

21. SILICOFAGELLATE BIOSTRATIGRAPHY AND PALEOECOLOGY IN THE EASTERN EQUATORIAL PACIFIC, DEEP SEA DRILLING PROJECT LEG 54

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INTRODUCTION

Leg 54 of the Deep Sea Drilling Project was designed to study young oceanic igneous rocks and associated geochemical phenomena in the tropical eastern Pacific Ocean. Several upper Pliocene to Quaternary biogenous sediment sections were cored incidentally to the primary igneous coring program. Two of the sites (Sites 424 and 425) are in the southern part of the Panama Basin on the flanks of the Galapagos spreading center. The others are clustered on the western flank of the East Pacific Rise at the junction of the Siqueiros fracture zone (Figure 1). The sediment sections of the Siqueiros area, Sites 419 through 423 and 427 through 429, contain sufficient silicoflagellates to recognize several previously described zones (Figure 2). Dissolution thinning of specimens is common and the uppermost Quaternary *Dictyocha aculeata aculeata* Zone is missing in all the Siqueiros sites but Site 427. One new silicoflagellate, *Dictyocha aculeata subaculeata* Bukry, is described from Leg 54.

The mid-Quaternary *Mesocena quadrangula* Zone is well represented in the Siqueiros and Galapagos areas. At Site 422, the regional acme of *Mesocena quadrangula* is found above and below an intercalated basaltic rock unit. The negative magnetization reported for the unit and the *M. quadrangula* abundance signify it is not part of the Jaramillo polarity event, but is probably only slightly older (Hays et al., 1969; Saito and Burckle, 1977) — about 1 m.y.

At Site 425 near the Galapagos Islands, silicoflagellates are especially abundant, diverse, and well preserved. This site was clearly affected by the high fertility of the Peru Current, since the assemblages are similar to those cored at DSDP Sites 157 and 321 to the south. The basal Quaternary samples contain sparse *Dictyocha perlaevis ornata*, a typical upper Pliocene and lowest Quaternary taxon in the Atlantic. This species may prove useful in biogeographic studies between the Pacific and Atlantic oceans, but was not recognized at the Siqueiros sites because of dissolution.

The occurrence of silicoflagellates at Sites 419, 420, 422, 425, 427, and 428 is shown in six separate figures which are interspersed through the text. These figures also record the number of opal phytoliths and *Thalassiosira leptopus elliptica* (diatom) encountered during the silicoflagellate counts. Opal phytoliths are skeletal elements from terrestrial grasses that are an aeolian

addition to the sediment (Bukry, this volume). *Thalassiosira leptopus elliptica* is a large distinctive form which was reported to occur only in the Quaternary of the tropical eastern Pacific (Bukry and Foster, 1973). That relation is supported by its near absence from the Pliocene at the four sites of Leg 54 where Pliocene was recovered, dissolution withstanding. See Barron (this volume) for taxonomic and stratigraphic discussion of this subspecies. Presence, absence, and blooms of the giant diatom *Ethmodiscus rex* are also indicated on the figures.

ZONATION

The four silicoflagellate zones used to characterize Leg 54 assemblages include three widespread zones identified from the Atlantic Ocean and one regional zone or subzone for the tropical eastern Pacific Ocean. The *Dictyocha stapedia stapedia* Zone, *Mesocena quadrangula* Zone, and *Dictyocha aculeata aculeata* Zone are widely applicable and have been described in Bukry (1979a). The *Dictyocha perlaevis delicata* Zone (or Subzone) was defined as a local zone from a re-study of Site 157 (Bukry, 1976a). Its presence at Site 425 in the Galapagos area and Sites 419, 420, and 428 in the Siqueiros area confirms its local utility in the equatorial eastern Pacific near Sites 157 and 425 and extends its range over 8° of latitude to the northwest to include the northern part of the tropical eastern Pacific.

Because the *Dictyocha stapedia stapedia* Zone and *Dictyocha perlaevis delicata* Zone or Subzone were both defined immediately below the cosmopolitan low- to mid-latitude *Mesocena quadrangula* Zone, a shortened (emended) *D. stapedia stapedia* Zone could be employed in the eastern Pacific to accommodate the *D. perlaevis delicata* Zone. Alternatively, the *D. perlaevis delicata* biostratigraphic unit could be designated an upper subzone of the more cosmopolitan *D. stapedia stapedia* Zone. Whichever usage prevails, the first *D. perlaevis delicata* s. str. is used to identify the base of the *D. perlaevis delicata* biostratigraphic unit. The last consistent *D. perlaevis delicata* and the beginning of the *M. quadrangula* acme are used to mark the top of the zone. These criteria overlap at one site (Site 420), where the abrupt diminution of *D. perlaevis delicata* is used to designate the top of the subzone. The regional *D. perlaevis delicata* disappearance is considered more isochronous than the beginning of the *M. quadrangula* acme, since identification is less equivocal.

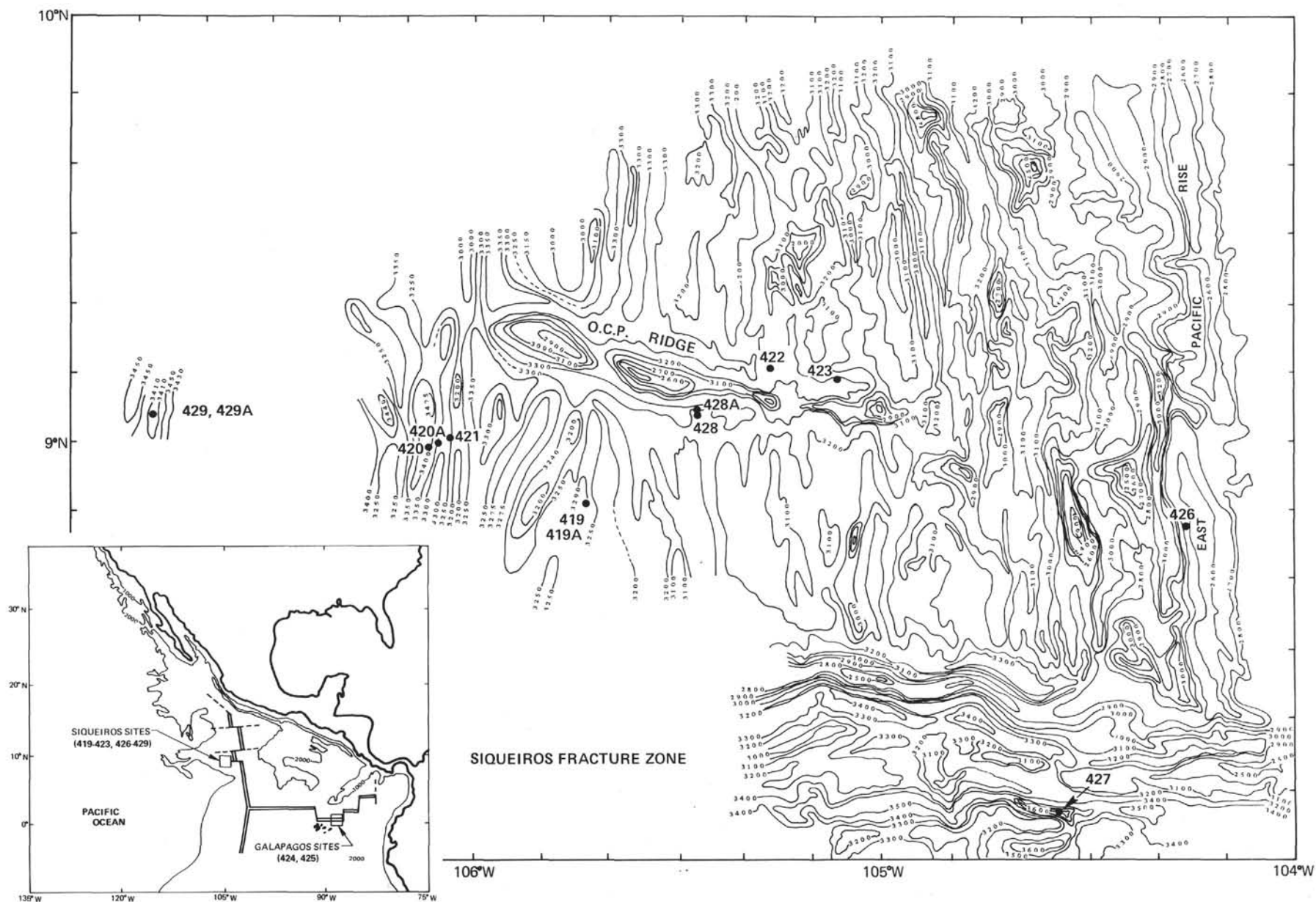


Figure 1. Location of Sites 419 through 423 and 426 through 429 for DSDP Leg 54; bathymetry in meters. Inset: Location of Sites 424 and 425 on the flanks of the Galapagos Rise Crest; bathymetry in fathoms.

Age	Zone	419	420	422	425	427	428
Quaternary	<i>Dictyocha aculeata aculeata</i>				1-1 to 3-6	3-2 to 4-2	
	<i>Mesocena quadrangula</i>	4-1 to 4-5	4-5 to 7-1	4-2 to 8-3	4-1 to 5-1	7-1 to 8-5	2-3 to 3-3
	<i>Dictyocha perlaevis delicata</i>		7-4 to 10-5		5-2 to 5-4		3-5 to 5-1
	<i>Dictyocha stapedia stapedia</i>		11-1 to 13-1		6-1 to 6-2		
Pliocene							

Figure 2. Summary of silicoflagellate zonal assignments for Leg 54. The numbers assigned to zonal intervals are core and section numbers of samples examined.

SITE SUMMARIES

Site 419

(08°55.96'N, 105°41.17'W, depth 3274 m)

Dissolution has strongly affected the Quaternary silicoflagellates at Site 419. At least half of the specimens of the dominant species, *Mesocena quadrangula* and *Dictyocha stapedia stapedia*, in Sample 419-4-4, 132–134 cm (25 m) are solution thinned and ghostlike in appearance. The samples from Cores 1 through 3 are barren of silicoflagellates. That interval is also the upper interval of the Quaternary, where the warm-water coccolith *Gephyrocapsa oceanica* becomes abundant throughout the region. Thus, the lack of silicoflagellates could be primary, resulting from a major change in fertility, or secondary, resulting from accelerated dissolution in carbonate-rich sediment (Mikkelsen, 1978) or a combination of both. The occurrence pattern of silicoflagellates is highly variable, as two samples, 50 cm apart, in a single section (Section 2) of Core-5 have abundant and trace numbers (Figure 3).

A distinctive lower Quaternary species, *Dictyocha lingii* occurs in Sample 419-4-1, 124–126 cm (21 m) and in only two other samples from Leg 54, Sections 422-4-2 and 425-5-3. The occurrences at Sites 419 and 422 are in the *Mesocena quadrangula* Zone, its typical range (Dumitrică, 1973a). The occurrence at Site 425 is slightly lower in the *Dictyocha perlaevis delicata* Zone, but all three occurrences are within the coccolith *Emiliania ovata* Subzone.

Site 420

(09°00.10'N, 106°06.77'W, depth 3381 m)

Although Site 420 is the most stratigraphically comprehensive and best preserved site from the standpoint of calcareous plankton, the upper Pliocene and Quaternary silicoflagellate assemblages are sparse or poorly preserved except in Cores 7 and 8. The major shift in silicoflagellate assemblages occurs between Sections 7-1 and 7-4, where prominent *Dictyocha perlaevis* s. ampl. of the lower Quaternary are displaced by the acme of

Mesocena quadrangula (Figure 4). This event might represent slight cooling, but there is no significant change in the abundance of temperature-sensitive *Distephanus speculum speculum*, so changes in nutrient levels may be involved.

The top of the silicoflagellate-bearing section is in Core 4, which, like Site 419, is also the level where the regional upper Quaternary abundance of the warm-water coccolith *Gephyrocapsa oceanica* begins.

It should be pointed out that *Mesocena quadrangula* occurs in Pliocene and basal Quaternary samples of Site 420 below its zonal acme level. This helps to confirm its older distribution as reported at Site 157 (Bukry and Foster, 1973; Saito and Burckle, 1977). The first Quaternary occurrence of *M. quadrangula* may be illusory, because low counts of a silicoflagellate assemblage may not detect its presence until the level of its acme is encountered. The mid-Quaternary acme of *M. quadrangula* has been widely applied for biostratigraphy, following its popularization by Hays et al. (1969) in the tropical eastern Pacific. Saito and Burckle (1977) report that the extinction of *M. quadrangula* can be correlated as occurring between the Jaramillo polarity event and the end of the Matuyama polarity epoch (0.70 to 0.89 m.y. B.P.) in the North and equatorial Pacific; this would support the isochronous disappearance reported by Ling (1970). They also identify this extinction at Isotopic Stage 22 of Shackleton and Opdyke (1976), a time of Northern Hemisphere glaciation. They therefore conclude a climatic linkage with its extinction. Unfortunately, dissolution tops at several sites and mixing at Site 425 preclude correlation by this means at Leg 54 sites.

Site 422

(09°10.59'N, 105°16.27'W, depth 3247 m)

The assemblages of silicoflagellates at Site 422 are dominated by *Mesocena quadrangula* (Figure 5) and are all strongly dissolved. The specimens from Cores 4 and 5 above a 4-meter basaltic rock layer are solution thinned and ghostlike in appearance. Specimens from below the rock layer, in Core 8, are only slightly better. Regardless of preservation, it is clear that the silicoflagellate assemblages above and below the basalt layer are part of the *Mesocena quadrangula* acme interval, estimated to have its peak 0.85 to 0.95 m.y. B.P. (Jousé and Mukhina, 1973), but to range from 0.79 to 1.3 m.y. B.P. (Burckle, 1977). Therefore, the negatively magnetized basalt layer which occurs within sediment above a positively magnetized Olduvai polarity event basement is probably slightly older than the Jaramillo event (0.89 to 0.95 m.y. B.P., LaBrecque et al., 1977). Assuming the Hays et al. (1969) correlation is correct, an age of approximately 1 m.y. could be assigned to the basalt layer.

Site 424, Hole 424B

(00°35.82'N, 86°07.82'W, depth 2699 m)

An assemblage of 19 silicoflagellates from Sample 424B-2-3, 120–122 cm (8 m) contains 10 *Dictyocha perlaevis perlaevis*, 4 *D. stapedia aspinosa*, 2 *D. sp.*, 1 *D.*

Age	Zone	Site 419 Sample (Interval in cm)	Depth (m)	Total specimens	<i>Dictyocha aculeata aculeata</i>	<i>D. aculeata subaculeata</i>	<i>D. calida ampliata</i>	<i>D. calida calida</i> (s. str. and thick burred)	<i>D. lingii</i>	<i>D. perlaevis delicata</i>	<i>D. perlaevis perlaevis</i> s. ampl.	<i>D. stapedia aspinosa</i>	<i>D. stapedia stapedia</i>	<i>Distephanus speculum speculum</i>	<i>Mesocena quadrangula</i>	Opal Phytoliths	<i>Thalassiosira leptopus elliptica</i>	<i>Ethmodiscus rex</i>
Quaternary	<i>Mesocena quadrangula</i>	4-1, 124-126	21	50			2	28	2		36		22		10	5	10	+
		4-4, 132-134	25	100	2	1						3	17		77	-	-	+
		4-5, 89-91	26	200		1	2	3			1		17		77	3	8	
	<i>Dictyocha perlaevis delicata</i>	5-2, 69-71	31	300						33	4		60	1	2	19	2	
Pliocene		5-2, 123-127	32	5						X	X		X		X	2	0	+
		5-5, 48-50	36	0												0	0	+

Figure 3. Quaternary silicoflagellates recorded as percentages from Cores 4 and 5 at Site 419. Samples from Cores 1 through 3 are barren. Numbers of opal phytoliths and the diatom *Thalassiosira leptopus elliptica* intersected during traverses for silicoflagellates are recorded. Dash = not recorded. x = present. The occurrence of the distinctive diatom *Ethmodiscus rex* (see Mikkelsen, 1977) is also recorded. ● = abundant. + = present. Sample 419-5-5, 48-50 cm is assigned to the Pliocene on the basis of coccolith stratigraphy.

Age	Zone	Site 420 Sample (Interval in cm)	Depth (m)	Total specimens	<i>Dictyocha aculeata subaculeata</i>	<i>D. sp. cf. D. brevipina</i>	<i>D. calida ampliata</i>	<i>D. calida calida</i>	<i>D. sp. cf. D. calida calida</i> (thick bar)	<i>D. perlaevis delicata</i>	<i>D. sp. aff. D. perlaevis flexatella</i>	<i>D. perlaevis perlaevis</i> s. ampl.	<i>D. stapedia aspinosa</i>	<i>D. stapedia stapedia</i>	<i>D. stapedia (cruxoid)</i>	<i>D. sp.</i>	<i>Distephanus boliviensis boliviensis</i>	<i>D. speculum pentagonus</i>	<i>D. speculum speculum</i>	<i>D. sp. A. of Bukry (1979a)</i>	<i>Mesocena quadrangula</i>	<i>M. sp. (circular, one-spined)</i>	Opal Phytoliths	<i>Thalassiosira leptopus elliptica</i>	<i>Ethmodiscus rex</i>
Quaternary	<i>Mesocena quadrangula</i>	4-5, 123-125	30	2	X																X		3	1	+
		5-2, 122-124	36	20			X	X				X		X							X		6	5	+
		6-1, 121-123	44	100	22							2		20					1		55		18	50	+
		6-3, 122-124	47	300			1	3				2	<1	51					1	<1	42		20	-	+
		7-1, 124-126	53	300	3		3	<1				2		28	<1		1		1		63		23	5	●
	<i>Dictyocha perlaevis delicata</i>	7-4, 100-102	57	200				1		50		15		30	<1				1		4		7	-	●
		7-6, 122-124	60	200				4		44		17		32						2	2		17	5	+
		8-1, 124-126	63	100			1	1		27		37		30				1	1		2		31	6	●
		8-3, 115-117	66	100				3		22		25		48				1	1				54	4	●
		8-5, 122-124	69	300				<1	<1			30	1	65					1	<1	2		5	0	●
		9-1, 124-126	72	100				1		39		17		36	2				2		3		36	0	●
		9-3, 124-126	75	50			4	16				52		26				2					7	0	●
		9-5, 124-126	78	6						X		X											5	0	●
		10-1, 124-126	82	50			2	14	4	12	2	20		36				2	2	2	4		7	2	+
		10-3, 122-124	85	20				X		X		X		X				X					5	0	●
		10-5, 122-124	88	100		2	1		5	11		46	6	24					2	1	1	1	17	0	●
Pliocene	<i>Dictyocha stapedia</i> ?	11-1, 142-144	91	2								X		X									3	0	
		11-2, 124-126	92	25				X				X	X	X			X						11	0	
		11-3, 127-129	94	10								X	X	X							X		6	0	
		12-1, 123-125	101	1													X						1	0	+
		12-4, 122-124	105	1										X									1	0	+
		13-1, 124-126	110	20					X		X	X	X	X						X	X		19	0	
		13-4, 127-129	115	0																			0	0	

Figure 4. Quaternary and Pliocene silicoflagellates recorded as percentages or presence (where counts are too sparse) from Cores 4 through 13 at Site 420. Numbers of opal phytoliths and the diatom *Thalassiosira leptopus elliptica* intersected during traverses for silicoflagellates are recorded. Dash = not recorded. x = present. The occurrence of the distinctive diatom *Ethmodiscus rex* (see Mikkelsen, 1977) is also recorded. ● = abundant. + = present.

sp. (naviculopoid), 1 *Distephanus speculum speculum*, and 1 *Mesocena quadrangula*. This is a poorly diagnostic assemblage which can be assigned to the Quaternary based on assemblages at nearby Site 425.

Site 425

(01°23.68'N, 86°04.22'W, depth 2850 m)

Silicoflagellate assemblages of Site 425 are the most abundant, diverse, and best preserved of Leg 54. The

transition from the last common *Distephanus speculum speculum* to the first common *Mesocena quadrangula* between Cores 5 and 6 (Figure 6) matches the same transition at Site 321 under a more southerly part of the Peru Current (Bukry, 1976a). In general, Site 425 is comparable to the Peru Current sites of Legs 16 and 34 rather than to the Siqueiros sites of Leg 54.

The basal assemblages of Core 6 contain *Dictyocha perlaevis ornata* and *D. perlaevis flexatella* which pro-

Age	Zone	Site 422 Sample (Interval in cm)	Depth (m)	Total specimens	<i>Dictyocha aculeata subaculeata</i>	<i>D. calida amplata</i>	<i>D. calida calida</i>	<i>D. sp. cf. D. calida calida</i>	<i>D. sp. cf. D. hessii</i>	<i>D. lingii</i>	<i>D. perlaevis delicata</i>	<i>D. perlaevis perlaevis s. ampl.</i>	<i>D. stapedia stapedia</i>	<i>D. sp.</i>	<i>Mesocena quadrangula</i>	<i>Octactis pulchra</i>	Opal Phytoliths	<i>Thalassiosira leptopus elliptica</i>	<i>Ethmodiscus rex</i>
Quaternary	Mesocena quadrangula	3-6, 125-126	24	1								X					1	1	+
		4-2, 120-121	28	80	3		26	X	X	1	1	X	X	4	2	63	6	X	+
		4-3, 120-121	30	18			X	X				X	X				1	2	+
		5-6, 110-111	44	35			X	X			X	X	X				3	2	●
		Basaltic Rock Unit 45 to 49 m																	
		8-1, 100-101	50	50			10				2	6	22		58	2	0	1	●
		8-3, 100-101	52	100		2	11				5	17		65		10	5		

Figure 5. Quaternary silicoflagellates recorded as percentages from Cores 3 through 5, and 8 at Site 422; Cores 6 and 7 contain a basaltic rock unit. Samples from Cores 1 and 2 are barren. Numbers of opal phytoliths and the diatom *Thalassiosira leptopus elliptica* intersected during traverses for silicoflagellates are recorded. Dash = not recorded. x = present. The occurrence of the distinctive diatom *Ethmodiscus rex* (see Mikkelsen, 1977) is also recorded. ● = abundant. + = present.

vide correlation of upper Pliocene and basal Quaternary assemblages between the North and South Atlantic (Bukry, 1977a, b; 1979b). Poor preservation of this level at the Siqueiros sites prevents their correlation there.

Site 427

(08°06.79'N, 104°36.35'W, depth 3834 m)

The only *Dictyocha aculeata* Zone silicoflagellates preserved in the Siqueiros sites occur in Cores 3 and 4 at Site 427. These low-diversity, solution-thinned assemblages with sparse *D. aculeata aculeata* (Figure 7) occur between barren horizons — Samples 2-2, 70-71 cm (4 m) and 6-4, 74-76 cm (66 m). These assemblages are dominated by *Dictyocha* species, indicating warm-water conditions.

The *Mesocena quadrangula* Zone of Cores 7 and 8 is dominated by *M. quadrangula* and probably represents the upper part of the zone, approximately 0.8 to 1.05 m.y. B.P.

Site 428

(09°02.77'N, 105°26.14'W, depth 3295 m)

A dramatic shift from *Dictyocha perlaevis delicata* dominated assemblages to *Mesocena quadrangula* dominated ones occurs within the lower part of Core 3 (Figure 8). The upper *D. perlaevis delicata* Zone or Subzone sediment has fewer foraminifers (less carbonate) and more sponge spicules than the following *M. quadrangula* Zone interval. The relation in abundances between these two silicoflagellates at Sites 419 and 420 in the Siqueiros area is the same, but carbonate shows the opposite change. Carbonate content decreases in an upward direction across the zone boundary there, as evidenced by reduced coccolith abundances (see *Initial Core Descriptions*, DSDP Leg 54). Samples from above and below the boundary at Site 428 contain, respective-

ly, sparse and abundant *Ethmodiscus rex* (diatom), whereas at Site 420, samples that bracket the boundary both contain abundant *E. rex*. The change in dominance from *D. perlaevis delicata* to *M. quadrangula* is a useful regional biostratigraphic guide, because it occurs consistently in the same interval relative to events in other microfossil groups. It occurs in the lower *Emiliania ovata* Subzone of coccoliths, the *Nitzschia reinholdii* (b) Zone (below the *Rhizosolenia matuyamai* Horizon) of diatoms, and in the *Anthocyrtidium angulare* Zone of radiolarians at Sites 419, 420, and 428.

SILICOFLAGELLATE TAXONOMY

Genus DICTYocha Ehrenberg, 1837

Dictyocha aculeata aculeata (Lemmermann) (Plate 1, Figures 1-3)

- not *Dictyocha aculeata* Ehrenberg, 1840, p. 148.
Dictyocha epidon Ehrenberg, Ehrenberg, 1854 (in part), pl. 25B (IV), fig. 10.
 not *Dictyocha aculeata* Ehr., Stöhr, 1880, p. 120, pl. 7, fig. 7a, b.
Dictyocha fibula var. *aculeata* Lemmermann, 1901, p. 261, pl. 11, fig. 1, 2.
Dictyocha fibula var. *aculeata* Lemm., Gemeinhardt, 1930, p. 55, fig. 43a, b.
Dictyocha fibula var. *aculeata* Lemm., Frenguelli, 1935, pl. 13, fig. 1-9.
 not *Dictyocha speculum* var. *aculeata* (Ehrenberg) Frenguelli, 1941, p. 94, pl. 1, fig. 6.
Dictyocha fibula Ehr. var. *aculeata* Lemmermann, Tsumura, 1963, p. 54, pl. 10, fig. 9; pl. 23, fig. 6.
Dictyocha fibula "var." *aculeata* Lemmermann, Ling, 1970, p. 91, pl. 18, fig. 11-13.
Dictyocha fibula Ehrenberg s. l., Martini, 1971 (in part), p. 1696, pl. 1, fig. 5.
Dictyocha fibula var. *aculeata* Lemmermann, Tampieri, 1972, p. 378, pl. 34, fig. 1, 2; pl. 35, fig. 1.
Dictyocha aculeata (Lemmermann), Dumitrică, 1973a, p. 907, pl. 9, fig. 5-10.

Age	Zone	Site 425 Sample (Interval in cm)	Depth (m)	Total specimens	<i>Dictyocha aspera</i>	<i>D. aculeata aculeata</i>	<i>D. aculeata aculeata</i> (cruxoid)	<i>D. sp. aff. D. aculeata aculeata</i>	<i>D. aculeata subaculeata</i>	<i>D. brevispina</i>	<i>D. calida ampliata</i>	<i>D. calida calida</i>	<i>D. sp. cf. D. calida calida</i> (thick bar)	<i>D. constricta</i>	<i>D. hesili</i>	<i>D. lingii</i>	<i>D. perlaevis delicata</i>	<i>D. perlaevis flexatella</i>	<i>D. perlaevis ornata</i>	<i>D. perlaevis perlaevis</i> s. ampl.	<i>D. perlaevis perlaevis</i> (elongate)	<i>D. sp. aff. D. pulchella</i>	<i>D. stapedia aspinosa</i>	<i>D. stapedia stapedia</i>	<i>D. sp. cf. D. stapedia stapedia</i> (rounded)	<i>D. sp. (naviculopsoid)</i>	<i>D. spp.</i>	<i>Diastrephanus boliviensis boliviensis</i>	<i>D. speculum minutus</i>	<i>D. speculum pentagonus</i>	<i>D. speculum speculum</i>	<i>D. sp. A of Bukry (1979a)</i>	<i>D. sp. (cruxoid)</i>	<i>Mesocena circulus</i>	<i>M. quadrangula</i>	<i>Octactis pulchra</i>	Opal Phytoliths	<i>Thalassiosira leptopus elliptica</i>	<i>Ethmodiscus rex</i>			
Quaternary	<i>Dictyocha aculeata aculeata</i>	1-1, 60-62	1	200		29		5	4	1									5				3	36	15										2	0	0					
		1-2, 110-112	3	300		43		2			1							1		5				1	32										1	2	0	0				
		2-1, 74-76	6	300		8		3				<1		29	<1				8				1	49												1	2	0	0			
		2-3, 74-76	9	200		24		15	4				1	1					2					52												1	1	2	3			
		2-5, 74-76	12	200		14		4	4					2					2				1	70												1	3	1	0			
		3-1, 74-76	25	200		2		3			3	10							20				38	24												1	3	0	2			
		3-2, 74-76	27	200		6	2	5	1	1	2	5	28						36					3	11											1	2	0	0			
		3-3, 74-76	28	200		23		2	4			1							3				58	9												1	1	0	4			
		3-4, 74-76	30	200		7		9	3			1							21				55	2											2	2		1	0			
		3-5, 74-76	31	200		5		11	6		1	5							22				12	38											1	2		1	0	1		
		3-6, 74-76	33	200		14		30	9	1	1	1							8					32											5			1	0	3		
	<i>Mesocena quadrangula</i>	4-1, 74-76	44	300					8		<1		2						48				1	18													21	1	1	10		
		4-2, 74-76	46	300					2			1							23					20													51	1	1	2	+	
		4-3, 74-76	47	300					1			2							19				1	45		<1		<1									27	2	1	-		
		5-1, 74-76	63	300					1	7		1							23					1	14			<1		<1							51	<1	0	1		
	<i>Dictyocha perlaevis delicata</i>	5-2, 74-76	65	300				2											4					5	33												26	1	0	0		
		5-3, 74-76	66	300								1				1	1	23				4		32													11	1	-	-		
		5-4, 74-76	68	300					1	1			3					6		<1	20	1		55			<1		1								10	<1	-	-		
	<i>Dictyocha stapedia stapedia?</i>	6-1, 74-76	73	200	1				1		11								1	40	11	3	5	4																-	-	
		6-2, 74-76	74	100							7								1	1	1	19	34	1	5				12												-	-

Figure 6. Quaternary silicoflagellates recorded as percentages from Cores 1 through 6 at Site 425. Number of opal phytoliths and the diatom *Thalassiosira leptopus elliptica* intersected during traverses for silicoflagellates are recorded. Dash = not recorded. x = present. The occurrence of the distinctive diatom *Ethmodiscus rex* (see Mikkelsen, 1977) is also recorded. ● = abundant. + = present.

Age	Zone	Site 427 Sample (Interval in cm)	Depth (m)	Total specimens	<i>Dictyocha aculeata aculeata</i>	<i>D. aculeata subaculeata</i>	<i>D. calida ampliata</i>	<i>D. calida calida</i>	<i>D. perlaevis delicata</i>	<i>D. perlaevis perlaevis</i> s. ampl.	<i>D. stapedia aspinosa</i>	<i>D. stapedia stapedia</i>	<i>D. sp.</i>	<i>Mesocena quadrangula</i>	<i>Octactis pulchra</i>	Opal Phytoliths	<i>Thalassiosira leptopus elliptica</i>	<i>Ehmodiscus rex</i>	
Quaternary	<i>Dictyocha aculeata</i>	3-2, 70-72	15	50	2	16	2	12	2	18		46			2	2	3	+	
		4-2, 40-42	34	50	2	14	6	4		26	2	46				5	2	+	
		6-4, 74-76	66	0												0	0	+	
	<i>Mesocena quadrangula</i>	7-1, 74-76	90	8					X				X		X		-	-	+
		7-3, 74-76	93	50					12		24	2	22		40		-	-	●
		8-2, 74-76	120	3									X		X		-	-	+
		8-4, 74-76	123	200		1	1	1					19		77	1	-	-	●
		8-5, 7-8	124	20		X	X							X	X		9	1	+
		8-6, 120-127	126	0													0	0	

Figure 7. Quaternary silicoflagellates recorded as percentages from Cores 3 through 8 at Site 427. Numbers of opal phytoliths and the diatom *Thalassiosira leptopus elliptica* intersected during traverses for silicoflagellates were recorded for some samples. Dash = not recorded. x = present. The occurrence of the distinctive diatom *Ethmodiscus rex* (see Mikkelsen, 1977) is also recorded. ● = abundant. + = present.

Age	Zone	Site 428 Sample (Interval in cm)	Depth (m)	Total specimens	<i>Dictyocha aculeata subaculeata</i>	<i>D. calida ampliata</i>	<i>D. calida calida</i>	<i>D. sp. cf. D. calida calida (thick bar)</i>	<i>D. perlaevis delicata</i>	<i>D. perlaevis perlaevis s. ampl.</i>	<i>D. stapedia stapedia</i>	<i>D. sp.</i>	<i>Distephanus boliviensis boliviensis</i>	<i>D. speculum speculum</i>	<i>D. sp. A of Bukry (1979a)</i>	<i>Mesocena quadrangula</i>	<i>Opal</i>	<i>Thalassiosira leptopus elliptica</i>	<i>Ethmodiscus rex</i>
Quaternary	<i>Mesocena quadrangula</i>	2-1, 74-76	30	0													0	0	
		2-3, 74-76	33	50	2			2		4	10					82	1	27	+
		3-1, 74-76	39	100	9	1	4			3	35					48	25	1	+
	<i>Dictyocha perlaevis delicata</i>	3-3, 74-76	42	300				1		<1	1	1				96	1	15	+
		3-5, 74-76	45	200		1	3		51	9	36			1	1		21	6	●
		4-1, 74-76	49	100			2		42	18	28				1	9	18	6	+
		4-3, 74-76	52	100		1	5		51	22	13	1			4	3	5	10	+
		4-5, 74-76	55	100	2		6		54	18	17		1		2		67	13	+
		5-1, 74-76	58	100		2	1		19	19	43	2		1	2	11	7	1	+
	Pliocene	5-3, 77-79	61	0													0	0	

Figure 8. Quaternary silicoflagellates recorded as percentages from Cores 2 through 5 at Site 428. A sample from Core 1 is barren, but contains sparse opal phytoliths. The number of opal phytoliths and the diatom *Thalassiosira leptopus elliptica* intersected during traverses for silicoflagellates are recorded. The occurrence of the distinctive diatom *Ethmodiscus rex* (see Mikkelsen, 1977) is also recorded. ● = abundant. + = present. Sample 428-5-3, 77-79 cm is assigned to the Pliocene on the basis of coccolith stratigraphy.

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

Dictyocha aculeata (Lemmermann), Dumitrică, 1973b, p. 849, pl. 4, fig. 9-11.

Dictyocha aculeata (Lemmermann), Perch-Nielsen, 1975, p. 686, pl. 5, fig. 3, 4.

Dictyocha fibula var. *aculeata* Lemmermann, Ling, 1975, p. 768, pl. 1, fig. 7, 8.

Dictyocha epidon Ehrenberg, Poelchau, 1976, p. 170, pl. 1, fig. e, f; pl. 4, fig. 2d.

Dictyocha fibula var. *aculeata* Ehrenberg, Ling 1976, pl. 29, fig. 2.

Dictyocha aculeata (Lemmermann), Martini, 1976 (in part), p. 442, pl. 1, fig. 2, (not pl. 2, fig. 3a, b).

Dictyocha mandrai Ling, nom. nov., 1977, p. 209, pl. 1, fig. 13, 14.

Dictyocha aculeata (Lemmermann), Bukry, 1977a, p. 921.

Remarks: The distinctive Quaternary silicoflagellate skeleton, having four definite peripheral pikes on the basal ring between the axial

spines, was first illustrated by Ehrenberg as *Dictyocha epidon*, and later as *Dictyocha fibula* var. *aculeata* by Lemmermann. The latter name has achieved majority usage in this century, even though prior to Locker's (1974) type selection, *D. epidon* could have been given priority (Bukry, 1977a). Owing to this long-term usage in the literature, a suggested substitute name (*Dictyocha mandrai* Ling, 1977) is not used here and it is recommended that the name *Dictyocha aculeata* (Lemmermann) be conserved.

Historically, Ehrenberg (1840) used the name *Dictyocha aculeata* first, but applied it to a hexagonal, apical-ringed silicoflagellate, before the genus *Distephanus* (apical-ringed silicoflagellates) had been named. Ehrenberg's taxa was transferred to *Distephanus* by Haeckel (1887), because it was very similar to the type species *D. rotundus* and differed only by the prominence of its apical or basal pikes.

I agree with Ling (1977, p. 210) that *Distephanus aculeatus* (Ehrenberg) is virtually conspecific with *Distephanus speculum* (Ehrenberg) which, in turn, is virtually conspecific with *Distephanus*

rotundus, the type species of genus *Distephanus* (see Stöhr, 1880, pl. 7). However, because *Distephanus aculeatus* (Ehrenberg) was transferred into genus *Distephanus* by Haeckel (1887) prior to the naming of *Dictyocha fibula* var. *aculeata* Lemmermann (1901), the name *aculeata* was not preoccupied in genus *Dictyocha* and may be considered the first available use of the name for purposes of priority at that rank. This relationship is supported by ICBN Art. 60 (Lanjouw et al., 1966). Also, by ICBN Art. 14, Note 5, if *Dictyocha aculeata* (Lemmermann) is considered a conserved name because of its long consistent usage, then it may be conserved against any earlier homonym. Although the application may be indirect, ICZN Art. 59(C)i (Stoll et al., 1964) indicates that if the senior of two homonyms (in the same genus) is no longer considered congeneric and is transferred to another genus, then the former junior homonym takes precedence in the genus.

In short, Ehrenberg's *aculeatus* should be legitimate in genus *Distephanus* and Lemmermann's *aculeata* should be legitimate in genus *Dictyocha*. A substitute name would be necessary only if both were placed into the same genus.

Dictyocha aculeata aculeata can be distinguished from *D. aculeata subaculeata* by the four peripheral pikes on the basal ring and by the exposed location of all four inwardly directed basal pikes. Other criteria are discussed under *D. aculeata subaculeata*. Short-spined, large specimens of *D. aculeata aculeata* that lack one or two peripheral pikes but are otherwise comparable are tabulated as *D. sp. aff. D. aculeata aculeata* (Plate 1, Figures 4–7).

***Dictyocha aculeata subaculeata* n. subsp.**
(Plate 1, Figures 8–17)

?*Dictyocha messanensis* Haeckel, Dumitrică, 1973a (in part), p. 907, pl. 8, fig. 11–13.

Dictyocha sp. cf. *D. aculeata* Lemmermann (rounded), Bukry, 1979a, p. 991, pl. 1, fig. 5, 6?, 7–9.

Dictyocha sp. cf. *D. aculeata* Lemmermann, Bukry, 1979b, p. 569, pl. 1, fig. 3, 4.

Description: *Dictyocha aculeata subaculeata* has a moderate to long bar which may or may not have a spire. The bar is slightly to moderately canted from the major axis. The four axial spines of the ring are moderate to long and the major axis spines, typically, are clearly longer than the minor axis spines, up to 2:1. The ring is basically rhomb-shaped with slightly rounded corners. The sides are slightly bowed out between the spines, sometimes forming a slight angle. Strut junctions are offset from the symmetry of the ring axes, and, of the four prominent basal pikes, two or three are widely offset from the junctions.

Remarks: *Dictyocha aculeata subaculeata* is often common in lower Quaternary assemblages. It appears to be the source of upper Quaternary *D. aculeata aculeata* and is distinguished from the latter by: (1) the absence of a set of four peripheral pikes on the interspine ring length; (2) the proximity of one or two basal pikes to the strut junctions — all four basal pikes are offset in *D. aculeata aculeata*; (3) the greater relative length of the major axis spines — *D. aculeata aculeata* populations are more nearly equant; and (4) the generally greater length of the spines relative to the inner diameter across the ring. It is distinguished from *D. messanensis* by its offset strut-ring junctions and inequant, shorter spines, and from *D. subarctios* by longer, inequant spines, the dominance of the major-axis spines, longer bar, and incompletely offset set of basal pikes.

Occurrence: *Dictyocha aculeata subaculeata* is a widespread subspecies that has been tabulated in the North Atlantic from the Mid-Atlantic Ridge (Site 412) to northwest Africa (Site 397) and in the North Pacific from Hess Rise (Site 310) to the Galapagos (Site 425). The illustrations by Dumitrică (1973a) are from Site 128 in the Mediterranean Sea. It ranges through most of the Quaternary at these mid- to low-latitude sites, but is most common in the lower or middle Quaternary.

Size: Maximum internal diameter 20 to 30 mm.

Holotype: USNM 258919 (Plate 1, Figure 8).

Isotypes: USNM 258920 to 258928.

Type locality: Equatorial eastern Pacific Ocean, Sample 425–4–2, 74–76 cm (46 m).

***Dictyocha aspera* (Lemmermann)**
(Plate 2, Figure 1)

Dictyocha fibula var. *aspera* Lemmermann, 1901, p. 260, pl. 10, fig. 27, 28.

***Dictyocha brevispina* (Lemmermann)**
(Plate 2, Figure 2)

Dictyocha fibula var. *brevispina* Lemmermann, 1901, p. 260.

Dictyocha fibula var. *aspera* f. *rhombica* Schulz, 1928, p. 253, fig. 37.

***Dictyocha calida ampliata* Bukry**
(Plate 2, Figure 6–8)

Dictyocha calida ampliata Bukry, 1979a, p. 982, pl. 2, fig. 1, 2, 9.

Dictyocha calida ampliata Bukry, 1979b, p. 560, pl. 1, fig. 5, 6.

***Dictyocha calida calida* Poelchau**
(Plate 2, Figure 3)

Dictyocha calida Poelchau, 1976, p. 169, pl. 1, fig. c, d; pl. 3, fig. a–f.

Dictyocha calida calida Poelchau, Bukry, 1979b, p. 560, pl. 1, fig. 7.

Remarks: Many specimens of *Dictyocha calida* s. ampl. from Leg 54 resemble the type suite (Poelchau, 1976) very closely, except for having a thicker bar that matches the thickness of the struts and ring, instead of being thinner. Although this distinction may or may not be useful or even consistently reproducible, an attempt to establish the abundance of such forms was made by tabulating them as *D. sp. cf. D. calida calida* (thick bar). See Figures 4, 6, 8, and Plate 2, Figures 4 and 5.

***Dictyocha constricta* (Schulz)**

Dictyocha fibula fa. *constricta* Schulz, 1928, p. 253, fig. 35a, b.

Dictyocha constricta (Schulz) Bukry, 1979a, p. 983.

***Dictyocha hessii* Bukry**
(Plate 3, Figures 1–4)

Dictyocha hessii Bukry, 1978a, p. 642.

Dictyocha hessii Bukry, Bukry, 1979b, p. 560, pl. 1, fig. 8–12.

***Dictyocha lingii* Dumitrică**
(Plate 3, Figures 5–7)

Dictyocha lingii Dumitrică, 1973a, p. 906, pl. 8, fig. 1–7.

Dictyocha lingii Dumitrică, Bukry, 1979a, p. 983, pl. 2, fig. 5–8.

***Dictyocha pentagona* (Schulz)**

Dictyocha fibula var. *pentagona* Schulz, 1928, p. 255, fig. 41a, b.

Dictyocha pentagona (Schulz), Bukry, 1976b, p. 894.

***Dictyocha perlaevis delicata* Bukry**
(Plate 3, Figures 8–12)

Dictyocha perlaevis delicata Bukry, 1976a, p. 724, pl. 1, fig. 5–10.

***Dictyocha perlaevis flexatella* Bukry**

Dictyocha perlaevis flexatella Bukry, 1979a, p. 984, pl. 3, fig. 1–3.

Dictyocha perlaevis flexatella Bukry, Bukry, 1979b, p. 561, pl. 2, fig. 7–10.

***Dictyocha perlaevis ornata* Bukry**
(Plate 4, Figure 1, 2)

Dictyocha perlaevis ornata Bukry, 1977a, p. 922, pl. 1, fig. 1–6.

Dictyocha perlaevis ornata Bukry, Bukry, 1978a, p. 644, pl. 1, fig. 7, 8.

Dictyocha perlaevis ornata Bukry, Bukry, 1979b, p. 561, pl. 2, fig. 11–14.

Dictyocha perlaevis perlaevis Frenguelli
(Plate 4, Figures 3-9; Plate 5, Figures 1-3)

Dictyocha perlaevis Frenguelli, 1951, p. 279, fig. 4b, c.
Dictyocha perlaevis perlaevis Frenguelli, Bukry, 1979a, p. 984, pl. 3, fig. 6-11.

Remarks: *Dictyocha perlaevis perlaevis* s. ampl. includes small numbers of pentagonal, crinkled, and arrowhead variations in the tabulated counts. Medium and large specimens are undifferentiated also. Medium specimens approach *D. calida calida* in form, but can be distinguished by greater ring scalloping, and longer and thicker bar with concomitant disparity of portal size along minor and major axes.

A distinctive local population, *Dictyocha perlaevis perlaevis* (elongate), in the basal Quaternary at Galapagos Site 425, is medium sized and has a much shorter minor axis than typical *D. perlaevis perlaevis*. The elongate population is separately tabulated and illustrated (Plate 4, Figures 10-13).

Dictyocha pulchella Bukry

Dictyocha pulchella Bukry, 1975a, p. 687, fig. 1-3.
Dictyocha pulchella Bukry, Bukry, 1979a, p. 984, pl. 4, fig. 1, 2.

Dictyocha stapedia aspinosa Bukry
(Plate 5, Figures 4-7)

Dictyocha stapedia aspinosa Bukry, 1976a, p. 724, pl. 2, fig. 6-9.
Dictyocha stapedia Haeckel var. *aspinosa* Bukry, Stradner and Bachmann, 1978 (in part), p. 806, pl. 1, fig. 1, 2 (not 7, 8).
Dictyocha stapedia aspinosa Bukry, Bukry, 1979a, p. 984, pl. 4, fig. 4-6.

Dictyocha stapedia stapedia Haeckel
(Plate 5, Figures 8-10)

Dictyocha stapedia Haeckel, 1887, p. 1561, pl. 101, fig. 10-12.
Dictyocha stapedia stapedia Haeckel, Bukry, 1976a, p. 724, pl. 3, fig. 1-7.

Genus DISTEPHANUS Stöhr, 1880

Distephanus boliviensis boliviensis (Frenguelli)
(Plate 5, Figure 13; Plate 6, Figures 4-6)

Dictyocha boliviensis Frenguelli, 1940 (in part), p. 44, fig. 4a.
Distephanus boliviensis boliviensis (Frenguelli), Bukry, 1979a, p. 985, pl. 4, fig. 12; pl. 5, fig. 1.

Distephanus speculum minutus (Bachmann)
(Plate 5, Figure 14)

Dictyocha speculum f. *minuta* Bachmann in Ichikawa et al., 1967, p. 161, pl. 7, fig. 12-15.
Distephanus speculum minutus (Bachmann), Bukry, 1976b, p. 895, pl. 8, fig. 1-3.

Distephanus speculum pentagonus Lemmermann

Distephanus speculum var. *pentagonus* Lemmermann, 1901, p. 265, pl. 11, fig. 19.

Distephanus speculum speculum (Ehrenberg)
(Plate 5, Figures 15, 16; Plate 6, Figures 1-3)

Dictyocha speculum Ehrenberg, 1839, p. 150; Ehrenberg, 1854, pl. 18, fig. 57; pl. 19, fig. 41; pl. 21, fig. 44; pl. 22, fig. 47.
Dictyocha aculeata Ehrenberg, 1840, p. 148; fide Loeblich et al. (1968), figured by Bailey, 1843, pl. 3, fig. 17; Ehrenberg, 1854, p. 19, fig. 40; pl. 21, fig. 47; pl. 22, fig. 48a-d.
Dictyocha aculeata Ehr., Stöhr, 1880, p. 120, pl. 7, fig. 7a, b.
Distephanus aculeatus (Ehrenberg) Haeckel, 1887, p. 1565.
Distephanus speculum var. *aculeatus* (Ehrenberg) Lemmermann, 1901, p. 264, pl. 11, fig. 23.
not *Dictyocha fibula* Ehrenberg var. *aculeata* Lemmermann 1901, p. 261, pl. 11, fig. 1, 2.
not *Dictyocha fibula* var. *aculeata* Lemm., Frenguelli, 1935, pl. 13, fig. 1-9.

Dictyocha speculum var. *aculeata* (Ehrenberg) Frenguelli, 1941, p. 94, pl. 1, fig. 6.
not *Dictyocha fibula* var. *aculeata* Lemmermann, Ling, 1972, p. 161, fig. 16, 17.
not *Dictyocha aculeata* (Lemmermann) Dumitrică, 1973a, p. 907, pl. 9, fig. 5-10.

Distephanus aculeatus (Ehrenberg), Locker, 1974, pl. 3, fig. 5, 6, 9.

Remarks: *Distephanus aculeatus* (Ehrenberg) is a hexagonal silico-flagellate which was distinguished from *D. speculum* (Ehrenberg) only by the more prominent basal or apical pikes. Originally it was described, like *D. speculum*, in genus *Dictyocha*, but was transferred to *Distephanus* in 1887, soon after creation of the genus. Although *D. aculeata* (Ehrenberg) is a little-used concept, there has been no question about its affinities to the *D. speculum* group since Lemmermann recognized it as a variety within that species in 1901.

Distephanus sp. A Bukry
(Plate 6, Figures 7-9)

Distephanus sp. A Bukry, 1979a, p. 985, pl. 5, fig. 7-10.

Genus MESOCENA Ehrenberg, 1843

Mesocena circulus (Ehrenberg)
(Plate 7, Figures 5-7)

Mesocena circulus (Ehrenberg) Ehrenberg, 1844, p. 65.
Mesocena circulus (Ehrenberg), Bukry, 1975b, p. 868, pl. 6, fig. 1, 2.

Remarks: Sparse, short-spined forms of *Mesocena circulus* occur only in the basal Quaternary of Site 420? and 425, in conjunction with the maximum *Distephanus speculum speculum* abundance at those sites. The distribution of *M. circulus* at Sites 157 and 321 in the Eastern Pacific suggests it was at the north tropical and temporal end of its range. At mid-latitude Site 310 on Hess Rise and Site 362 on Walvis Ridge it occurs consistently through the Pliocene up to the Pliocene/Pleistocene boundary (Bukry, 1978a).

Mesocena quadrangula Ehrenberg ex Haeckel
(Plate 7, Figures 9-17; Plate 8, Figures 1-10)

Mesocena quadrangula Ehrenberg ex Haeckel, 1887, p. 1556, Lemmermann, 1901, pl. 10, fig. 5-7, fide Loeblich et al., 1968, p. 57.
Mesocena quadrangula Ehrenberg ex Haeckel, Bukry, 1978b, p. 819, pl. 7, fig. 1-5.

Remarks: The distinction of *Mesocena quadrangula* from *M. elliptica* (see Bukry, 1978b) includes longer, more equant spines; more quadrate form; and more noded surface. The contrast is emphasized by comparison of the curvature of the inner periphery of the ring near the short axis; it is a flatter curvature, part of a continuous long segment of an ellipse, for lower Miocene *M. elliptica* populations (Bukry, 1978b, pl. 6, fig. 6-13), but is more angular or more sharply curved in Quaternary *M. quadrangula* populations (Plates 7 and 8).

Genus OCTACTIS Schiller, 1926

Octactis pulchra Schiller
(Plate 8, Figures 11, 12)

Octactis pulchra Schiller, 1926, p. 67, fig. C.
Octactis pulchra Schiller, Bukry, 1979a, p. 986, pl. 7, fig. 2, 3.

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PLATE 1

Silicoflagellates from DSDP Leg 54.

All figures magnified $\times 800$; scale bar equals 10 μm .

- Figures 1-3 *Dictyocha aculeata aculeata* (Lemmermann).
 1, 2. Normal, Sample 425-1-1, 60-62 cm (1 m).
 3. Cruxoid, Sample 425-3-2, 74-76 cm (27 m).
- Figures 4-7 *Dictyocha* sp. aff. *D. aculeata* (Lemmermann).
 4. Irregular, Sample 425-1-2, 110-112 cm (3 m).
 5. Sample 425-3-6, 74-76 cm (33 m).
 6, 7. Long-barred, Sample 425-3-5, 74-76 cm (31 m).
- Figures 8-17 *Dictyocha aculeata subaculeata* n. subsp.
 8. Holotype, USNM 258919, Sample 425-4-2, 74-76 cm (46 m).
 9. USNM 258920, Sample 425-3-6, 74-76 cm (33 m).
 10. USNM 258921, Sample 425-3-3, 74-76 cm (28 m).
 11. USNM 258922, Sample 427-3-2, 70-72 cm (15 m).
 12. USNM 258923, Sample 425-2-3, 74-76 cm (9 m).
 13. USNM 258924, Sample 425-1-1, 60-62 cm (1 m).
 14. USNM 258925, Sample 425-1-1, 60-62 cm (1 m).
 15. USNM 258926, Sample 419-4-5, 89-91 cm (26 m).
 16. USNM 258927, Sample 425-3-2, 74-76 cm (27 m).
 17. USNM 258928, Sample 425-2-3, 74-76 cm (9 m).

PLATE 1

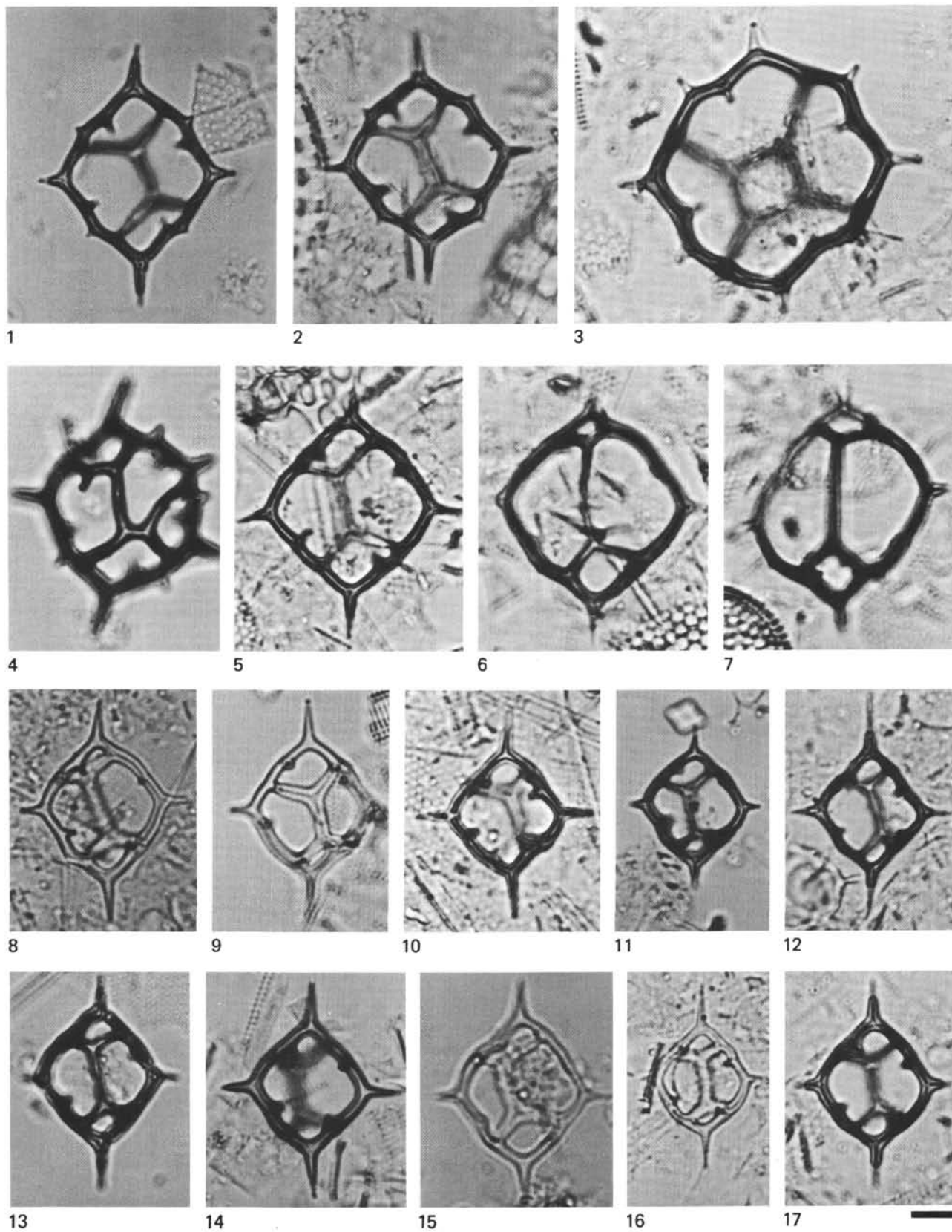


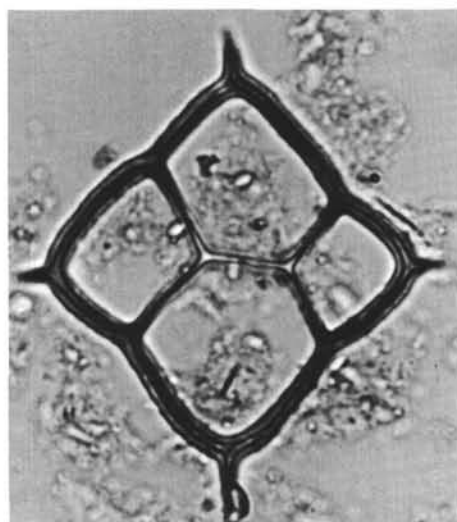
PLATE 2

Silicoflagellates from DSDP Leg 54.

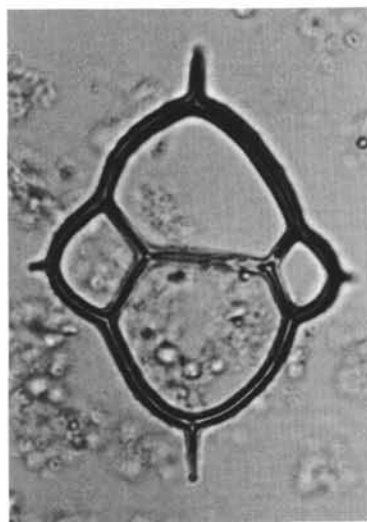
All figures magnified $\times 800$; scale bar equals $10\ \mu\text{m}$.

- Figure 1 *Dictyocha aspera* (Lemmermann).
Sample 425-6-1, 74-76 cm (73 m).
- Figure 2 *Dictyocha brevispina* (Lemmermann).
Sample 425-6-2, 74-76 cm (74 m).
- Figure 3 *Dictyocha calida calida* Poelchau.
Sample 428-4-1, 74-76 cm (49 m).
- Figures 4, 5 *Dictyocha* sp. cf. *D. calida calida* Poelchau.
Thick barred.
4. Sample 425-3-1, 74-76 cm (25 m).
5. Sample 419-4-1, 124-126 cm (21 m).
- Figures 6-8 *Dictyocha calida ampliata* Bukry.
6. Sample 420-7-1, 124-126 cm (53 m).
7. Sample 419-4-5, 89-91 cm (26 cm).
8. Sample 425-3-1, 74-76 cm (25 m).

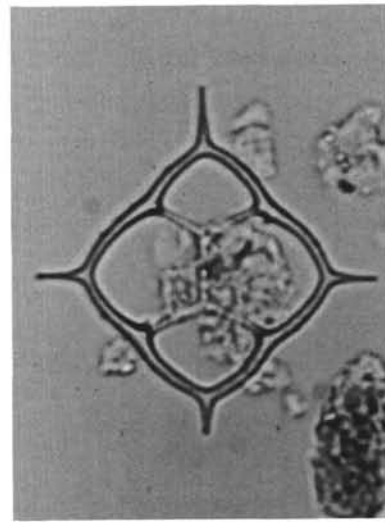
PLATE 2



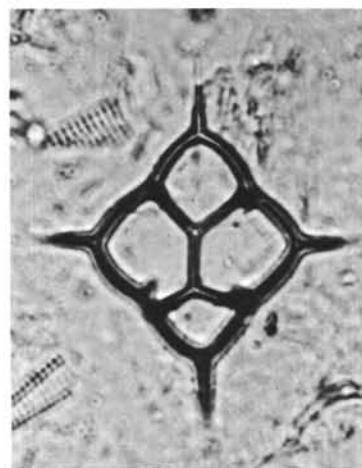
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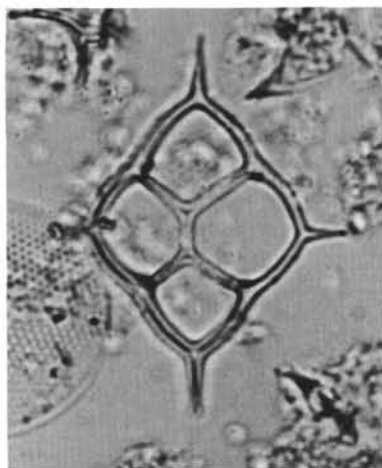
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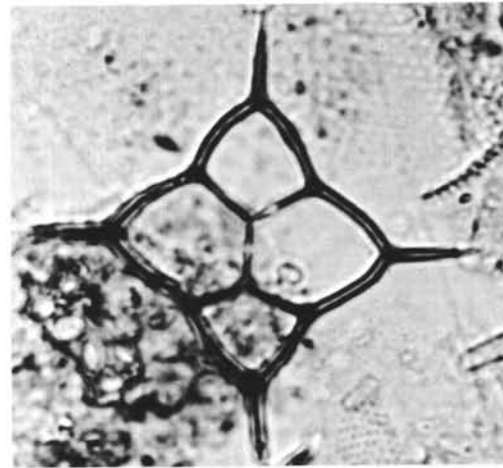
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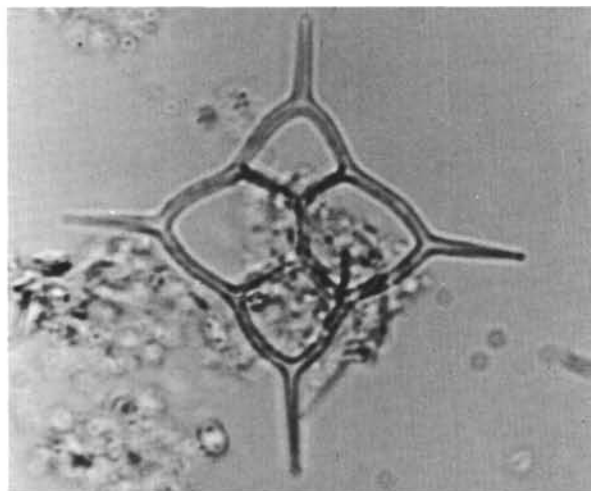
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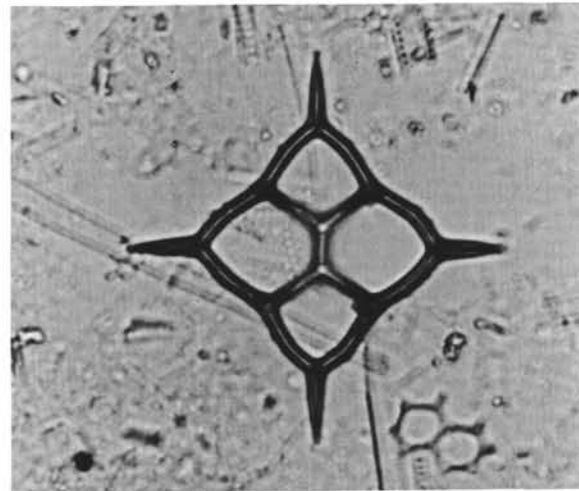
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PLATE 3

Silicoflagellates from DSDP Leg 54.

All figures magnified $\times 800$; scale bar equals 10 μm .

- Figures 1-4 *Dictyocha hessii* Bukry.
Sample 425-5-3, 74-76 cm (66 m).
1, 2. Pike location transitional to *D. lingii*.
3, 4. Pike and bar transitional to *D. lingii*.
- Figures 5-7 *Dictyocha lingii* Dumitrică.
5, 6. Low and high focus, Sample 422-4-2,
120-121 cm, (28 m).
7. Sample 419-4-1, 124-126 cm (21 m).
- Figures 8-12 *Dictyocha perlaevis delicata* Bukry.
8, 9. Sample 425-5-3, 74-76 cm (66 m).
10. Sample 425-5-4, 74-76 cm (68 m).
11. Variant, Sample 425-5-2, 74-76 cm (65 m).
12. Variant, Sample 425-5-3, 74-76 cm (66 m).

PLATE 3

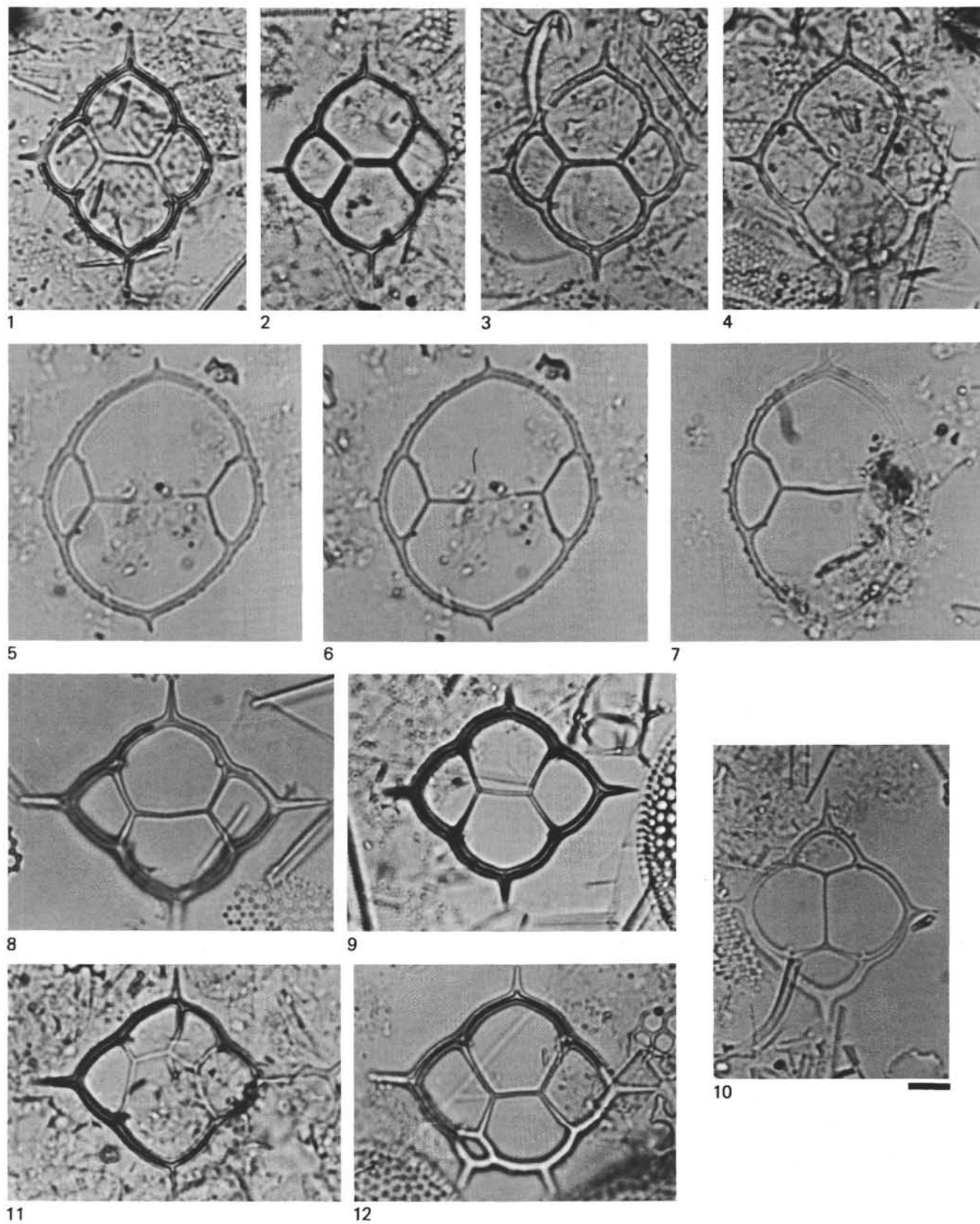


PLATE 4

Silicoflagellates from DSDP Leg 54.

All figures magnified $\times 800$; scale bar equals $10\ \mu\text{m}$.

- Figures 1, 2 *Dictyocha perlaevis ornata* Bukry.
Sample 425-6-1, 74-76 cm (73 m).
- Figures 3-9 *Dictyocha perlaevis perlaevis* Frenguelli.
3. Sample 425-4-1, 74-76 cm (44 m).
4. Sample 425-3-2, 74-76 cm (27 m).
5. Sample 425-5-4, 74-76 cm (68 m).
6, 8. Sample 425-6-1, 74-76 cm (73 m).
7. Sample 425-3-6, 74-76 cm (33 m).
9. Variant, Sample 419-5-2, 69-71 cm (31 m).
- Figures 10-13 *Dictyocha perlaevis perlaevis* Frenguelli.
Elongate variation (some have small spire).
10, 11. Sample 425-6-1, 74-76 cm (73 m).
12, 13. Sample 425-6-2, 74-76 cm (74 m).

PLATE 4

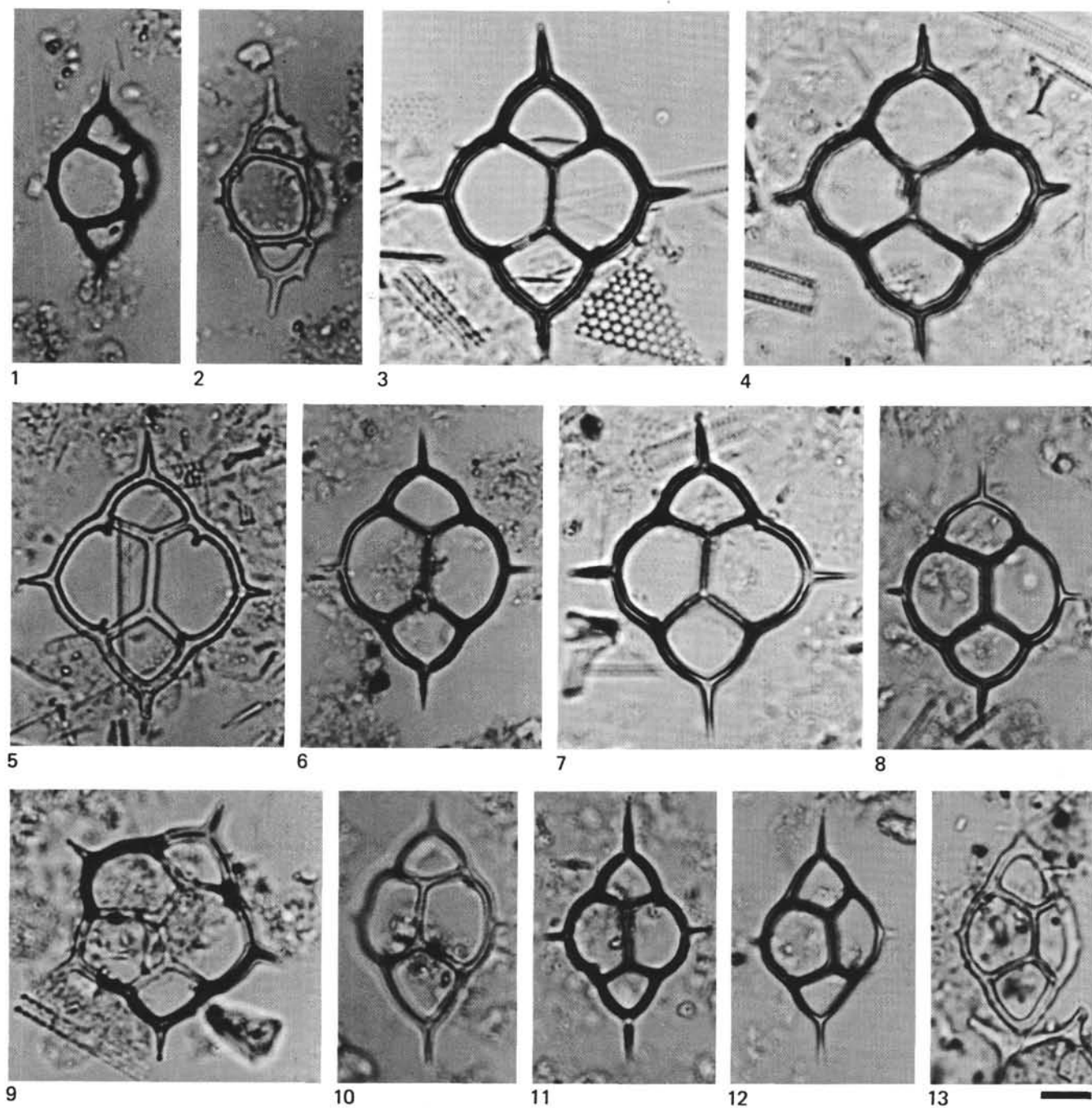


PLATE 5

Silicoflagellates from DSDP Leg 54.

Figures 1-12, 14-16 magnified $\times 800$, scale bar equals 10 μm .

Figure 13 magnified $\times 550$; scale bar equals 20 μm .

- Figures 1-3 *Dictyocha perlaevis perlaevis* Frenguelli.
1. Crinkled, Sample 420-5-2, 122-124 cm (36 m).
2. Arrowhead, Sample 420-8-5, 122-124 cm (69 m).
3. Five-strut, Sample 425-3-1, 74-76 cm (25 m).
- Figures 4-7 *Dictyocha stapedia aspinosa* Bukry.
4. Sample 425-3-1, 74-76 cm (25 m).
5, 6. Sample 425-3-3, 74-76 cm (28 m).
7. Sample 425-3-4, 74-76 cm (30 m).
- Figures 8-10 *Dictyocha stapedia stapedia* Haeckel.
8. Sample 420-10-1, 124-126 cm (82 m).
9. Sample 425-4-1, 74-76 cm (44 m).
10. Cruxoid, Sample 427-7-3, 74-76 cm (93 m).
- Figures 11, 12 *Dictyocha* sp. (naviculopsoid).
11. Sample 425-5-4, 74-76 cm (68 m).
12. Sample 425-4-3, 74-76 cm (47 m).
- Figure 13 *Distephanus boliviensis boliviensis* (Frenguelli).
Sample 428-4-5, 74-76 cm (55 m).
- Figure 14 *Distephanus speculum minutus* Bachmann.
Sample 425-1-2, 110-112 cm (3 m).
- Figures 15, 16 *Distephanus speculum speculum* (Ehrenberg).
15. Small form that predominates at Sites 420 and 428, Sample 425-4-1, 74-76 cm (44 m).
16. Oblique view of elongate specimens that occur only in Sample 425-6-2, 74-76 cm (74 m), where elongate *Dictyocha perlaevis perlaevis* is abundant. See also Plate 6, Figures 1, 2.

PLATE 5

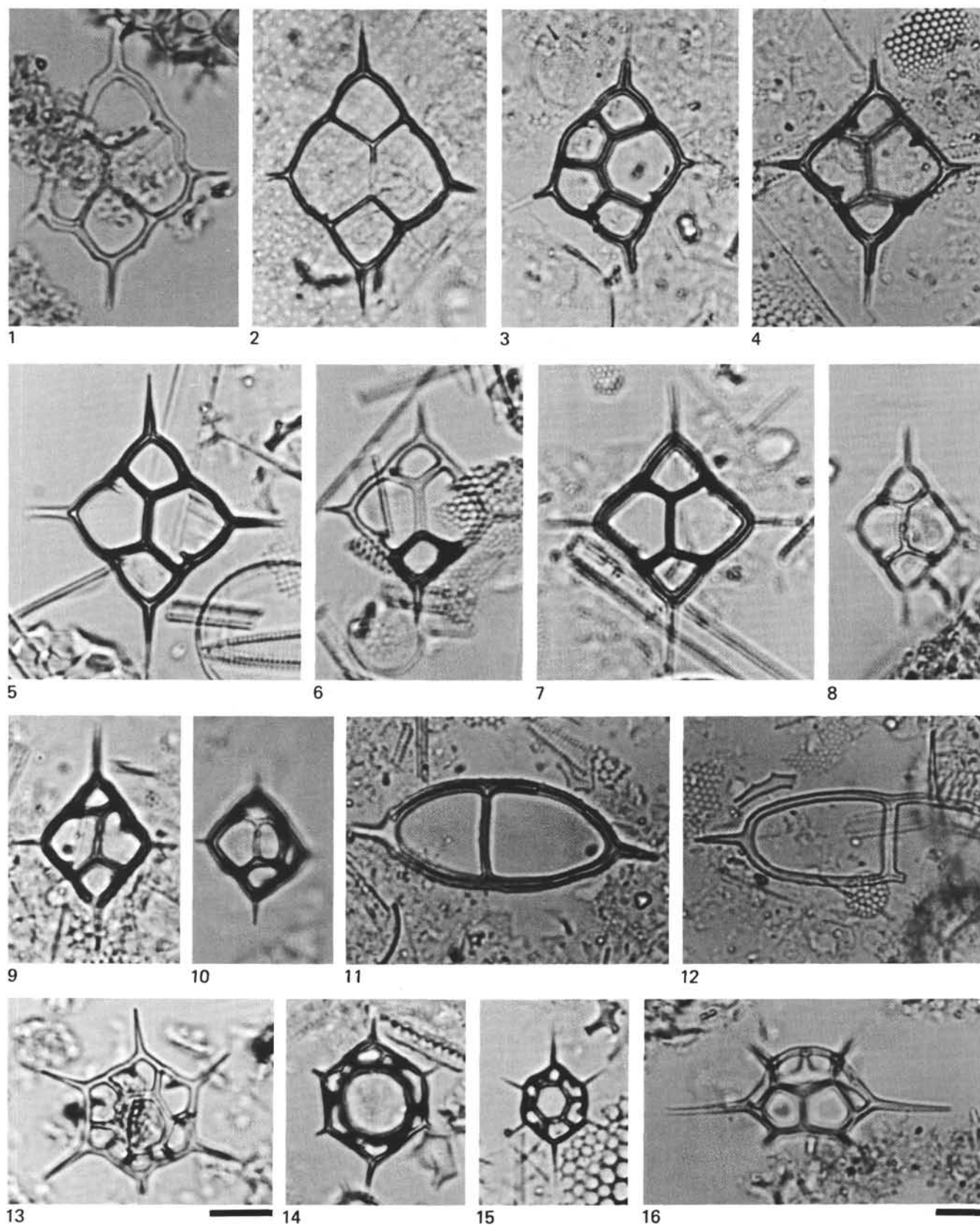


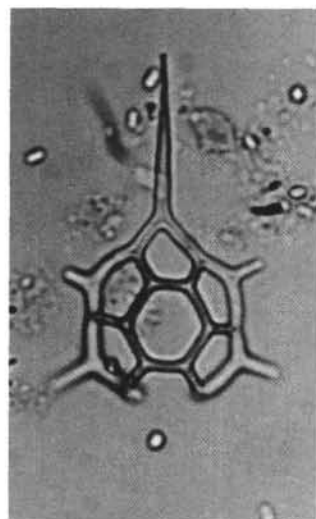
PLATE 6

Silicoflagellates from DSDP Leg 54.

All figures magnified $\times 800$; scale bar equals $10\ \mu\text{m}$.

- Figures 1, 2 *Distephanus speculum speculum* (Ehrenberg).
Elongated axial spine form found only in Sample 425-6-2, 74-76 cm (74 m), where elongate *Dic-tyocha perlaevis perlaevis* is most abundant.
- Figure 3 *Distephanus speculum speculum* (Ehrenberg) at left and elongate *Distephanus boliviensis boliviensis* (Frenguelli) at right. Sample 425-6-1, 74-76 cm (73 m).
- Figures 4-6 *Distephanus boliviensis boliviensis* (Frenguelli).
Note that spine pairs lack radial symmetry through center point shown by *D. speculum speculum*.
4. Sample 425-5-2, 74-76 cm (65 m).
5, 6. Apical and basal focuses, Sample 425-3-5, 74-76 cm (31 m).
- Figures 7-9 *Distephanus* sp. A Bukry (1979).
7. Sample 428-4-3, 74-76 cm (52 m).
8. *Ethmodiscus rex* diatom fragment in back-ground, Sample 420-8-5, 122-124 cm (69 m).
9. Sample 425-5-4, 74-76 cm (68 m).

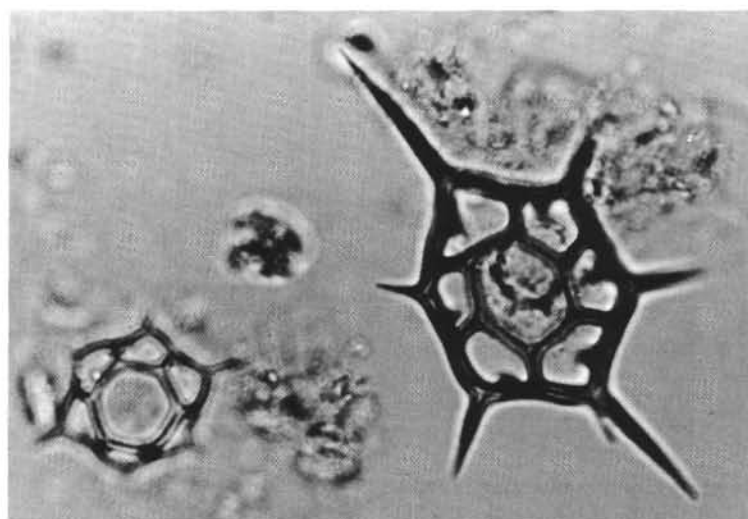
PLATE 6



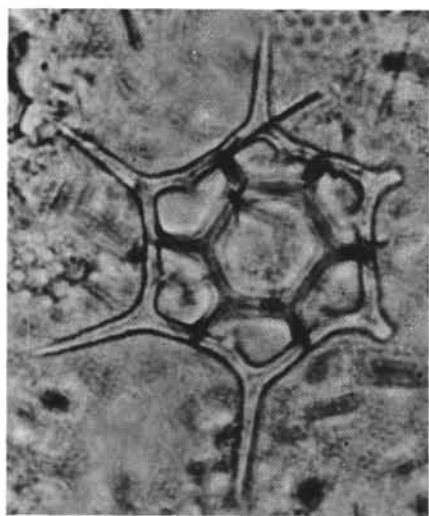
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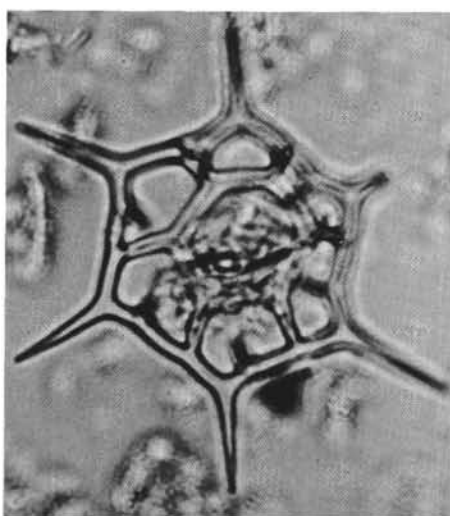
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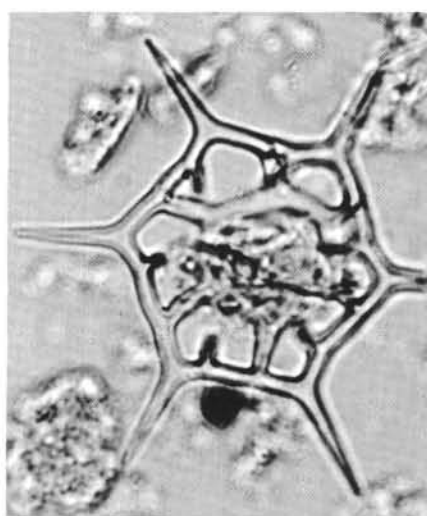
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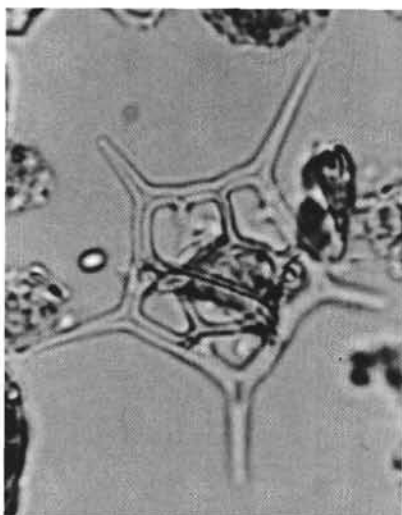
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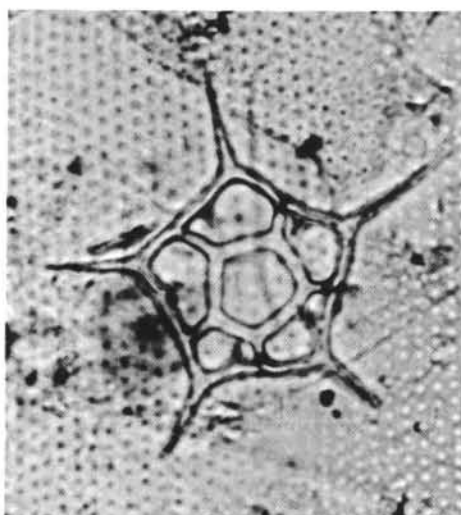
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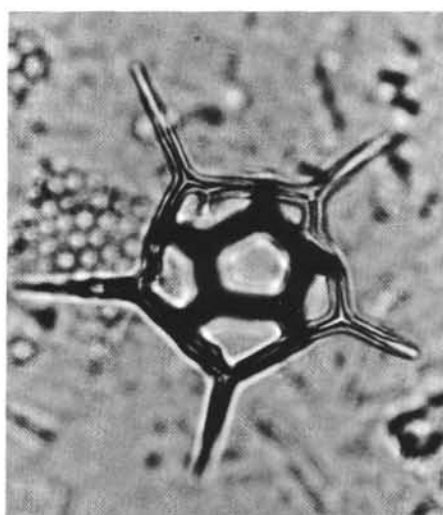
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PLATE 7

Silicoflagellates from DSDP Leg 54.

All figures magnified $\times 800$; scale bar equals $10\text{ }\mu\text{m}$.

- Figures 1-4 *Distephanus* sp. (cruxoid).
1. Sample 425-4-3, 74-76 cm (47 m).
2. *D. stapedia* variant?, Sample 420-7-1, 124-126 cm (53 m).
3. Sample 425-6-2, 74-76 cm (74 m).
4. Sample 425-6-1, 74-76 cm (73 m).
- Figures 5-7 *Mesocena circulus* (Ehrenberg).
Sample 425-6-1, 74-76 cm (73 m).
- Figure 8 *Mesocena* sp. (one-spined).
Sample 420-10-5, 122-124 cm (88 m).
- Figures 9-17 *Mesocena quadrangula* Ehrenberg ex Haeckel.
9. Sample 425-4-3, 74-76 cm (47 m).
10, 14, 17. Sample 420-7-1, 124-126 cm (53 m).
11, 15, 16. Sample 419-4-4, 132-134 cm (25 m).
12. Sample 425-4-2, 74-76 cm (46 m).
13. Sample 428-3-1, 74-76 cm (39 m).

PLATE 7

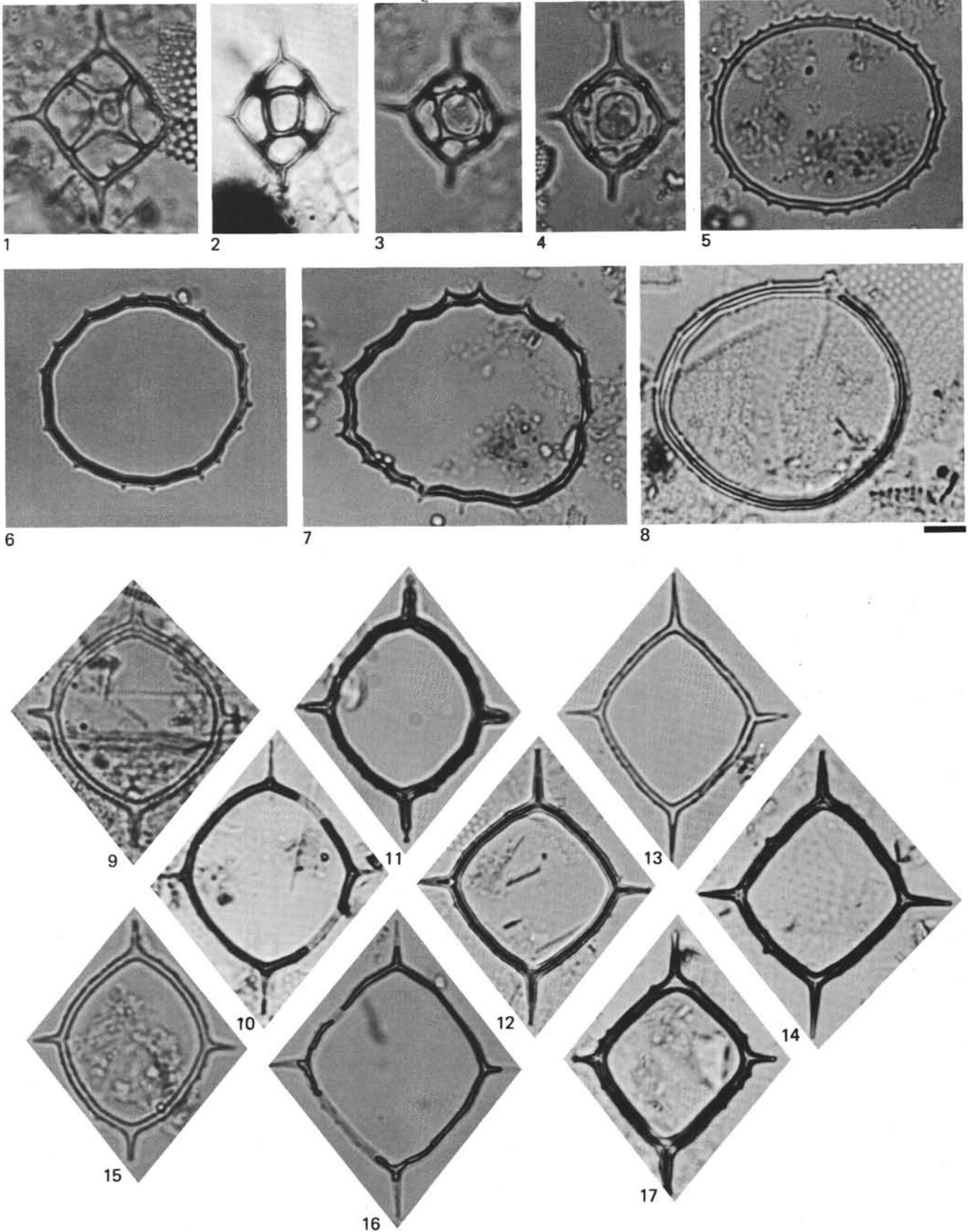


PLATE 8

Silicoflagellates from DSDP Leg 54.

All figures magnified $\times 800$; scale bar equals 10 μm .

Figures 1-10 *Mesocena quadrangula* Ehrenberg ex Haeckel.
Low-frequency or unique variants.

1. Noded, see *Mesocena elliptica verrucosa* of Dumitrică (1973a), Sample 419-4-5, 89-91 cm (26 m).
2. Indented quadrant, Sample 425-5-3, 74-76 cm (66 m). Recorded elsewhere near the beginning of the *Mesocena quadrangula* Zone in Samples 425-5-1, 74-76 cm (63 m); 427-8-4, 74-76 cm (123 m); and 428-3-1, 74-76 cm (39 m).
- 3, 6. Sample 425-5-1, 74-76 cm (63 m).
4. Sample 420-5-2, 122-124 cm (36 m).
5. Four symmetric nodes, Sample 428-4-1, 74-76 cm (49 m).
7. Sample 425-5-2, 74-76 cm (65 m).
8. Sample 425-4-1, 74-76 cm (44 m).
- 9, 10. Sample 425-5-4, 74-76 cm (68 m).

Figures 11, 12 *Octactis pulchra* Schiller.

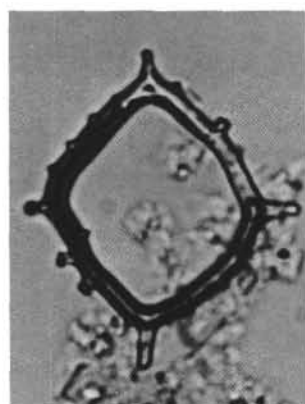
11. Sample 425-1-2, 110-112 cm (3 m).
12. Sample 427-3-2, 70-72 cm (15 m).

Figures 13-16 *Dictyocha* spp.

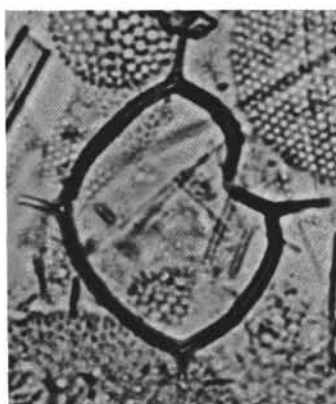
Unique variants.

13. Sample 425-3-5, 74-76 cm (31 m).
14. Sample 425-3-3, 74-76 cm (28 m).
15. Sample 425-5-1, 74-76 cm (63 m).
16. Sample 428-4-3, 74-76 cm (52 m).

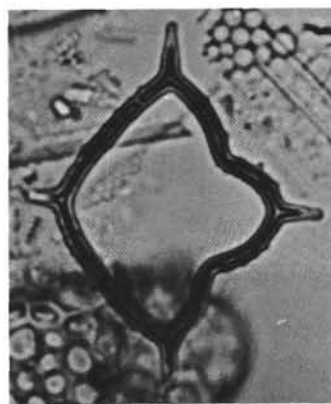
PLATE 8



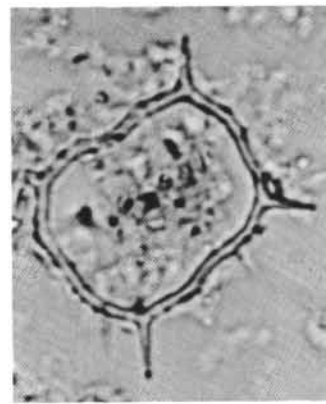
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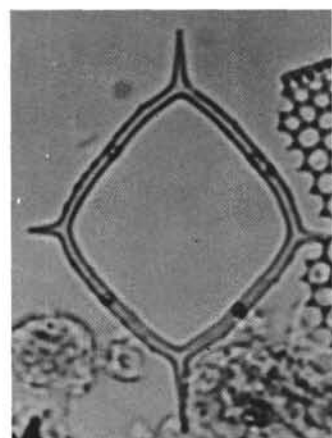
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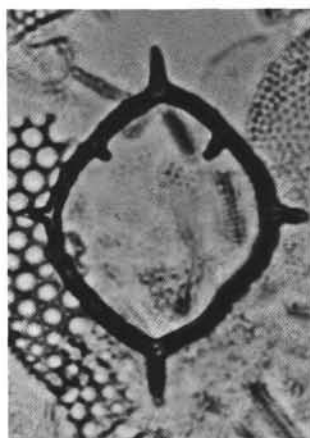
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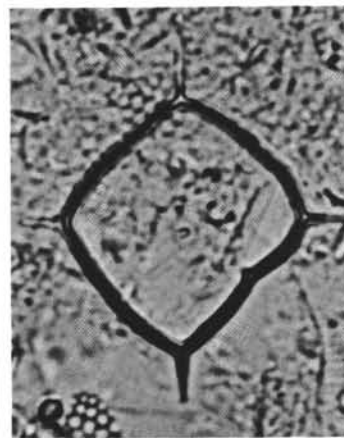
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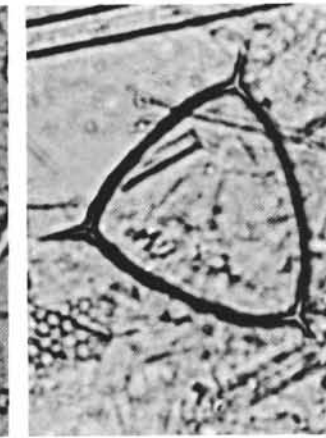
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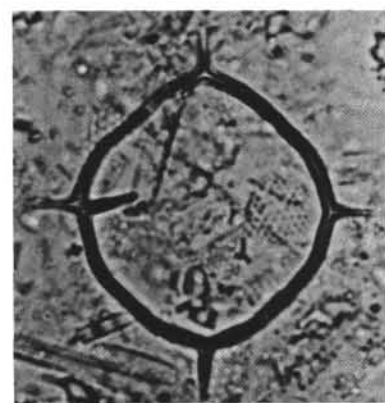
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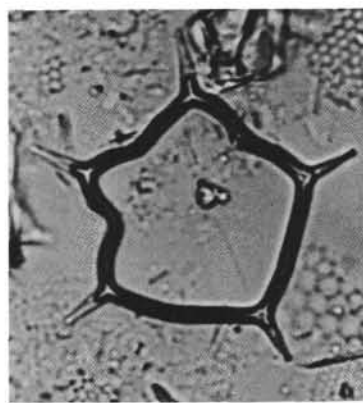
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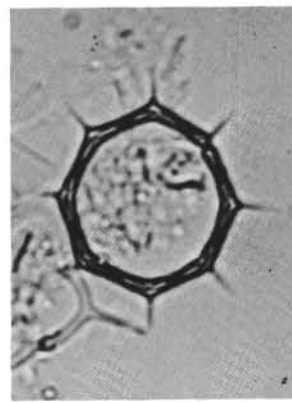
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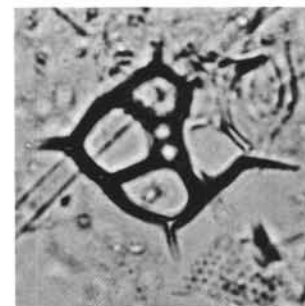
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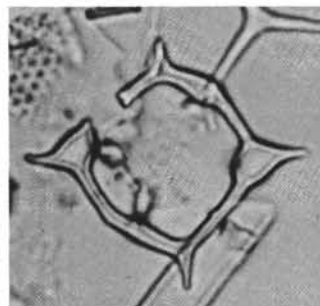
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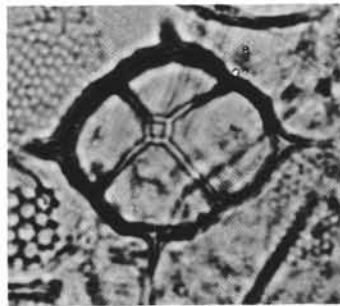
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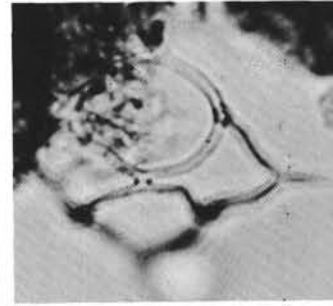
13



14



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16

PLATE 9

Silicoflagellates (Figures 1, 2), Diatoms (Figures 3-6). Sponge Spicules (Figures 7-10), and Opal Phytoliths (Figures 11-14) from DSDP Leg 54.

Figures 1, 2, 4-14 magnified $\times 800$; scale bar equals 10 μm .

Figure 3 magnified $\times 350$; scale bar equals 20 μm .

- Figures 1, 2 *Dictyocha* sp.
Variant from *Ceratolithus cristatus* Subzone of the Galapagos sites; scarce.
1. Sample 425-2-3, 74-76 cm (9 m).
2. Sample 424B-2-3, 120-122 cm (8 m).
- Figures 3, 4 *Thalassiosira leptopus elliptica* (Kolbe).
3. Sample 428-2-3, 74-76 cm (33 m).
4. Sample 425-4-1, 74-76 cm (44 m).
- Figure 5 *Coscinodiscus reniformis* Castracane.
Sample 425-4-2, 74-76 cm (46 m).
- Figure 6 *Liostephanina* sp.
Remnant *Asteromphalus* areolation. Sample 425-6-1, 74-76 cm (73 m).
- Figures 7, 8 Oxea, curved.
Widely distributed in Leg 54 and deep-sea sediment.
7. Sample 427-7-3, 74-76 cm (93 m).
8. Sample 425-2-3, 74-76 cm (9 m).
- Figure 9 Microsclere or small radiolarian spicule?
Widely distributed in Leg 54 lower Quaternary.
Sample 427-7-3, 74-76 cm (93 m).
- Figure 10 Spiraster.
Sample 425-2-3, 74-76 cm (9 m).
- Figures 11-14 Panicoid opal phytoliths.
11. Sample 428-3-1, 74-76 cm (39 m).
12. Sample 420-11-2, 124-126 cm (92 m).
13. Sample 428-4-3, 74-76 cm (52 m).
14. Panicoid arrangement within a grass sliver, Sample 428-4-5, 74-76 cm (55 m).

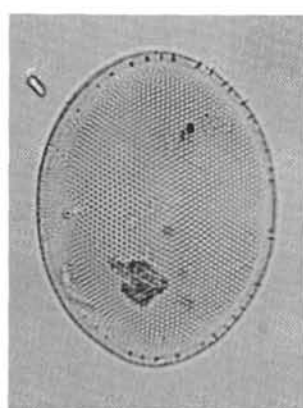
PLATE 9



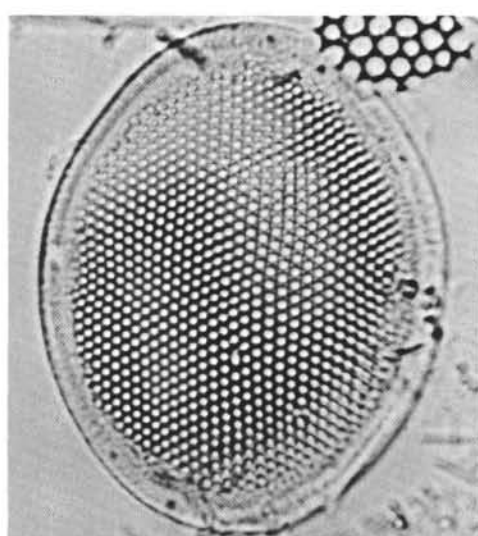
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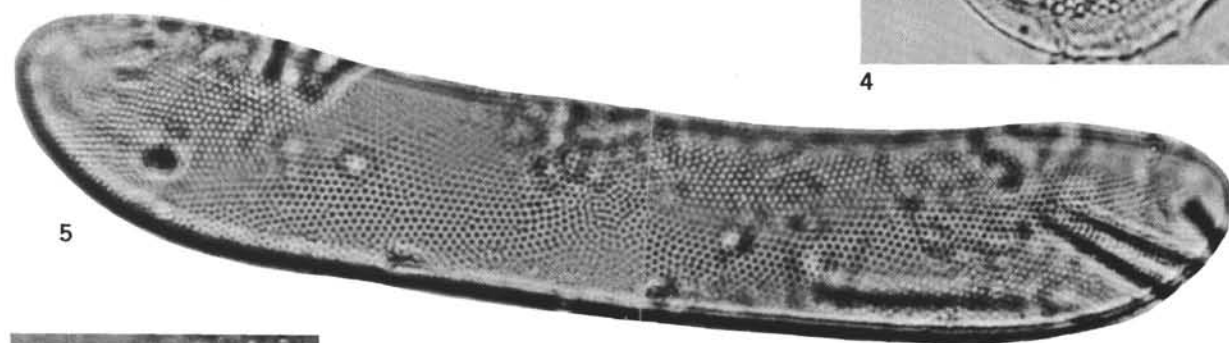
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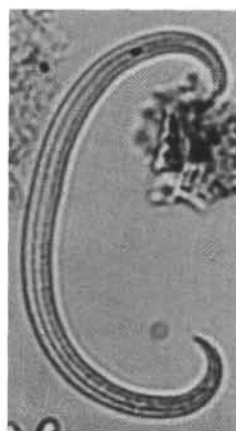
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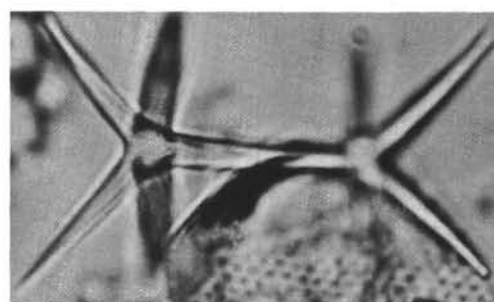
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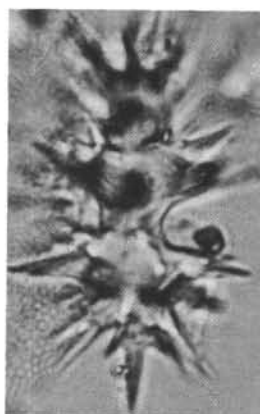
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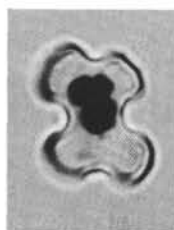
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