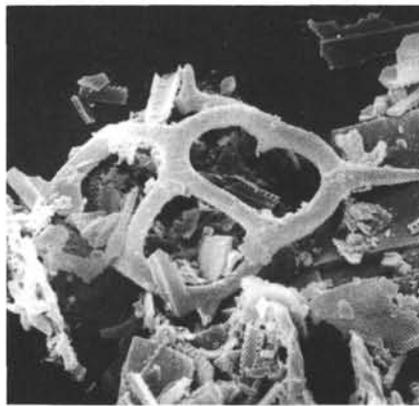
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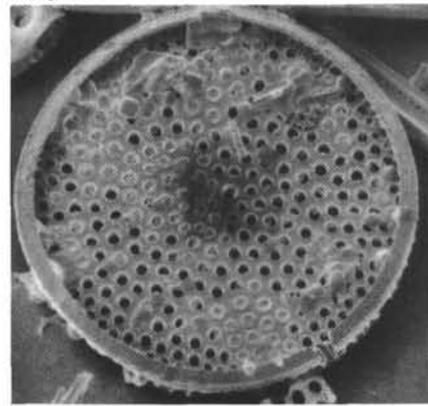
5a



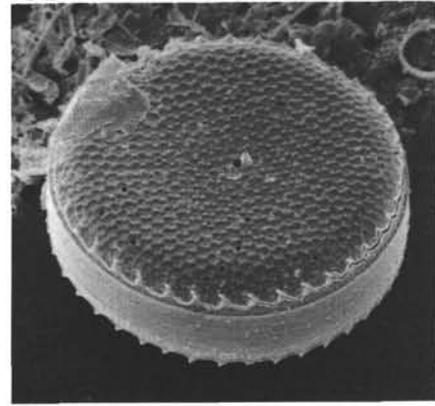
5b



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7



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