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8. SILICOFLAGELLATES AND EBRIDIANS FROM LEG 138, EASTERN EQUATORIAL PACIFIC[1]

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ABSTRACT

The biostratigraphic distribution and abundance of middle Miocene to Pleistocene silicoflagellates is documented from Ocean Drilling Program (ODP) Leg 138 Holes 844B, 847B, 848B, 849B, 850B, 851B, 852B, and 854B from the eastern Equatorial Pacific Ocean. The silicoflagellates were generally abundant and well preserved and frequently exhibited an unusually large range of variation. The upper Miocene of near-equatorial sites includes an assemblage of *Bachmannocena diodon nodosa,* which includes a bridge across the width of the basal ring. Stratigraphically below this, at sites within 5° of the equator is a lengthy interval of specimens of *Distephanus speculum tenuis,* which have a fragile apical structure. Both the intervals of *Bachmannocena diodon nodosa* plexus and *Distephanus speculum tenuis* are biostratigraphically useful within 5° of the equator, but are less useful beyond that. An unusual range of variation also is observed for *Dictyocha* in the Pliocene sediments at about the point where *D. perlaevis* and *D. messanensis* appear in the geologic record. This variation may be explained by hybridization between diverging species.

INTRODUCTION

Eleven sites were drilled in the eastern Equatorial Pacific Ocean during Ocean Drilling Program (ODP) Leg 138 in May and June, 1991. These sites were chosen so as to sample each of the major oceanographic features of the equatorial current system (Fig. 1 and Table 1). The sites are divided into two complementary north-south transects. The western transect is centered at about 110°W and was chosen to provide information about the equatorial circulation system in an area far removed from the influence of the eastern boundary of the Pacific Ocean. Sites of the eastern transect occur 15° to 20° to the east and, thus, are located closer to Central and South America.

Leg 138 is the fifth ODP expedition to examine the evolution of global climate change during the late Cenozoic using high-resolution analyses of deep-sea sediments. During previous legs, the equatorial Atlantic (Leg 108), the Peru Current (Leg 112), the western tropical Pacific Ocean (Leg 130), and the northwestern Indian Ocean (Leg 117) were sampled; of these, only Leg 112 (Martini, 1990) included published work on silicoflagellates. The paucity of silicoflagellate studies associated with these legs does not reflect an absence of silicoflagellates, which are exceptionally abundant and diverse in tropical waters, but reflects the limited number of silicoflagellate specialists. Silicoflagellate studies from equatorial sites published in *Initial Reports* from the Deep Sea Drilling Project (DSDP) and ODP are summarized in Table 2.

This report documents the biostratigraphic occurrence and abundance of silicoflagellates from Holes 844B, 847B, 848B, 849B, 850B, 851B, 852B and 854B. Silicoflagellates generally occur throughout the continuous stratigraphic sequence, although samples examined from Hole 854B were barren of silicoflagellates in the Miocene interval. Samples from nearer the equator have silicoflagellate assemblages, showing unusual skeletal variability, that are less abundant or not found in holes located farther from the equator (Hole 845B, 854B). Morphological variation among the four-sided *Dictyocha,* with bridges parallel to the major axis, is also extraordinary, as numerous intermediate morphotypes occur between several well-known morphotaxonomic end-members.

Other minor siliceous microfossil groups also occur in the Leg 138 samples. Endoskeletal dinoflagellates, particularly *Actiniscus,* are frequently abundant, while ebridians and siliceous sponge spicules are generally rare; ebridian occurrences are tabulated in this study for Holes 844B, 848B, 850B and 851B.

SAMPLE PREPARATION

Samples used in this study are the same as those used for diatom investigations (Baldauf and Iwai, this volume). Raw samples were prepared as smear slides with a 22-/50-mm cover slip. Where silicoflagellates were abundant, 300 specimens were counted, and the approximate amount of the slide required to find that many specimens is recorded in the abundance charts (Tables 3 through 10). Each tenth of a slide examined represents approximately 1.1 cm^2; the relative abundance of any two slides can be obtained by dividing the total count by the area of each slide examined. In most cases, where silicoflagellates were less abundant, the whole slide was examined, although sometimes less than a whole slide was counted when silicoflagellates were extremely rare or when only a brief examination was needed to more precisely place zonal boundaries. Less than 300 counts were made in some cases, where the slide was difficult to examine or where silicoflagellates were scarce.

Only those fragments representing more than one-half of a silicoflagellate were included in the counts. A separate tally has been made of teratoid (aberrant) specimens because these may be an indication of environmental stress. Common aberrant skeletons included those having deformed or incomplete basal rings, multiple spines on a basal corner, or multiple struts to a side (see McCartney and Loper, 1989, for a discussion of the basic rules of silicoflagellate form). Because aberrants are often counted among the specific taxa, the number of aberrants was not included in the total counts.

Parts of this study were conducted by undergraduate students having limited experience of silicoflagellates. These students had a year of training and were closely supervised by the first author. Because of the complexity of silicoflagellate taxonomy and variability, the relative inexperience of these students' work should be taken into account when evaluating this study. Because this study is the work of three microscopists, there can be variations in species concept from one hole to another. Sherry Churchill conducted the census for Holes 849B and 852B; Linda Woestendiek performed the microscope work for Holes 844B and 847B.

SILICOFLAGELLATE ZONATION

A number of low-latitude silicoflagellate zonations have been previously proposed (Bukry, 1979a, 1981a, 1981b, 1982a, 1983, 1985; Locker and

[1] Pisias, N.G., Mayer, L.A., Janecek, T.R., Palmer-Julson, A., and van Andel, T.H. (Eds.), 1995. *Proc. ODP, Sci. Results,* 138: College Station, TX (Ocean Drilling Program).

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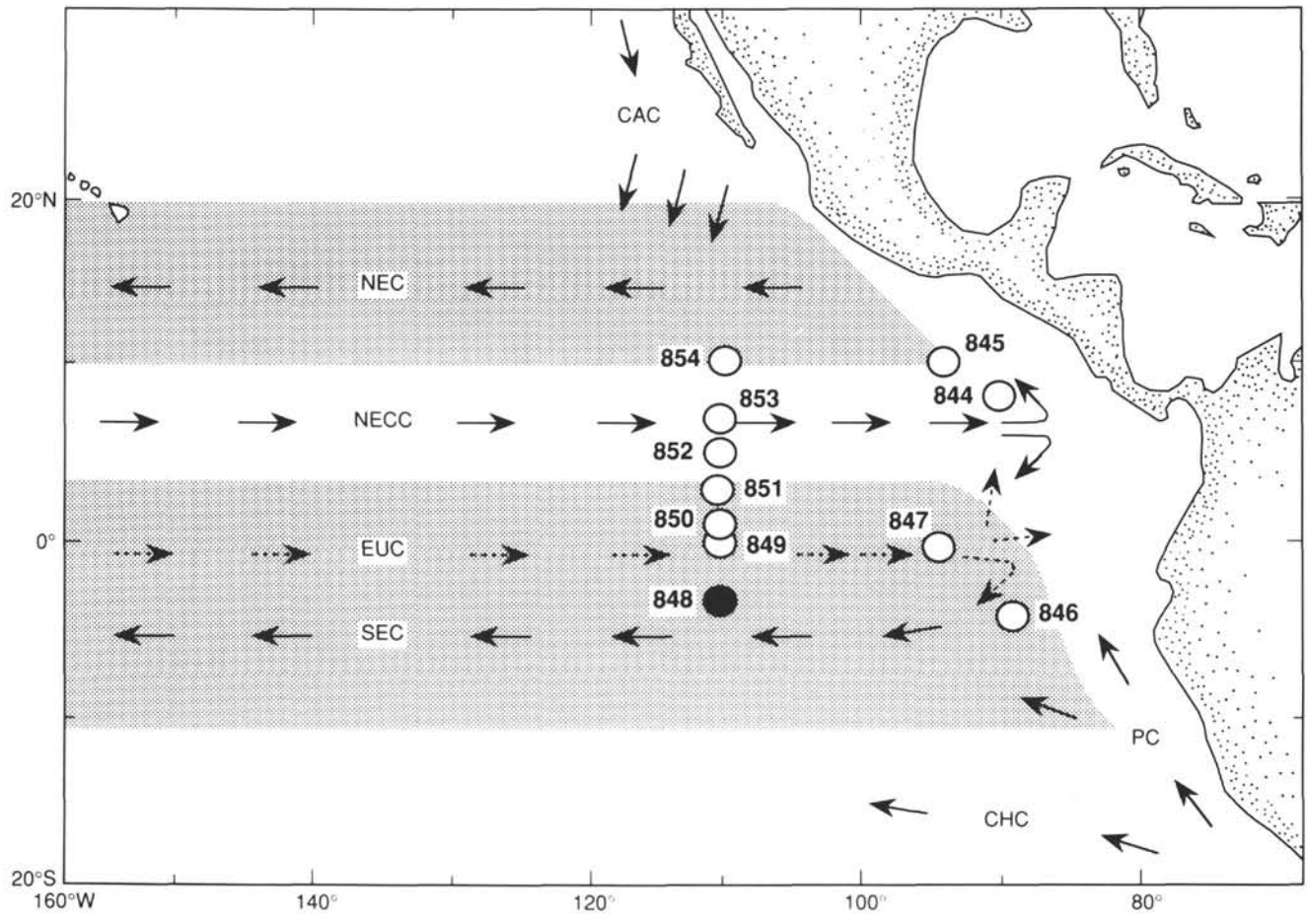

Figure 1. Location map showing sites drilled during Leg 138. CAC = California Current; CHC = Chile Current; NEC = North Equatorial Current; NECC = North Equatorial Countercurrent; EUC = Equatorial Undercurrent; SEC = South Equatorial Current; PC = Peru Current.

Martini, 1986b; Martini, 1990). These zonations tend to be similar for the Pleistocene and late Pliocene, but differ widely for the early Pliocene and Miocene. Our study shows that some taxa, such as *Distephanus speculum tenuis* and *Bachmannocena diodon nodosa,* are narrowly restricted latitudinally, suggesting that several zonations may be required to subdivide sequences stratigraphically in the tropical regions.

Here, horizons are used for biostratigraphic intervals that are short enough that they may be missed at a sample interval of approximately 5 m (Fig. 2). Although these intervals are biostratigraphically useful, their brief duration often prevents their consistent discovery at all sites at the sample interval used in this study. The usage here differs from Bukry (e.g., 1985), who used taxa that are abundant in brief intervals as subzones.

Table 1. Details of Leg 138 holes examined for silicoflagellates in this study.

Hole	Latitude (°N or S)	Longitude (°W)	Water depth (m)	Cored (m)	Recovery (%)
844B	07° 55.279′ N	90°28.846′	3414.5	290.0	99
847B	00° 11.593′ N	95°19.227′	3334.3	247.0	98
848B	02° 59.634′ S	110°28.791′	3855.6	93.8	104
849B	00° 10.983′ N	110°31.183′	3855.6	350.5	98
850B	01° 17.827′ N	110°31.286′	3786.3	398.8	99
851B	02° 46.223′ N	110°34.308′	3760.3	320.5	99
852B	05° 17.566′ N	110°04.579′	3859.9	113.4	105
854B	11° 13.433′ N	109°35.652′	3567.4	45.4	105

Corbisema triacantha Range Zone

Definition: Interval from the last occurrence of *Naviculopsis* species to last occurrence of *C. triacantha.*

Author: Martini (1971).

Common species: Common species include *Dictyocha varia, D. extensa, D. fibula fibula, D. fibula ausonia,* and *Distephanus crux. Distephanus stauracanthus* is scattered and can be common in the upper part of this zone.

Remarks: This zone was found only in Hole 844B, and includes two horizons. The *Distephanus stauracanthus* Horizon has been described by Martini (1972), and Locker and Martini (1986b), and occurred over an interval of about 50 m in Hole 844B; despite its thickness it is here considered as a horizon because we are uncertain of its geographic distribution and because of its usage as a horizon by previous workers. The horizon extends from the first to the last appearance of the nominate taxon. Near the bottom of Hole 844B is the *Dictyocha varia* (deflandroid) Acme Horizon, in which deflandroid variants of *D. varia* and *D. extensa* are abundant. These horizons are discussed in greater detail by Woestendiek and McCartney (this volume).

Dictyocha varia Interval Zone

Definition: The bottom of this zone is defined as the last occurrence of *Corbisema triacantha* Acme. The top of this zone is defined as the first occurrence of *D. speculum tenuis;* where *D. speculum tenuis* does not occur, as happens at locations farther from the equator, the top of this zone is defined as the first consistent occurrence of *Dictyocha extensa.*

Author: Modified from Locker and Martini (1986b).

Common species: *Dictyocha varia* is generally the dominant species with *Distephanus speculum speculum* as a secondary species. *Dictyocha extensa* is usually present and can be abundant, particularly near the top of the zone, such as in Samples 138-850B-28X-1, 120–121 cm, and 138-851B-20X-1, 120–121 cm. *D. fibula fibula, D. fibula ausonia,* and *Distephanus crux* are scattered. *Dictyocha subclinata* occurs in a narrow horizon (see remarks below).

Remarks: The overall diversity of silicoflagellate species is low, especially in the lower part of this zone. This zone includes the *Dictyocha subclinata* Horizon, which is found in Samples 138-850B-33X-1, 120–121 cm, and -851B-25X-1, 120–121 cm.

Table 2. Silicoflagellate studies from equatorial sites (<25°).

Leg (Sites)	Pleistocene	Pliocene	Miocene	Oligocene	Eocene	Paleo.	Cretaceous	Reference
7 (65–66)	X	X	X					Martini, 1971
13 (124–128)	X	X	X					Dumitrica, 1972
16 (157–158)	X	X	U,M					Bukry and Foster, 1973
22 (216)							X	Bukry, 1974
33 (315–316)	X	X	X					Martini, 1976
34 (329–321)	X	U						Bukry, 1976b
39 (354)				X				Perch-Nielsen, 1977
40 (362)	X	X	X	X				Bukry, 1978c
54 (419–428)	X	X						Bukry, 1980
63 (471)			U					Bukry, 1981a
67 (495)	X	X	X					Bukry, 1982a
68 (503)		X	U					Bukry, 1982b
69 (504)	X	X	U					Bukry, 1983
78 (543)			L					Bukry, 1984
85 (572, 575)		X	X	X				Bukry, 1985
112 (682–688)	X	X	X					Martini, 1990

Notes: Only publications with charts that show relative or absolute abundances are listed here. X = present throughout the series; U, M, L = subseries.

Distephanus speculum tenuis Range Zone

Definition: Interval from the first to last common occurrence of *Distephanus speculum tenuis.*

Author: McCartney, Churchill and Woestendiek (this paper).

Common species: The dominant species is usually *Dictyocha extensa; D. varia* is much less abundant within this zone than in the intervals immediately above and below it. Other important species are *D. speculum speculum, D. fibula fibula,* and *D. fibula ausonia.*

Remarks: This zone occurs over a thick sediment interval and has abundant *D. speculum tenuis* only at locations near the equator.

Dictyocha extensa Interval Zone

Definition: Interval from the last common occurrence of *Distephanus speculum tenuis* to the first common occurrence of *Dictyocha messanensis.*

Author: McCartney, Churchill and Woestendiek (this paper).

Common species: *Dictyocha fibula, D. varia,* and *Distephanus speculum* are generally present, and the *Bachmannocena diodon nodosa* assemblage is abundant in a narrow horizon near the bottom of this zone (see remarks below).

Remarks: The *Dictyocha extensa* Zone includes two horizons. The first of these, the *Distephanus xenus* Horizon, was not found in holes examined as part of this study, but occurs in Hole 849B and Hole 847B. The *Bachmannocena diodon nodosa* assemblage Horizon occurs near the bottom of this zone. It is most pronounced near the equator and rapidly thins beyond a latitude of 5°N and 5°S. This horizon is much less pronounced at sites studied from the eastern transect, suggesting that it may be severely restricted geographically. We consider this interval as a horizon, rather than a zone, because it could not be consistently found in all Leg 138 holes.

Dictyocha messanensis Partial Range Zone

Definition: Interval from the last common occurrence of *Dictyocha extensa* to the first common occurrence of *Bachmannocena quadrangula.*

Author: Bukry (1981b), as the *Dictyocha stapedia stapedia* Zone.

Common species: *Dictyocha perlaevis, Distephanus speculum,* with scattered *Distephanus pulchra.* A wide variety of *Dictyocha* cannot be easily placed into established species and are here listed as *Dictyocha* sp.

Remarks: In Holes 850B and -851B, the dominant silicoflagellate group is often what is here listed as *Dictyocha* sp. North and south of these holes, the occurrence of this group declines markedly, and silicoflagellate are more easily placed into the established taxonomy.

Bachmannocena quadrangula Range Zone

Definition: Interval from the first common to last common occurrence of *Bachmannocena quadrangula.*

Author: Described by Bukry and Foster (1973) as *Mesocena elliptica* Zone (see Bukry, 1979b).

Common species: *Dictyocha perlaevis* and *D. messanensis; Distephanus pulchra* also occur with the nominate species.

Remarks: *Bachmannocena quadrangula* is dominant in a narrow interval. Locker and Martini (1986b) considered this interval as a horizon, but we found it throughout the Leg 138 study area and thick enough to be found at a sample interval of two samples per core (approximately 5 m); thus, we follow the usage of Bukry (1979b, 1981b), who used it as a zone. The zones above and below this interval would be difficult to divide consistently without the use of *Bachmannocena quadrangula* as a boundary between the zones.

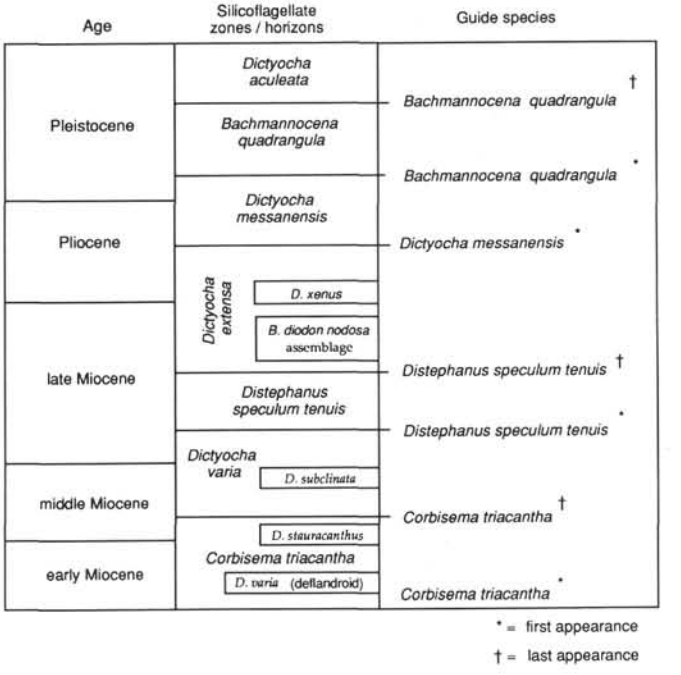

Figure 2. Silicoflagellate zonation used for Leg 138.

Dictyocha aculeata Interval Zone

Definition: Interval from the last common occurrence of the *Bachmannocena quadrangula* at the zone base; the top is not defined.

Author: Bukry (1981b).

Common species: *Dictyocha perlaevis* and *D. messanensis; Distephanus pulchra* is scattered.

Remarks: This zone is best exhibited in Hole 849B, where an extended sequence contains abundant *D. aculeata.* In Holes 850B and -851B, *Dictyocha aculeata* and *D. subaculeata* are less common than *D. perlaevis* and *D. messanensis.* The relative abundance of *D. perlaevis* varies considerably.

SITE SUMMARIES

Site 844

Site 844 is located in the Guatemala Basin of the eastern equatorial Pacific Ocean within the eastward-flowing North Equatorial Countercurrent (see Fig. 1). It lies in the region of the Costa Rica Dome, in which wind-induced doming of the thermocline produces surface upwelling and high open-ocean productivity, and of the Leg 138 sites

Table 3. Abundance of silicoflagellates and ebridians in selected samples from Hole 844B.

Age	Zone	Core, section, interval (cm)	Depth (mbsf)	Slide	*Bachmannocena apiculata curvata*	*B. circulus*	*B. diodon diodon*	*B. diodon nodosa*	*B. diodon triodon*	*B. elliptica*	*B. quadrangula*	*Corbisema triacantha*	*Dictyocha aculeata aculeata*	*D. aculeata subaculeata*	*D. calida*	*D. extensa extensa*	*D. extensa extensa* (deflandroid)	*D. varia* (canted bridge)	*D. extensa extensa* (medusid)	*D. extensa longa*	*D. fibula ausonia*	*D. fibula fibula*	*D. fibula mutabilis*	*D. messanensis*	*D. perlaevis perlaevis*
Pleistocene	*D. aculeata*	1H-2, 119–120	2.7	1.0									1			11								40	
		1H-3, 119–120	4.2	1.0									5											23	
		2H-2, 120–121	7.2	1.0									5			20						1		73	4
	B. quadrangula	2H-4, 120–121	10.2	1.0							22					26			1					43	25
	D. messanensis	3H-1, 120–121	15.2	1.0																				3	2
late Pliocene		3H-4, 120–121	19.7	1.0													1						3	21	4
early Pliocene	*D. extensa*	4H-2, 120–121	26.2	1.0							1					6								5	2
		4H-4, 120–121	29.2	1.0												11									
late Miocene	*D. speculum tenuis*	5H-2, 120–121	35.7	0.3							1	4			6	80				7	68	6	39		66
		5H-4, 120–121	38.7	0.3								2				209									34
	D. varia	6H-2, 120–121	45.2	1.0								2				20			1			2	12		
		6H-4, 120–121	48.2	0.5		6						1				32			17			4	1		
		7H-2, 120–121	54.7	0.3		3		1				3			5	13			6		1	4	31		
		7H-4, 120–121	57.7	0.4		2										2					3				
		8H-2, 119–120	64.2	0.3		4	2					1				8			2		1				
		8H-4, 120–121	67.2	0.4		3					1	1				3	1								
		9H-2, 120–121	73.7	0.3		1	12		5		5	1			5	6			1						
		9H-4, 120–121	76.7	0.2		2	22		5			1				5			5						
		10H-2,120–121	83.2	0.3												5			2						
		10H-4, 120–121	86.2	0.3								2				3		1							
		11H-2, 120–121	92.7	0.3												11		27	5						
middle Miocene	*C. triacantha*	11H-4, 120–121	95.7	0.5					3		2	9				10			1						
		12H-2, 120–121	102.2	0.9								45				23			1	3					
		12H-4, 120–121	105.2	0.7			1					56				15			1						
		13H-4, 120–121	113.7	1.0								4						1							
		14H-2, 120–121	121.2	1.0								35				1		5	1						
		14H-4, 120–121	124.2	1.0						1		8			1	9		10							
		15H-2, 120–121	130.7	0.5								21				32			2						
		15H-4, 120–121	133.7	0.8						2		142				11		10	2			1			
		16H-2, 120–121	140.2	0.4		1						117						8							
		16H-4, 120–121	143.2	0.3								46						3	5	5					
		17H-2, 120–121	149.7	0.2								79				14		3	7						
		17H-4, 120–121	152.7	0.3								64				1					16	1			
		18H-2, 120–121	159.2	1.0								13									5		1		
		18H-4, 120–121	162.2	0.9								151						2			37		24		
		19H-2, 120–121	168.7	0.8								106									80		28		
		19H-4, 120–121	171.7	1.0								6									13		19		
		20H-2, 120–121	180.2	1.0								58									4		2		
		20H-4, 120–121	183.2	0.8								47				7	13		8		26		189		
		21X-2, 120–121	187.7	0.4								33				9	3		5		20		11		
		22X-2, 120–121	197.3	0.8								19				10			3		54	21	14		
		22X-4, 120–121	200.3	0.2								30				23			1		5	4	31		
		23X-2, 120–121	207.0	0.3								35			2	99			3		46	13	6		
		23X-4, 120–121	210.0	1.0								27			2	170			3		4	1	2		
		24X-2, 110–111	216.5	1.0								4				89			4		18	5	10		
		24X-4, 110–111	219.5	0.8								43				121			6		5	3	3		
		25X-2, 120–121	226.3	1.0	1							47				3			1		26	10	18		
		25X-4, 120–121	229.3	1.0								19				1					38	2	9		
		26X-2, 118–119	236.0	1.0								177				3	1		1		29	12			
		26X-4, 123–124	239.0	0.8	3							89				4					40	12	25		
		27-CC, 11–12	243.0	0.4								188				4			2		23		2		
		28X-2, 122–123	255.3	1.0								27									5				
early Miocene		28X-4, 121–122	258.3	1.0								116				2	1		1		3	1	1		
		29X-2, 120–121	264.6	0.6								63				21	49		9		1	1			
		29X-4, 122–123	267.6	1.0								53				13	6		1		1				
		30X-2, 121–121	274.3	1.0		1				4		34				4						2	12		
		30X-4, 67–68	276.8	1.0						25		94				7					3	2	73		
		31X-2, 133–134	284.0	1.0						5		1									43		4		
		31X-5, 92–93	287.8	1.0								2				1					19		4		

Notes: Species (in alphabetical order) are recorded as total number of specimens found in the slides examined.

is the one closest to a major landmass. This hole is noteworthy for a lengthy middle and upper Miocene interval (Table 3).

Four holes were drilled at this site to assure continuous recovery and to provide sufficient volume of material for high-resolution analyses. Study of magnetic susceptibility and GRAPE-measured sediment density show that Holes 844B through 844D recovered a continuous sequence of the upper 185 m of the section. Three lithologic units are recognized. Unit I (0–22 mbsf; Pliocene–Pleistocene) is a clay-rich biogenic silica ooze with little carbonate. Unit II (22–74.9 mbsf; late early Miocene to late Miocene) is an alternating carbonate and silica-rich biogenic ooze. Unit III (74.9–291 mbsf; late early Miocene to late Miocene) has varying lithologies dominated by biogenic calcium carbonate. Samples from Hole 844B, which was cored with the APC to 185 mbsf, then with the XCB to basement at 291 mbsf, were examined for silicoflagellates.

Silicoflagellates from Hole 844B showed marked similarities in a lack of abundance, when compared with other Leg 138 sites in the late Pleistocene *Dictyocha aculeata* Zone (Fig. 3 and Table 3). They do

TABLE 3 (continued).

D. subclinata	*D. varia*	*D. varia* (deflandroid)	*D. varia* (canted bridge)	*Distephanus boliviensis boliviensis*	*D. bolivensis* (multiwindowed)	*D. crux crux*	*D. crux longispinus*	*D. polyactis*	*D. pulchra*	*D. quinquangellus*	*D. speculum giganteus*	*D. speculum hemisphaericus*	*D. speculum minutus*	*D. speculum patulus*	*D. speculum pentagonus*	*D. speculum speculum*	*D. s. s.* f. *pseudofibula*	*D. speculum tenuis*	*D. stauracanthus* f. *stauracanthus*	*D. stauracanthus* f. *octagonus*	Aberrants	Total silicoflagellates	*Ebriopsis antiqua antiqua*	*Ammonodochium erotinum*	*Parathranium intermedium*	*Hermesinum adriaticum*
																						52				
																						28				
									1												1	104				
																1					1	118				
																						5				
						1									1	2						33				
																						14				
																2						13				
	3	1	6			2										6		5			3	300				
	4	2		1		1	1									36		10			1	300				
	41		3							3						45						129				
	213		2			3		1								20					1	300				
44	93	32	6			13	2								21	22					2	300				
	262					5	5			3	2	2			2	11			1		2	300				
	263					5										14					2	300				
	272	2	1					1			2					13						300				
	217	7	1	1		1										37					2	300				
1	216	1	2			13	1			1						25					6	300				
	224	1				17	12					2				37					4	300				
	219	1				34					18				1	21					3	300			1	
	177	18				10					17					34	1				2	300				
	211					43					3					18						300				
	223									1	2					2					1	300				
	132	1				40		2								19			33		1	300			1	
	18	6	1			11										4						45				
	13	2				24							1			5			2	1	1	90			1	
	122	11				104				1	1		1			6			8		1	283	1		7	1
	156	3				70										4			6	6	3	245		2	2	5
6	90	12				14				1	1	1			1	6					5	300			4	4
	72	18				26	46									8			4		3	300		2	1	
	191	25				1	8				3					1			11	1	3	300				
	163	8				9	9									5			3		2	300				
	37	1				14	76							2		4			84		7	300				
	8						8									1					1	300		6	3	
	15					66	2					3									3	300		1		
	39					36	3									8					1	86		8		
	3					18															1	59		1		
	78					14																156		2		1
	2	7	1																		3	300		2		
	185	1				29					3	1										300				1
	177					1					1											300				
	205					1															6	300				
3	36	6				45					1		2			1	2				3	300				
	58					2					2										1	271				
	53							1													1	184				
5	110		1									1				2						300				
	31					6					3					3						149		1		
	39					4															1	112				
	40	1	5			9					4										2	282				
	106			2		11				1	5	1				1					1	300				
	70	1				4					2					4					4	300				
	41																					73				
1	40	1	1			4	17					2				3					1	194				
	57	90				6					1					2					1	300		3	1	
	76	5				3										2					2	160				
	37											1										95				
	44					8					5	5									5	266				
	52																				1	105				
	27											1									2	54				

not become more abundant until Sample 138-844B-5H-2, 120–121 cm, in the end of the late Miocene, where they appear to have had one last population surge before dwindling.

Silicoflagellates are generally not abundant in the Pleistocene and Pliocene, with the total number of silicoflagellates on a microscope slide frequently less than 50 specimens. *Dictyocha aculeata* are uncommon within the *Dictyocha aculeata* Zone; this taxon is especially abundant near the equator and the relative abundance declines toward higher latitudes. The *Bachmannocena quadrangula* Zone is represented by 22 specimens in Sample 138-844B-11H-2, 120–121 cm. Both the *Dictyocha messanensis* and the *D. extensa* zones are very short when compared to other Leg 138 holes.

The *Bachmannocena diodon nodosa* plexus was not discovered in Hole 844B. This horizon thins rapidly away from the equator; if it occurs at all in Hole 844B it must be thinner than the approximately 5-m sample interval used in this hole. The *Distephanus speculum tenuis* Zone is found only in Samples 138-844B-5H-2, 120–121 cm, and -5H-4, 120–121 cm, although specimens of the nominative taxon are uncommon.

The *Corbisema triacantha* Zone makes up almost two-thirds of the Hole 844B interval. The top of this zone is placed in Sample

Age	Silicoflagellate zones / horizons	Hole 844B	Hole 847B	Hole 848B	Hole 849B	Hole 850B	Hole 851B	Hole 852B	Hole 854B
Pleisto-cene	*Dictyocha aculeata*	1H-1 to 2H-2	1H-1 to 3H-4	1H-1 to 2H-4	1H-1 to 3H-1	1H-1	1H-1 to 2H-1	1H-1	1H-1
	Bachmannocena quadrangula	2H-4	4H-4 to 5H-4	3H-1 to 3H-4	3H-4 to 4H-4	2H-4 to 3H-1	3H-1	2H-1	1H-4
Pliocene	*Dictyocha messanensis*	3H-1 to 4H-2	6H-4	4H-1 to 5H-1	5H-1 to 6H-1	3H-4 to 6H-4	4H-4 to 9H-1	3H-1 to 4H-1	2H-1 to 2H-4
	Dictyocha extensa	4H-4	7H-4 to 22X-1	6H-1 to 7H-1	6H-4 to 24X-1	7H-1 to 16X-1	10H-1 to 12H-4	5H-1 to 7H-1	
late Miocene	*Distephanus xenus*		21X-1 to 22X-1		20X-1				
	B. diodon nodosa assemblage		22X-4	7H-4	20X-4	16X-4	13H-1		
	Distephanus speculum tenuis	5H-2 to 5H-2	22X-4 to 24X-1	8H-1	25X-1 to 28X-1	17X-1 to 26X-1	14H-1 to 19X-1	8H-1	
	Dictyocha varia	6H-2 to 11H-2		9H-1 to 10H-4	29X-1 to 37X-1	27X-1 to 42X-1	20X-1 to 26X-1	9H-1 to 12H-1	
middle Miocene	*Dictyocha subclinata*	7H-4				33X-1	25X-1		
early Miocene	*Corbisema triacantha*	11H-4 to 31X-5							
	Distephanus stauracantha	12H-4 to 17H-5							
	D. varia (deflandroid)	29X-2							

Figure 3. Silicoflagellate zones found in Leg 138 sediments.

138-844B-11H-4, 120–121 cm, which is the last consistent occurrence of *C. triacantha,* although this taxon made up only 9 of 300 specimens that were counted. The taxon was scattered in samples that were located higher in the interval, but these are presumed to have been reworked. The *Distephanus stauracanthus* Horizon (see Locker and Martini, 1986b) occurs from Samples 138-844B-12H-4, 120–121 cm, to -17H-4, 120–121 cm. The occurrence of *D. stauracanthus,* however, is not consistent through this interval and it appears to be most abundant at the very top and very bottom of the horizon.

Sample 138-844B-15H-2, 120–121 cm, includes abundant deflandroid variants of *Dictyocha varia* and *D. extensa.* A similar acme has been described by Bukry (1984, 1985) and appears to be of the same age. The acme is recognized here as the *Dictyocha varia* (deflandroid) Horizon.

Site 847

Site 847 is the equatorial site for the eastern transect and is located 21 km from the equator and about 389 km west of the Galapagos Islands. The site was selected to obtain a detailed record of the equatorial divergence near the American continents, where the Equatorial Undercurrent (Fig. 1) interacts with surface waters. Backtracking the location of this site shows that it has remained within the equatorial divergence throughout its history.

The sedimentary section at Site 847 spans the lower Miocene to Pleistocene and comprises a single lithologic unit of diatom nannofossil ooze. There are two intervals (1.5–1.9 and 4.3–4.6 Ma) where the section is dominated by diatom ooze. Sedimentation rates averaged about 30 m/m.y., peaking at a rate of 50 m/m.y. during the early Pliocene. Hole 847B, which was examined for silicoflagellates, was APC-cored to 139 mbsf, then XCB-cored until reaching a chert layer at 251 mbsf.

Abundances of *Dictyocha aculeata* are much higher in the Pleistocene section of Hole 847B than are those in Hole 844B (Table 4). This taxon thrives in near equatorial water and its relative abundance decreases away from the equator. *Bachmannocena quadrangula* also is thicker and more abundant in Hole 847B than in Hole 844B. The *Dictyocha messanensis* Zone is represented by two samples in Hole 847B, and in a single sample in Hole 844B. This zone is much thicker in holes studied from the western transect.

The *Dictyocha extensa* Zone extends for 130 m in the lower Pliocene and upper Miocene sediments. This zone includes the *Distephanus xenus* Horizon near the bottom of the zone. The *Distephanis speculum tenuis* Zone is represented by three samples near the bottom of the cored Hole 847B interval. This zone is not as thick in Hole 847B as it is at equatorial sites on the western transect. Sample 138-847B-22X-4, 120–121 cm, which is the topmost sample of the *D. speculum tenuis* Zone, is very unusual in comparison to the other Leg 138 sites because it shows a co-occurrence of *D. speculum tenuis* and the *Bachmannocena diodon nodosa* plexus. These taxa do not co-occur at Holes 848B, 850B, and 851B, and in Hole 949B where the two intervals are separated by several samples. We do not have an explanation for this finding.

Site 848

Site 848 is the southernmost site of the western transect (Fig. 1). Four holes were drilled at this site to assure continuous recovery and to provide sufficient volume of material for high-resolution analyses. Samples from Hole 848B, which was APC-cored to basement at 93.3 mbsf, were examined for silicoflagellates.

Hole 848B provided a continuous sedimentary section spanning the time interval from the Quaternary to the middle Miocene. The sedimentary sequence consisted of a single lithologic unit dominated by foraminifer nannofossil ooze. Siliceous microfossils were present in minor amounts throughout the section with rhythmically interbedded layers of diatom nannofossil ooze. Preservation of siliceous fossils generally is very good, although the lower 10 m of the section is barren. Silicoflagellates are relatively abundant through most of the section, but ebridians are absent (Table 5).

Silicoflagellates generally are not found to be abundant in the late Pleistocene *Dictyocha aculeata* Zone but are more abundant in the rest of the Pleistocene and Pliocene. The *Bachmannocena quadran-*

gula Zone occurs in Samples 138-848B-3H-1, 120–121 cm, and -848B-3H-4, 120–121 cm, but the nominate taxon is less abundant in the latter sample. The lowest common *Dictyocha messanensis* occurs in Sample 138-848B-5H-1, 120–121 cm, while the highest abundant *Dictyocha extensa* was found in Sample 138-848B-6H-1, 120–121 cm; Sample 138-848B-5H-4, 120–121 cm, located between these two events has been left unzoned.

The *Bachmannocena diodon nodosa* plexus was found in Sample 138-848B-7H-4, 120–121 cm, where the plexus morphologies represent a majority of the silicoflagellates, but was absent in samples from a few meters above and below it. The *Neonaviculopsis* morphologies were not found. Whether the thinness of this horizon is due to the slow accumulation rate (about 5 m/m.y.) or because of zonal thinning away from the equator is uncertain. *Distephanus speculum tenuis,* which forms a distinct and thick zone at sites very near the equator is rare in Hole 848B, with only three specimens found in Sample 138-848B-8H-1, 119–120 cm.

Site 849

Site 849 is located less than 20 km from the equator, within the equatorial divergence zone (Fig. 1). Four holes were drilled. Hole 849B, was APC-cored to 120.7 mbsf, then XCB-cored to basement at 350.5 m. This hole provided a sedimentary section that spanned the time interval from the Quaternary to the middle Miocene (Fig. 3). The sedimentary sequence consisted of a single lithologic unit composed primarily of a diatom nannofossil ooze with minor intervals of diatom ooze.

Sedimentation rates in the upper Pliocene and Pleistocene sediments were relatively high and ranged from 25 to 35 m/m.y. This is reflected in a *Dictyocha aculeata* Zone that is relatively thick when compared to that at the nearby Hole 850B. *Dictyocha aculeata* is also much more abundant in Hole 849B than at other sites, suggesting that this species thrives particularly well near (<1° latitude) the equator. An unusual abundance of *Dictyocha calida ampliata* was found in Sample 138-849B-1H-4, 120–121 cm; this taxon was rare in all other Leg 138 holes studied for silicoflagellates (Table 6).

The *Bachmannocena quadrangula* Zone occurs in Samples 138-849B-4H-1, 130–131 cm, and -4H-4, 120–121 cm. *Bachmannocena quadragula* is abundant in these samples, but is not predominant as Holes 848B, 850B, and 851B, suggesting that the abundance of this taxon may decrease close to the equator. This zone also included abundant *Dictyocha aculeata,* which is rare in the *B. quadrangula* Zone of Holes 848B, 850B, 851B; again this suggests that this species does especially well in near-equatorial waters and further indicates that *D. aculeata* may have evolved in near-equatorial waters and spread from there to higher latitudes.

The *Dictyocha messanensis* Zone extends downward to Sample 138-849B-9H-1, 120–121 cm. One interesting sample in this interval is Sample 138-849B-6H-4, 120–121 cm, in which *D. messanensis* was not found at all, while *Distephanus speculum speculum* has an unusual dominance. This may suggest a cooling at the time that the sediments of this sample were deposited, since a dominance of *D. speculum* typically is associated with cooler climatic conditions.

Samples 138-849B-25X-1, 120–121 cm, to -28X-1, 120–121 cm, contains an unusual six-sided *Distephanus* that often lacks an apical ring as a result of the weakness of the thin structure; this constitutes the *Distephanus speculum tenuis* Zone. The nominate taxon of this zone appears to be common only in sites that are within about 5° of the equator. *D. speculum tenuis* is especially abundant in Sample 138-849B-27X-1, 120–121 cm.

An unusual assemblage of *Bachmannocena diodon nodosa* variants occurs in Sample 138-849B-20X-4, 120–121 cm. This marks the *Bachmannocena diodon nodosa* Assemblage Horizon of the *Dictyocha extensa* Zone. This assemblage includes a wide variety of bachmannocenid morphologies in which an apical bridge extends across the width of the skeleton. The similar *Neonaviculopsis neonautica* occurs in Sample 138-849B-19X-4, 120–121 cm, which is just above the *B. diodon nodosa* Horizon.

Site 850

The location for Site 850 was chosen to increase the spacial resolution between Sites 849 and -851 to detect narrow gradients (±1° of latitude) of change in surface productivity within the equatorial divergence zone. Only two holes were drilled. Hole 850B, which was used for silicoflagellate study, was APC-cored to 98 mbsf, then XCB-cored to basement at 399.9 mbsf.

The sedimentary section at Site 850 spans the upper middle Miocene to Pleistocene and comprises a single lithologic unit of nannofossil ooze. Silicoflagellates are generally abundant, and preservation is good. As at Site 848, silicoflagellates are relatively sparse in the late Pleistocene. Silicoflagellates are abundant, with *Bachmannocena quadrangula* predominating, in Samples 138-850B-2H-4, 120–121 cm, and -850B-3H-1, 120–121 cm; the nominate taxon is less predominant in Sample 138-850B-3H-4, 120–121 cm (Table 7).

An interval in the late early Pliocene and early late Pliocene, extending from Sample 138-850B-6H-4, 120-121 cm, to -850B-9H-1, 120–121 cm, was difficult to interpret because of a wide range of silicoflagellates that were intermediate between *D. messanensis, D. extensa,* and *D. perlaevis;* this interesting group was simply categorized as *Dictyocha* species. A similar range of *Dictyocha* skeletal morphologies was found at other Leg 138 sites near the equator and Bukry (1982a, 1982b, 1983) found a similarly ambiguous grouping of silicoflagellates at equatorial sites that he termed "*D. fibula* s. ampl." This interval may create difficulties in zoning because those who study silicoflagellates will probably interpret this group in different ways.

As at Hole 848B, unusual skeletal morphologies associated with *Bachmannocena diodon nodosa* were found in a narrow interval. These morphologies were abundant in Sample 138-850B-16X-4, 120–121 cm, but did not occur in samples from a few meters above and below. However, unlike the occurrence in Hole 848B, *Neonaviculopsis* morphologies were found associated with *B. d. nodosa,* as well as in the samples immediately above and below the *nodosa*-bearing slide.

An interesting morphology of *Distephanus speculum speculum* that lacks an apical apparatus occurs over a lengthy interval extending from Sample 138-850B-17X-1, 120–121 cm, to 850B-26H-1, 120–121 cm. This interval, the *Distephanus speculum tenuis* Zone, covers almost 100 m of strata. At Site 850, this zone occurs just below the *Bachmannocena diodon nodosa* Horizon. Lengthy sediment intervals that include this taxon occur only at sites very near the equator.

Site 851

Site 851 is presently located at the northern edge of the westward-flowing South Equatorial Current (SEC) (Fig. 1). The sedimentary sequence spans the interval from the uppermost middle Miocene to the Pleistocene and comprises a single lithologic unit composed of foraminifer nannofossil oozes and diatom nannofossil ooze. Hole 851B, which was examined for silicoflagellates, was APC-cored to 121.5 mbsf and then XCB-cored to basement at 318 mbsf. The age of basement is about 11 to 12 m.y., showing a high sediment accumulation rate caused by elevated productivity.

The silicoflagellate occurrences in Hole 851B are similar to those of Hole 850B (Table 8). Silicoflagellate abundances are low in the Pleistocene *Dictyocha aculeata* Zone, and *Bachmannocena quadrangula* are abundant in a narrow interval. *Dictyocha* sp., the varied group of four-sided silicoflagellates mentioned earlier that do not fit easily into the established taxonomy, occurs throughout the *Dictyocha*

Table 4. Abundance of silicoflagellates and ebridians in selected samples from Hole 847B.

Age	Zone	Core, section, interval (cm)	Depth (mbsf)	*Bachmannocena circulus*	*B. diodon diodon*	*B. diodon nodosa*	*B. diodon nodosa* f. *transemna*	*B. elliptica*	*B. quadrangula*	*B. quadrangula* (5-sided)	*Dictyocha aculeata aculeata*	*D. aculeata subaculeata*	*D. calida ampliata*	*D. calida calida*	*D. delicata bisecta*	*D. extensa extensa*	*D. extensa* (canted bridge)	*D. extensa extensa* (medusid)
Pleistocene	*D. aculeata*	1H-1, 120-121	1.2								32	69		12				
		2H-4, 120-121	12.2								6	13		13				
		3H-4, 120-121	21.7								15	47		4				
	B. quadrangula	4H-4, 120-121	31.2						118	7	1		1					
		5H-4, 120-121	40.7						90									
late Pliocene	*D. messanensis*	6H-4, 120-121	50.2						1				8		1	117		
		8H-1, 120-121	64.7										5			99		
	D. extensa	10H-2, 120-121	85.2	7												88		
		11H-1, 113-114	93.1	30											3	29	19	1
		12H-1, 120-121	102.7	5									2	1		98	5	
early Pliocene		13H-1, 123-124	112.2													230	10	
		14X-1, 124-125	121.7													104	41	
		15X-1, 120-121	131.2	9										13		80		
		16X-1, 123-124	140.7	17									6	8		125	5	
		17X-1, 123-124	147.0	43					1							43	40	
		18X-1, 123-124	156.7	9					18						15	110	26	
		19X-1, 123-124	165.9						2							45		
		20X-1, 122-123	175.1						29						3	39	31	
		21X-1, 122-123	184.7						10							41	5	
late Miocene		22X-1, 123-124	194.4			1			4					3		83		
	Ds. speculum tenuis	22X-4, 123-124	204.0			48	2									1		
		23X-4, 122-123	213.7											2		58		
		24X-1, 122-123	222.4													173		
	D. varia	25X-1, 122-123	232.1													213		

Notes: Species (in alphabetical order) are recorded as total number of specimens found in the slides examined.

Table 5. Abundance of silicoflagellates and ebridians in selected samples from Hole 848B.

Age	Zone / Horizon	Core, section, interval (cm)	Depth (mbsf)	Slide	*Bachmannocena circulus*	*Bachmannocena diodon nodosa*	*B. d. n. transemna*	*B. d. n. navicula*	*B. elliptica*	*B. quadrangula*	*B. quadrangula* (5-sided)	*Dictyocha aculeata aculeata*	*D. aculeata subaculeata*	*D. calida calida*	*D. clinata*	*D. extensa extensa*	*D. extensa longa*	*D. fibula ausonia*	*D. fibula fibula*
Pleistocene	*Dictyocha aculeata*	1H-1, 120–121	1.2	1.0								17	9						
		1H-2, 35–36	1.8	1.0								6	1	1					
		2H-1, 120–121	3.4	1.0						2			1						
		2H-4, 120–121	7.9	0.6								8	8			1	2		
	Bachmannocena quadrangula	3H-1, 120–121	12.9	0.3						208				1					
		3H-4, 120–121	17.4	0.4						45	1								
early Pliocene	*Dictyocha messanensis*	4H-1, 120–121	22.4	0.3						1							1		
		4H-4, 120–121	26.9	0.8									1				5		
		5H-1, 120–121	31.9	1.0													42		
late Miocene	Unzoned	5H-4, 120–121	36.4	1.0													9	15	5
	Dictyocha extensa B. d. n. Horizon	6H-1, 120–121	41.4	0.8	6											39	13	4	15
		6H-4, 120–121	45.9	0.6												10	58	47	8
		7H-1, 116–117	50.9	0.7												6	35	6	12
		7H-4, 120–121	55.4	0.4		94	73	4	2						1	2			
	D. speculum tenuis	8H-1, 119–120	60.4	0.5												6		4	9
middle Miocene	*Dictyocha varia*	9H-1, 50–51	69.2	1.0													1	1	31
		10H-1, 120–121	79.4	1.0												3			
		10H-4, 120–121	83.9	0.5								B	A				R		

Note: Species (in alphabetical order) are recorded as total number of specimens found in the slides examined.

Table 4 (continued).

D. extensa longa	*D. fibula ausonia*	*D. fibula fibula*	*D. fibula mutabilis*	*D. messanensis*	*D. messanensis*	*D. perlaevis flexatella*	*D. perlaevis ornata*	*D. perlaevis perlaevis*	*D. perlaevis* (thin apical elements)	*D. tantarae*	*D. varia*	*Distephanus boliviensis boliviensis*	*D. crux crux*	*D. pulchra*	*D. quinquangellus*	*D. speculum gigantеus*	*D. speculum hemisphaericus*	*D. speculum minutus*	*D. speculum pentagonus*	*D. speculum speculum*	*D. speculum tenuis*	*D. xenus*	Aberrants	Total silicoflagellates
					170			6	1					10									1	300
				23	95			132	2					15			1							300
				151	63			3		2				10					5				1	300
				122	7			35						6						3				300
				143	4			44	3	2				14										300
				21	52		2	35	14			1		4	6				4	34				300
					40			69	4						28				23	32			1	300
		1				25	13	112	11							6				38				300
								175	1		5	10					4			22				300
	1	8	5					120	19		3				1		1	2	4	25			2	300
		1						31	8		1	1								18			1	300
		5	1					12			8									22				193
								98			27	5	1			2				65			1	300
4		9	1					85				1	1		2			4		32				300
		5						7				1	2			22		4		132				300
22			6					24				4	7		1	9		8		41				300
2	12		15					5			142	4	6			11				56				300
8	3	12	4					3			9	3	1		2			1	1	151				300
11	18	7	3					3			10	11	4			119				58				300
11	4	4	4					1			75	2	3			45				46		14		300
13	7							31			52	7				30		4		99		19		300
	18	5	120								11	3	3		1	10			1	41	14			300
7								15					3			25				43	41			300
		3										3	28			2		3	1	30	10			300

Table 5 (continued).

D. fibula mutabilis	*D. lingii*	*D. messanensis*	*D. delicata bisecta*	*D. perlaevis flexatella*	*D. perlaevis perlaevis*	*D. varia*	*Dictyocha* sp.	*Distephanus boliviensis*	*D. crux*	*D. pulchra*	*D. quinquangulus*	*D. speculum speculum*	*D. s. speculum* (7-sided)	*D. s. speculum* (8-sided)	*D. s. speculum* (5-sided)	*D. speculum tenuis*	Abb-rants	Total silicoflagellates
		133			4					1							2	164
		52			144		2										2	206
		98			2		1			18								122
		69			133	1	53			20		5					1	300
		62			13			1			5	10					1	300
		212			4			1		5		31			1			300
		105			93	2	87				11							300
		77			38		171					7			1		1	300
		18			63		40				1	13					4	177
				1	173		15					22						240
	1?				1	4	172					44			2			294
		1	1		45	10	104		1			15					1	300
					2	90	24		7			115			1		1	300
		1			15	15	24		1			70					2	300
					19	57	140		40			25						303
2					3	4	203					36	1	4				286
						34			1			4						42
	0	N	R	B														0

Table 6. Abundance of silicoflagellates and ebridians in selected samples from Hole 848B.

Age	Zone/Horizon	Core,section, interval (cm)	Depth (mbsf)	Slide	*Bachmannocena circulus*	*B. diodon nodosa*	*B. diodon nodosa* f. *coccoensis*	*B. diodon nodosa* f. *transemma*	*B. elliptica*	*B. quadrangula*	*Dictyocha aculeata aculeata*	*D. aculeata subaculeata*	*D. angulata*	*D. callida ampliatta*	*D. callida callida*	*D. climata*	*D. delicata bisecta*	*D. extensa extensa*
Pleistocene	*D. aculeata*	1H-1, 120–121	1.2	0.8							264	16						
		1H-4, 120–121	5.7	0.3							88	78		92	6			
		2H-1, 120–121	7.9	0.6							91	114						
		2H-4, 120–121	12.4	1.0							52	68	4	6				3
		3H-1, 130–131	17.5	0.3		7				2	183	72		4				4
	B. quadrangula	3H-4, 120–121	21.9	0.4						14	58	117						22
		4H-1, 130–131	27.0	0.3						120	14	32		3				11
		4H-4, 120–121	31.4	0.2						113	17	41						
	D. messanensis	5H-1, 120–121	36.4	0.4						4	2							188
		5H-4, 120–121	40.9	0.3						1								102
		6H-1, 120–121	45.9	0.4														121
late Pliocene	*D. extensa*	6H-4, 120–121	50.4	0.3	1								5					127
		7H-1, 120–121	55.4	0.6										27	9			248
		8H-1, 120–121	64.9	1.0														237
		9H-1, 120–121	74.4	0.3														237
		10H-1, 120–121	83.9	1.0														114
		11H-1, 120–121	93.4	0.5									5					221
early Pliocene		12H-1, 120–121	102.9	0.3									10					205
		13H-1, 123–124	112.4	1.0														31
		14X-1, 120–121	121.9	1.0											3			123
		15X-1, 120–121	131.5	0.6	72								13					151
		16X-1, 120–121	141.2	0.6	8				4								4	219
		17X-1, 120–121	150.9	0.6									3					255
		18X-1, 120–121	160.5	0.8											3			169
		19X-1, 120–121	169.7	0.2					6									88
		19X-4, 120–121	174.2	0.3												4		38
		20X-1, 119–120	178.9	0.5		4			13							4		43
Miocene		20X-4, 119–120	183.4	0.3		1	119	105										
		21X-1, 120–121	188.5	0.6											1			89
		22X-1, 120–121	198.2	0.4									4					240
		23X-1, 120–121	207.8	0.5									2		4			206
		24X-1, 120–121	217.5	0.3														265
	S. tenuis	25X-1, 120–121	227.2	0.3					1						4			220
		26X-1, 120–121	236.9	0.3											8	3		144
		27X-1, 120–121	246.5	0.3											4			140
		28X-1, 120–121	256.2	0.6										2				76
early Miocene	*D. varia*	29X-1, 120–121	265.9	0.3														15
		30X-1, 134–135	275.5	0.2											6			187
		31X-1, 120–121	285.1	0.9														
		32X-1, 120–121	294.8	0.9	4													
		33X-1, 120–121	304.4	0.4		1												53
		34X-1, 120-121	314.1	1.0														
		35X-1, 120-121	323.8	1.0														2
		36X-1, 119-120	333.4	0.2					5									19
		37X-1, 119-120	343	1.0														4

Note: Species (in alphabetical order) are recorded as total number of specimens found in the slides examined.

messanensis and *D. extensa* zones and reaches a peak in Sample 138-851B-10H-1, 120–121 cm.

The *Bachmannocena diodon nodosa* Horizon was found in Sample 138-851B-13H-1, 120–121 cm; this is in a narrow interval, as neither this assemblage nor the *Neonaviculopsis* morphologies were found in samples from above and below this horizon. Unlike at other Leg 138 holes, an interval exists between the last occurrence of *Distephanus speculum tenuis* and the *Bachmannocena diodon nodosa* Horizon. This interval is represented by Sample 138-851B-14H-1, 120–121 cm, and contains an unusually large abundance of *Dictyocha perlaevis perlaevis*. The *Distephanus speculum tenuis* Zone extends for about 50 meters, which is half the thickness of the zone in Hole 850B; the nominate taxon is also less abundant in Hole 851B. The decreasing thickness of the *Distephanus speculum tenuis* interval and the declining predominance of these skeletal morphologies suggest that the environmental conditions that produced this unusual occurrence are located near the equator and rapidly change away from that latitude.

Site 852

Site 852 is located at the seasonal boundary between the westward-flowing South Equatorial Current (SEC) and the eastward-flowing North Equatorial Current (NEC) (Fig. 1). The sedimentary sequence consists of a single lithologic unit that extends from the uppermost middle Miocene to Pleistocene. Pliocene and Pleistocene sediments consist of a mixture of formaminifer nannofossil and nannofossil foraminifer oozes, with a radiolarian nannofossil ooze in the lower Pliocene and Miocene. Sedimentation rates are much less than at Site 849.

Hole 852B was APC-cored to 113.4 mbsf, which was near the basement. Silicoflagellates usually were much less abundant here than in other holes nearer the equator (Table 9). The *Bachmannocena quadrangula* Zone was not found, suggesting that it may be too thin at this location to be readily detected using a 5-m sample interval. The *Distephanus speculum tenuis* Zone was recognized

Table 6 (continued).

D. fibula fibula	*D. fibula ausonia*	*D. fibula mutabilis*	*D. messanensis*	*D. perlaevis* (with thin apical elements)	*D. perlaevis flexatella*	*D. perlaevis ornata*	*D. perlaevis perlaevis*	*D. tamerae*	*D. varia*	*D. varia* (medusid)	*Distephanus boliviensis*	*D. crux*	*D. pulchra*	*D. quinquangellus*	*D. speculum gigantius*	*D. speculum speculum*	*D. speculum tenuis*	*D. xenus*	*Naviculopsis neonautica*	Total silicoflagellates
			14	21			10						8	1		1				300
			61										1							300
			84	2			11						23							300
			18				8						14							241
													10							300
			8				85						12	1		5				300
			63				2						1	2		41				300
			117										1							300
			90	5		1							3	1		6				300
1		1	164									2	2	5		22				300
			146	10									2	21						300
		1						5			2			1		158				300
1			6											1		8				300
			33					9								18				297
			32					5			3			2		21				300
																140				254
					15							5				54				300
12								1	1			6				65				300
1																19				51
9									14		13	1		1		42				206
		3							6			2				53				300
1		5				5						6				48				300
5			2						5		2	4				24				300
12		6		1					40		19	2				48				300
8		2							9		100	2		1		84				300
		23									82	4			14	47			6	300
7		1							62		59				46	21		39		300
4		1							21							49				300
2	2	3							23		111	7		2		60				300
2?												25		2	4	25				300
1	2?	2							39		1	20				25				300
1	1								4					12		17				300
		27						30	1			2		15	15		12			300
	3?	23						2	2?	1					18		99			300
6		4							6			1				11	113			300
									6					3		179	24			300
		129							27			1?				128	1			300
		22							22	7						56				300
8	72								30		172	9			9					300
3		29							79		165	8		1	11					300
									195	2		5		10	7	27				300
									9						7					16
		1							207			9			6	29				254
6									210	2	29	11			18					300
									151		14	20			2					191

in Sample 138-852B-8H-1, 119–120 cm, but only on the basis of five specimens.

Site 854

Site 854 is the northernmost site on the western transect and was drilled to provide a record of eolian sedimentation in a region influenced by Northern Hemisphere tradewind circulation. The site is presently located in the westward-flowing Northern Equatorial Current (NEC) (Fig. 1). Hole 854B, which was used for silicoflagellate study, was cored with the APC to 45.4 mbsf.

Of the seven samples from Hole 854B that were examined for this study, silicoflagellates were relatively abundant only in Sample 138-854B-1H-4, 120–121 cm (Table 10). Silicoflagellates were uncommon to rare in Samples 138-854B-1H-1, 120–121 cm, and -854B-2H-4, 120–121 cm, and were barren in the bottommost three samples. *Bachmannocena quadrangula* was abundant and predominant in Sample 138-854B-1H-4, 120-121 cm, and was much less abundant in Sample 138-854B-2H-1, 120–121 cm.

SYSTEMATIC PALEONTOLOGY

The synonomies here include only the first description and representative references that show the development of the taxon in the literature. In some cases, the taxonomic usage in this study differs from previous usage by the first author or from others who have studied silicoflagellates; these changes have been made to develop a more standardized silicoflagellate taxonomy or to show infraspecific variation in skeletal morphology that previous researchers have placed in separate genera. An introduction to each of these taxa has been used

Table 7. Abundance of silicoflagellates and ebridians in selected samples from Hole 850B.

Age	Zone	Core, section, interval (cm)	Depth (mbsf)	Slide	*Bachmannocena circulus*	*B. diodon nodosa*	*B. d. n. cocoensis*	*B. d. n. transenna*	*B. ellipitica*	*B. quadrangula*	*Dictyocha aculeata subaculeata*	*D. calida*	*D. delicata bisecta*	*D. extensa extensa*	*D. extensa extensa* (5-sided)	*D. extensa (medusid)*	*D. extensa longa*	*D. fibula ausonia*	*D. f. ausonia* (praenauticid)	*D. fibula fibula*	*D. fibula mutabilis*	*D. lingii*	*D. messanensis*	*D. messanensis* (5-sided)	*D. perlaevis flexatella*
Pleistocene	*D. aculeata*	1H-1, 120–121	4.2	1.0																			56		
	Bachmannocena quadrangula	2H-4, 120–121	18.2	0.2						183													32		
		3H-1, 120–121	23.2	0.3						214	1						2						70	2	
late Pliocene	*Dictyocha messanensis*	3H-4, 120–121	27.7	0.3						13	1						1			1			41		
		4H-1, 120–121	32.7	0.3																			179		
		5H-1, 120–121	42.2	0.3													13					1	3		1
		6H-4, 120–121	56.2	0.7										58			5						3		49
early Pliocene	*Dictyocha extensa*	7H-4, 120–121	65.7	0.6					1					95			2								
		9H-1, 120–121	80.2	0.6										60			4								2
		10H-1, 120–121	89.7	0.8										52			2								
		11X-1, 120–121	99.2	0.3										64			3	6							
		12X-1, 120–121	108.7	0.2	9				26					29				1							
		13X-1, 120–121	118.3	0.5					1				2	71			2								
		14X-1, 120–121	128.0	0.4					1					121				10							
		15X-1, 120–121	137.6	0.4					2					46				3		9					
		16X-1, 120–121	147.3	0.6					5					22				4		2					
	B. d. n. Horizon	16X-4, 120–121	151.8	0.3		167	1	21						6						1					
late Miocene	*Distephanus speculum tenuis*	17X-1, 120–121	156.9	0.2										81											
		17X-4, 120–121	161.4	0.3										28											
		18X-1, 120–121	166.2	0.3										49						5					
		19X-1, 120–121	175.4	0.4										233	1					5					
		20X-1, 120–121	185.0	0.2										176						2					
		21X-1, 120–121	194.7	0.5										180				64	1	2					
		22X-1, 120–121	204.3	0.4										219				16		31					
		23X-1, 120–121	214.0	0.2										225				9	4	15					
		24X-1, 120–121	223.7	0.2										119				17		8					
		25X-1, 120–121	233.3	0.3										94				4		5					
		26X-1, 120–121	243.0	0.6					8					62	1	2		25		17					
middle Miocene	*Dictyocha varia*	27X-1, 120–121	252.2	0.5					3					68				15		32					
		28X-1, 120–121	261.9	0.2										198		2		20		7					
		28X-4, 120–121	266.4	0.1										38		1				3					
		29X-1, 120–121	271.5	0.1										23		3				1					
		30X-1, 120–121	281.1	0.1										15	2	1				2					
		31X-1, 120–121	290.8	0.3	2									7				1							
		32X-1, 120–121	300.4	0.1										26		2		1							
		33X-1, 120–121	310.1	0.3										16				11		2					
		34X-3, 120–121	322.8	1.0										5											
		35X-1, 120–121	329.4	0.4										4				9		1					
		36X-1, 120–121	339.0	0.8										3											
		37X-4, 120–121	353.2	0.5																					
		38X-1, 120–121	358.3	0.5										1											
		39X-1, 120–121	368.0	1.0										3						1					
		40X-1, 120–121	377.6	0.3										5											
		41X-1, 120–121	387.3	0.3										6											
		42X-1, 120–121	397.0	0.9																					

Note: Species (in alphabetical order) are recorded as total number of specimens found in the slides examined.

Table 7 (continued).

Age	Zone	*D. perlaevis perlaevis*	*D. subclinata* (short axis)	*D. subclinata* (long axis)	*D. varia*	*D. varia* (cruxid)	*Dictyocha* sp.	*Distephanus boliviensis*	*D. crux*	*D. crux* (bridged)	*D. crux carolae*	*D. quinquangulus*	*D. speculum speculum*	*D. s. s.* (multiwindowed)	*D. s. s.* form varians	*D. s. s.* (7-sided)	*D. s. s.* (5-sided)	*D. speculum tenuis*	*D. pulchra*	*Neonaviculopsis neonautica neonautica*	*N. neonautica praenautica*	Aberrants	Total silicoflagellates	*Ebriopsis antiqua*	*Parathranium tenuipes*	*Hermesinum adriaticum*
Pleistocene	*D. aculeata*	3																					59			
	Bachmannocena *quadrangula*	82											1						2			2	300			
		1					2						7						1			2	300			
late Pliocene	*Dictyocha messanenis*	7					226					1	9									1	300			
		110							1			2	6						2				300			
		7			1		245		1			11	2				15					3	300	1		
		3					140	1					41									2	300		1	
early Pliocene	*Dictyocha extensa*	11			4		147	1					39									1	300			
		19					195		2				18										300			
		4					202		4				36										300			
					1		172	3	2			1	47			1							300			
					2		175	3	9			2	53										300	1		
					27		125		10			2	59			1						1	300			
					54		26		3				84	1								2	300		1	
					43		12		3				182										300		5	
late Miocene	*B. d. n.* Horizon				98		28		1		6		132							2			300		3	
							28		1				68							7		1	300			3
	Distephanus speculum tenuis											1	52			1		1		156	8		300			
							40					2	24				1	5					300			
					7				6	1			184	1		2		45				2	300			
							1	4	22	2		2	12					18				2	300		1	
							2	1	2				14					3					300			
					2							16	17					18					300			
									1				10					23					300			
					1		3		1				18					24					300			
							3		4				25					124					300			
					1		5	5					165				3	18					300			
					23		2						147	1			1	11				2	300		2	
	Dictyocha varia				10								172										300			
					31								42									2	300		2	
					225								33									1	300			
					218								54					1				2	300			
					140				1				139										300			
					180				5				106			1							300		7	2
					244								27										300			
			90	8	111								54				8						300		2	3
					132								18										155			
			1		221	2			5				56				1						300			
middle Miocene					216	1			44				36										300			
					128																		128			
					115								17										133			
					224	1			9				61		1								300			
				7	264								24										300			
				2	265				15				12										300			
					186				102				12										300			

Table 8. Abundance of silicoflagellates and ebridians in selected samples from Hole 851B.

Age	Zone / Horizon	Core, section, interval (cm)	Depth (mbsf)	Slide	*Bachmannocena circulus*	*B. diodon nodosa*	*B. d. n. cocoensis*	*B. d. n. transenna*	*B. elliptica*	*B. quadrangula*	*Dictyocha aculeata aculeata*	*D. aculeata subaculeata*	*D. calida calida*	*D. clinata*	*D. delicata bisecta*	*D. extensa extensa*	*D. extensa longa*	*D. extensa* (medusid)
Pleistocene	*D. aculeata*	1H-1, 120–121	1.2	0.5							14	36	3					
	B. quadrangula	2H-1, 120–121	8.7	1.0							5	22	1				11	
		3H-1, 120–121	18.2	0.6						227							1	
late Pliocene	*Dictyocha messenensis*	4H-4, 120–121	32.2	0.5												2	5	
		5H-1, 120–121	37.2	0.8												2	15	
		6H-1, 120–121	46.7	0.8	2											38	14	
		7H-1, 120–121	56.2	1.0									1		92	18	19	
		8H-1, 120–121	65.7	0.7									1			21	11	
		9H-1, 50–51	75.2	0.4													37	
early Pliocene	*D. extensa*	0H-1, 120–121	84.7	0.4													4	
		11H-1, 120–121	94.2	0.6	5											2		
		12H-1, 34–35	103.7	0.4					29							8	3	
		12H-4, 120–121	107.2	0.1					1							7		
		13H-1, 120–121	113.2	0.2		16	12	165								30		
	B. d. n. Horizon	13H-4, 120–121	115.7	0.2												27		
late Miocene	*Distephanus speculum tenuis*	14H-1, 120–121	122.7	0.9														
		15H-1, 120–121	132.2	0.3										2		150		
		16H-1, 120–121	141.7	0.3												159		
		17X-1, 120–121	151.3	0.3												199		
		18X-1, 120–121	161.0	0.3												154		
		19X-1, 120–121	170.6	0.4					9							77		
		20X-1, 120–121	180.3	0.2												198		
		21X-1, 120–121	189.5	0.2												176		
		22X-1, 120–121	198.7	0.3												21		2
	Dictyocha varia	23X-1, 120–121	208.3	0.2												6		
		24X-1, 120–121	218.0	0.3					15							7		1
		25X-1, 120–121	227.6	0.6												14		1
		26X-1, 120–121	237.3	0.3	1													1

Note: Species (in alphabetical order) are recorded as total number of specimens found in the slides examined.

to draw attention to the changes in interpretation and to clarify the reasons for them.

Silicoflagellates

Genus *BACHMANNOCENA* Locker, 1974, emend. Bukry, 1987

Bachmannocena apiculata curvata (Bukry) Bukry
(Pl. 4, Fig. 6)

Septamesocena apiculata (Schulz), Perch-Neilsen, 1975 (in part), p. 689, pl. 10, fig. 6.
Mesocena apiculata (Schulz), Bukry, 1975c, p. 856, pl. 5, fig. 7.
Mesocena apiculata curvata Bukry, 1976b, p. 849, pl. 2, fig. 15, 16.
Bachmannocena apiculata curvata (Bukry), Bukry, 1987, p. 403.

Remarks: Two specimens of this taxon were found in Sample 138-844B-26X-4, 120–121 cm, and a single specimen in Sample 138-844B-25X-2, 120–121 cm.

Bachmannocena circulus (Ehrenberg) Bukry
(Pl. 4, Figs. 1, 7; Pl. 8, Fig. 7)

Mesocena circulus (Ehrenberg), Ehrenberg, 1844, p. 65.
Bachmannocena circulus (Ehrenberg), Bukry, 1987, p. 404.

Remarks. *B. circulus* is a large, semi-circular skeletal structure displaying numerous small, pointed nodes along the outer margin of the ring. This taxon was generally uncommon, but consistently found in an interval from Sample 138-844B-6H-4, 120–121 cm, to -9H-4, 120–121 cm and is extremely abundant in Sample 138-849B-15X-1, 120–121 cm.

Introduction to the *Bachmannocena/Neonaviculopsis* Plexus

Remarks. An extremely unusual collection of silicoflagellate morphologies was found in the late Miocene section of several Leg 138 sites. This plexus can be divided into two parts: (1) a group of morphologies closely associated with *Bachmannocena diodon nodosa* and (2) a group of larger, more elongate skeletons that have a naviculopsid morphology. The two groups appear to be closely related, but the latter group has a longer geologic range and a wider geographic distribution. Previous workers have placed members of this plexus in several genera. The approach used here was to consider several morphologies as forms of *Bachmannocena diodon nodosa,* and place the remaining morphologies into the separate genus *Neonaviculopsis.* The variety of unusual morphologies, exceptional abundance, and short geologic range of this plexus is similar to the *pseudofibula* plexus that has been documented from extremely high latitudes (McCartney and Wise, 1990; McCartney and Harwood, 1992) and that occurred at approximately the same time.

The *Bachmannocena/Neonaviculopsis* plexus occurs in a narrow acme in which the *B. diodon nodosa* morphologies, in particular, can be extremely abundant. The *Bachmannocena* morphologies include typical *Bachmannocena diodon nodosa,* consisting of only a basal ring, but others have a bridge that may be positioned anywhere along the length of the skeleton. Bukry (1982a, 1982b) divided this group between two *Dictyocha* species: *D. navicula* and *D. transenna,* while noting that specimens were similar to co-occurring *Mesocena diodon nodosa* in size and shape. We consider these morphologies to be forms of *Bachmannocena diodon nodosa.* This group is predominant in a narrow interval of the late Miocene section of sites near the equator.

Associated with the *Bachmannocena diodon nodosa* forms are similar and obviously closely related silicoflagellates that have a more elongate basal ring. The general shape is similar to the extinct *Naviculopsis;* in some cases, the bridge can be supported by short struts that result in a morphology similar to *Dictyocha.* Locker and Martini (1986b) placed these morphologies into the

Table 8 (continued).

D. fibula ausonia	*D. fibula fibula*	*D. fibula mutabilis*	*D. messanensis*	*D. messanensis* (5-sided)	*D. perlaevis flexatella*	*D. perlaevis perlaevis*	*D. subclinata* (short axis)	*D. subclinata* (long axis)	*D. varia*	*D. varia* (cruxid)	*Dictyocha* sp.	*Distephanus boliviensis*	*D. crux*	*D. quinquangulus*	*D. speculum speculum*	*D. s. s.* (multiwindowed)	*D. s. s.* (5-sided)	*D. speculum tenuis*	*Ds. pulchra*	Aberrants	Total silicoflagellates	*Parathranium tenuipes*	*Hermesinum adriaticum*
			246																1	300			
	3		69			35													3		149		
			27		3	7					29	4			2					3	300		
			16		2	7					22			5			1				60		
			23		3	4					172			67	4		10				300		
			40		31	20					134	6			17						300		
2	10	1	7		14	7					81	1			42	5					300		1
	5		1		1	4					37				19						100		1
	2		2	1					51		149				55		3				300		
	20					3			3		226		4		40					1	300		
3						1			92		168				34					1	300		
	18								11		78		7		146						300	2	
1	1								44		2		3		41						100		
9	11								2		4		2	1	48					2	300		
	4								17		2		1		49					4	100		
4	15	3				125							4		111			38			300		1
91		1				11			1				26	1	17					1	300		
14	71	17				5			1					12	18			3		2	300		
3	43	10				8			1						21			15		1	300		
6	46	8				2									18			65	1		300		
15	58								28						106			7		1	300		1
1	21					3			9						68						300		1
	2	1							97						24						300		
	40							2?	172	1					62	2					300		
7	20								114				2		151					4	300		
	9								238						28	2					300		
	1						14	52	153				15	29	19	2					300		
								1	197				2	1	96	1					299		

separate genus *Neonaviculopsis.* While we are reluctant to give this the status of a separate genus because of its obviously close relationship to the *B. diodon nodosa* forms, the morphologies are distinct enough that it is difficult to consider these as additional forms of *B. diodon nodosa.* The *Neonaviculopsis* group appears to range somewhat higher than the *B. diodon nodosa* variants and is more widespread geographically; Locker and Martini described the group from sediments situated more than 30° south of the equator.

Bachmannocena diodon diodon (Ehrenberg) Bukry
(Pl. 4, Figs. 2, 8)

Mesocena diodon Ehrenberg, 1844, p. 71, 84.
Bachmannocena diodon (Ehrenberg), Bukry, 1987, p. 404.

Remarks. This taxon was relatively abundant in Samples 138-844B-9H-2, 120–121 cm, and -9H4, 120–121 cm. It was not found in any other Leg 138 sites. *B. diodon* is a moderately sized, oval structure having two prominent distal spines. Unlike *B. diodon nodosa, B. diodon diodon* has a smooth ring surface.

Bachmannocena diodon nodosa (Bukry) Bukry
(Pl. 1, Fig. 1; Pl. 4, Fig. 2; Pl. 8, Figs. 1, 2, 9)

Mesocena diodon nodosa Bukry, 1978b, p. 818-819, pl. 5, figs. 14, 15; pl. 6, fig. 1-5.
Bachmannocena diodon nodosa (Bukry), Bukry, 1987, p. 404.

Remarks. This taxon is characterized by an elongate oval ring with two predominant spines aligned with the major axis and a surface ornamented with small nodes. It is abundant in a narrow horizon at near-equatorial sites, such as Sites 850 and 851. Within this interval, it is associated with similar morphologies that have a bridge at varying points across the width of the basal ring. Several specimens of *Bachmannocena diodon nodosa* found in the Pleistocene sediments of Sample 138-849B-3H-1, 130–131 cm, have pikes that extend from the inner basal ring. Specimens of *B. diodon nodosa* are considerably smaller than typical *B. diodon diodon.*

Bachmannocena diodon nodosa forma *cocoensis* (Bukry) n. comb.
(Pl. 1, Fig. 4; Pl. 8, Fig. 7)

Dictyocha neonautica var. *cocoensis* Bukry, 1981a, p. 549, pl. 3, fig. 1-3.
Dictyocha neonautica var. *cocoensis* Bukry, 1982a, p. 430.
Dictyocha neonautica Bukry, 1982b, p. 316, pl. 3, fig. 2.

Remarks. *Bachmannocena diodon nodosa* f. *cocoensis* here is restricted to those skeletons in which the bridge is near the midpoint between the two spined corners without being precisely at that point.

Authorship of n. comb. McCartney, Churchill, and Woestendiek.

Bachmannocena diodon nodosa forma *neonautica* n. forma

Dictyocha navicula Ehrenberg, Bukry and Foster, 1973 (in part), p. 827, pl. 3, figs. 8.
Dictyocha neonautica var. *cocoensis* Bukry, 1982a (in part), p. 430, pl. 3, fig. 9.
Dictyocha neonautica Bukry, 1982b (in part), p. 316, pl. 3, fig. 1.

Description. This taxon has an oval ring with two major-axis spines and a bridge across the minor axis without struts or minor-axis spines. The ring is of small size with an aspect ratio usually less that 2.0, and is generally similar to co-occurring *Bachmannocena diodon nodosa.*

This taxon is considered to belong to *Bachmannocena* on the basis of that species' association and close relationship to*B. diodon nodosa.* Specimens that are more elongate are considered as *Neonaviculopsis neonautica. Neonavicu-*

Table 9. Abundance of silicoflagellates and ebridians in selected samples from Hole 852B.

Age	Zone	Core, section, interval (cm)	Depth (mbsf)	Slide	*Bachmannocena circulus*	*B. elliptica*	*B. quadrangula*	*Dictyocha acu eata auleata*	*D. aculeata subabuleata*	*D. calida calida,*	*D. delicata*	*D. extensa extensa*	*D. fibula fibula*	*D. fibula matabilus*	*Dictyocha messanensis*	*D. perlaevis*	*D. varia*	*Distephanus boliviensis*	*D. crux*	*D. quinquangellus*	*D. speculum gigantius*	*D. speculum speculum*	*D. speculum tenuis*	Total silicoflagellates
Pleistocene	*D. aculeata*	1H-1, 120–121	1.2	1.0											17									17
	B. quadrangula	2H-1, 120–121	10.1	1.0	1		29	2	1						28	27								90
late Pliocene	*Dictyocha messanensis*	3H-1, 120–121	19.6	1.0											105	38					1	2		155
		4H-1, 120–121	29.1	1.0						1	3	80			7					1		14		138
early Pliocene	*D. extensa*	5H-1, 120–121	38.6	1.0									1						1			1		3
		6H-1, 120–121	48.1	1.0	2							10	3	3										28
		7H-1, 116–117	57.6	1.0	2							13	2	3		17	6					2		45
late Miocene	*Ds. s. tenuis*	8H-1, 119–120	67.1	1.0	2							10	3	49		96			7	7		16	5	193
	Dictyocha varia	9H-1, 50–51	76.6	0.9	2							69	27	5		147		3		3	1	50		300
		10H-1, 120–121	86.1	1.0		6				3		13	6	125				3	1			3		168
		11H-1, 120–121	95.6	1.0	1					5		25	18	22		33	10	13	2		1			130
		12H-1, 120–121	105	1.0								1					53	4			2			60

Note: Species (in alphabetical order) are recorded as total number of speicmens found in the slides examined.

Table 10. Abundance of silicoflagellates and ebridians in selected samples from Hole 854B.

Age	Zone	Core, section, interval (cm)	Depth (mbsf)	Slide	*Bachmannocena quadrangula*	*Dictyocha aculeata subaculeata*	*D. messanensis*	*D. perlaevis*	*Dictyocha* sp.	*Distephanus quinquangellus*	*D. speculum speculum*	Total silicoflagellates
Pleistocene	*D. aculeata*	H-1, 120–121	1.2	0.5		1?		1				2
	B. quadrangula	H-4, 120–121	5.7	0.6	242	4	39	15				300
	Dictyocha messannensis	2H-1, 120–121	9.6	1.0	4		7	85	19	3	4	122
		2H-4, 120–121	14.1	1.0			13		5		1	19
	Unzoned	3H-1, 120–121	19.1	0.5		B	A	R	R	E	N	0
		4H-1, 120–121	28.6	0.3		B	A	R	R	E	N	0
		5H-1, 120–121	38.1	0.3		B	A	R	R	E	N	0

Note: Species (in alphabelical order) are recorded as total number of specimens found in the slides examined.

lopsis neonautica differs from this taxon in being more elongate and of generally larger size. The morphology is polyphyletic, since aberrants of *Dictyocha fibula* (McCartney and Wise, 1987) and *D. mutabilis* (Deflandre, 1950) are known to adopt a similar design.

Type specimen. The specimen illustrated in Plate 3, figure 9, of Bukry (1982a) is here designated as the type.

Authorship of n. forma. McCartney, Churchill, and Woestendiek.

Bachmannocena diodon nodosa forma *transenna* (Bukry) n. comb.
(Pl. 1, Figs. 2, 3)

Dictyocha transenna Bukry, 1982b, p. 315, pl. 4, fig. 1-12; pl. 5, fig. 1,2.

Remarks. Bukry (1981a, 1982a, 1982b) considered these unusual bridged morphologies to be members of the genus *Dictyocha,* but because these are obviously closely related to *Bachmannocena diodon nodosa* and distinct from other *Dictyocha,* they are here considered as varieties of *B. diodon nodosa.* The occurrence of bridged varieties of *Bachmannocena* is further evidence of the plasticity of the silicoflagellate skeleton and of the close phylogenetic relationships that may exist among separate genera of the current taxonomy.

This taxon has enormous variability, with the bridge occurring anywhere between the *B. diodon nodosa* and the *B. diodon nodosa* f. *neonautica* endmembers. Bukry (1982b) informally divided this range of variation into three groups, which he designated as Types A, B, and C, depending on the relative position of the bridge, but has not used these subdivisions in subsequent work. Bukry (1983, pl. 9, fig. 9–12) also found transennid variants of *Bachmannocena quadrangula.*

Authorship of n. comb. McCartney, Churchill, and Woestendiek.

Bachmannocena diodon triodon (Bukry) n. comb.

Mesocena triodon Bukry, 1978b, pp. 819-820, pl. 7, figs. 9, 10.

Remarks. Commonly associated with *Bachmannocena diodon* are specimens having a third spine. The position of the third spine varies, but it is usually smaller than the two spines that occur at opposite ends of the major axis. While this interesting skeletal morphology has previously been given species rank, it is here recombined to show its biological relationship to *Bachmannocena diodon,* as previously advocated informally by McCartney and Wise (1987) .

Bachmannocena elliptica (Ehrenberg) Bukry

Dictyocha (Mesocena) elliptica Ehrenberg, 1840, p. 208; Ehrenberg, 1854, pl. 20(1), fig. 44a, 44b.
Mesocena elliptica (Ehrenberg), Bukry 1978b, p. 819, pl. 6, figs. 6–13.
Bachmannocena elliptica (Ehrenberg), Bukry, 1987, p. 404.

Remarks. Bukry and Foster (1973) noted that there appeared to be two groups of four-sided mesocenids, one in the Miocene and another in the Quaternary; they referred to both of these as *M. elliptica.* Bukry (1978b, p. 819), reduces *M. elliptica* to small, smooth, specimens most common in the Miocene; upper Miocene to Quaternary specimens having a noded ornamentation on the basal ring are referred to as *M. quadrangula. Bachmannocena elliptica* were relatively common in a narrow interval from the middle Miocene section of Hole 844B.

Bachmannocena quadrangula (Ehrenberg ex Haeckel) Bukry
(Pl. 4, Fig. 3; Pl. 8, Fig. 5)

Mesocena quadrangula Ehrenberg ex Haeckel, 1887, p. 1556, Lemmermann, 1901, pl. 10, figs. 5–7, fide Loeblich et al., 1968, p. 57.
Mesocena quadrangula Ehrenberg ex Haeckel, Bukry, 1978b, p. 819, pl. 7, figs. 1–5.
Bachmannocena quadrangula (Ehrenberg ex Haeckel), Bukry, 1987, p. 405.

Remarks. *Bachmannocena quadrangula* differs from *B. elliptica* in having a more quadrate form with more equant spines and a more noded surface. This taxon is extremely abundant in a narrow interval of the late Pliocene. Specimens with three or five basal spines occur infrequently.

Genus *CORBISEMA* Hanna, 1928

Corbisema triacantha (Ehrenberg) Bukry and Foster
(Pl. 4, Figs. 4, 5)

Dictyocha triacantha Ehrenberg, 1844, p. 80.
Corbisema triacantha (Ehrenberg), Bukry and Foster, 1974, p. 305, fig. 1e.

Remarks. This taxon marks the *Corbisema triacantha* Zone and was often very abundant in the early and middle Miocene sections of Hole 844B.

Genus *DICTYOCHA* Ehrenberg, 1837

Dictyocha aculeata aculeata (Lemmermann) Dumitrica
(Pl. 9, Fig. 2)

Dictyocha fibula var. *aculeata* Lemmermann, 1901, p. 261, pl. 11, figs. 1, 2.
Dictyocha epiodon Ehrenberg, Bukry and Foster, 1973, pl. 2, fig. 7-8.
Dictyocha aculeata (Lemmermann), Dumitrica, 1973, p. 849, pl. 4, fig. 9–11.
Dictyocha mandrai Ling, 1977, p. 209, pl. 1, figs. 13, 14.

Dictyocha aculeata aculeata (Lemmermann), Bukry, 1980b, p. 549.

Remarks. This distinctive Quaternary silicoflagellate is considered by Gemeindhardt (1930; see Dumitrica, 1973, p. 907) as a warm-water species. Dumitrica's (1973) discussion includes measurements made of two varieties, large and small. Locker and Martini (1986b) considered this taxon to be within the variation of *D. messanensis;* we consider *Dictyocha aculeata* as a separate species on the basis of its generally larger size and more robust appearance.

Dictyocha aculeata subaculeata Bukry

Dictyocha aculeata subaculeata Bukry, 1980b, p 552, pl. 1, fig. 8-17.

Remarks. *Dictyocha aculeata subaculeata* here is distinguished from *D. aculeata aculeata* by having more linear sides and less pronounced pikes; it also commonly has a bridge that is less canted and of longer length relative to *D. aculeata aculeata.* This taxon is seen as an evolutionary intermediate between *D aculeata aculeata* and *D. messanensis.*

The microscopist for Holes 844B and 847B (Woestendiek) had some difficulty in distinguishing between *D. aculeata subaculeata* and *D. aculeata aculeata,* so the counts listed in Tables 3 and 4 for these taxa should not be taken as absolutely correct. Although Locker and Martini (1986b) consider this as a subspecies of *D. messanensis,* we consider *Dictyocha aculeata* as a separate species on the basis of its generally larger size and more robust appearance.

Dictyocha angulata Bukry
(Pl. 9, Fig. 5)

Dictyocha angulata Bukry, 1982a, p. 431, pl. 1, figs. 9–12; pl. 2, fig.1 .

Remarks: *Dictyocha angulata* is scattered throughout Hole 849B but was not recognized elsewhere in this study.

Dictyocha calida ampliata Bukry
(Pl. 9, Fig. 1)

Dictyocha calida ampliata Bukry, 1979b, p. 982, pl. 2, figs. 1, 2, 9.

Remarks. A single specimen of this unusual morphology with incised sides was found in -851B-4H-4, 120-121 cm. and was found scattered in several samples in Hole 847B, from the *Bachmannocena quadrangula* Zone to the middle of the *Dictyocha extensa* Zone.

Dictyocha calida calida Poelchau

Dictyocha calida Poelchau, 1976, p. 169, pl. 1, fig. c, d; pl. 3, fig. a-f.
Dictyocha calida calida Poelchau, Bukry, 1979a, p. 560, pl. 1, fig. 7.

Remarks. *Dictyocha calida* is characterized by a square basal ring having long equant spines and a short bridge. The taxon is abundant in oligotrophic waters of the modern Pacific Ocean (Poelchau, 1974, 1976), but is unusual in Leg 138 samples.

Dictyocha clinata (Bukry) n. comb.
(Pl. 9, Fig. 4)

Dictyocha aspera clinata Bukry, 1975a, p. 687, pl. 1, figs. 1–5.

Remarks. This taxon is characterized by a middle- to large-sized basal ring with a bridge that is canted with respect to the minor axis. It is generally smaller, somewhat more robust and often has longer basal spines than co-occurring *Dictyocha fibula,* and is thus listed here as a separate taxon. *D. clinata* generally occurs in the late Miocene section but was found in the middle Miocene of Hole 844B.

Authorship of n. comb. McCartney, Churchill, and Woestendiek.

Dictyocha delicata bisecta (Bukry) n. comb.
(Pl. 2, Fig. 6; Pl. 5, Fig. 6; Pl. 9, Figs. 7-8)

Dictyocha perlaevis delicata Bukry, 1976c, p. 724, pl. 1, figs. 5–10.
Dictyocha delicata (Bukry), Bukry, 1982a, p. 432, pl. 2, fig. 7.
Dictyocha delicata var. *bisecta* (Bukry), Bukry, 1983, p. 329, pl. 3, figs. 2–4.

Remarks. This taxon has a mid-sized basal ring with an apical structure made of thin skeletal elements. This morphology is abundant in Sample 138-851B-7H-1, 120–121 cm. The *Dictyocha delicata* specimens in this sample are distinctly smaller than the co-occurring *D. perlaevis* and have a bridge that extends across most of the length of the basal ring.

This taxon also occurs in Samples 138-850B-12X-4, 120–121 cm, and -850B-13X-1, 120–121 cm and was found scattered in Hole 847B; the specimens in these samples are similar to the co-occurring *Bachmannocena quadrangula* in size and surface ornamentation. However, there were not enough specimens to demonstrate a phyletic relationship. Four specimens were observed in Sample 138-649B-16X-1, 120–121 cm.

Authorship of n. comb. McCartney, Churchill, and Woestendiek.

Dictyocha extensa extensa (Locker) Locker and Martini
(Pl. 3, Figs. 2–5; Pl. 5, Figs. 3, 7; Pl. 8, Fig. 8)

Dictyocha varia f. *extensa* Locker, 1975, p. 99–101, figs. 1/2, 3/3.
Dictyocha extensa (Locker), Locker and Martini, 1986b, p. 903–904, pl. 2, figs. 10–12; pl. 11, fig. 3.

Remarks. In his original description, Locker believed this taxon was conspecific with *D. varia.* The close similarities in the size and shape of the basal ring, as well as the frequent co-occurrence with *D. varia* in the current study, lend support to this interpretation; however, it is listed as a separate species in order to be consistent with Locker's more recent usage. *D. extensa* ranges higher than *D. varia.* The change from *D. varia* to *D. extensa* marks the "aspera/fibula" transition that has been commented on by various workers (see Bukry, 1982b) and that Burckle (1981) placed in the lower part of Magnetic Epoch 7 (late Miocene).

In this study, *Dictyocha extensa extensa* was restricted to specimens that had a basal ring that was rounded at the major-axis corners. These specimens have a basal ring similar to that of typical *D. varia.* Specimens having pointed basal corners thus had a rhomboid rather than oval shape to the basal ring and were counted as *Dictyocha* sp. There appears to have been a change in the shape of the basal ring during the course of the Pliocene, and this change is partly reflected in the increasing abundance of *Dictyocha* sp.

The phylogenetic relationships between *D. extensa* and *D. varia,* as seen by the first author, are illustrated in Figure 4. The similarities in basal ring size, spine lengths, and the robustness of basal and apical elements suggests to us that these two taxa are closely related by evolution. It is possible, we believe, that these two morphotypes represent different parts of a single range of variation within a species, with the minor-axis bridge (*D. varia*) predominating in the late Miocene and the major-axis morphology (*D. extensa*) in the early Pliocene; this hypothesis certainly warrants testing. This close relationship is further suggested by the abundance of deflandroid variants of both taxa in Sample 138-844B-28X-2, 120–121 cm. However, there are other points of view. Locker (personal communication) sees these separate morphologies as representing distinct species, and suggests that a bifurcation into separate lineages would be better than the single lineage illustrated in figure 4. Such questions deserve careful study and may yield much information on silicoflagellate variability and evolution.

Five-sided specimens of *D. extensa extensa* were found in Samples 138-848B-6H-4, 120–121 cm, -850B-19X-1, 120–121 cm, -851B-26X-1, 120–121 cm, and -851B-30X-1, 120–121 cm.

Silicoflagellates counted as *Dictyocha extensa extensa* (medusid) are characterized by an apical structure in which the four struts meet at a precise point. Those specimens in which the four struts form a very short bridge (see Locker and Martini, 1986b, pl. 2,. figs. 14, 15; pl. 11, fig. 6) were counted as *D. extensa* or *D. varia,* depending on the orientation of the bridge. The decision to place this form in *Dictyocha extensa,* rather than *D. varia,* is arbitrary. Medusid variants of *D. extensa* (pl. 5, fig. 7) were relatively abundant in Hole 844B.

Dictyocha extensa longa (Bukry) n. comb.
(Pl. 5, Fig. 10)

Dictyocha perlaevis perlaevis Frenguelli, Bukry, 1980b (in part), p. 553, pl. 4, figs. 10–13.
Dictyocha longa Bukry, 1982a, p. 432, pl. 2, figs. 8-13, pl. 3, figs. 1,2.

Remarks. Bukry (1982a) described this taxon as having a somewhat elongate basal ring of moderate-size with an apical structure that has an I-shaped appearance. Specimens found in Leg 138 samples are similar to *D. extensa extensa,* but generally possess a longer apical bridge. The angles between the bridge and the struts, as seen from apical view, are significantly less than 120°. The relative abundance of *D. extensa longa,* seen in this study, is less than that observed by Bukry (1982a, 1982b, 1983), suggesting that some

of the range of variation counted as *D. longa* by Bukry in this study were placed within *D. extensa extensa* or *Dictyocha* sp.

Authorship of n. comb. McCartney, Churchill, and Woestendiek.

Introduction to *Dictyocha fibula*

Considerable disagreement has evolved about the use of the term "*Dictyocha fibula*." During the early DSDP legs (e.g., Martini, 1971, 1976; Ling, 1975, Bukry and Foster, 1973) the term was applied to a wide range of skeletal morphologies having an apical bridge parallel to the major axis. The term "*Dictyocha aspera*" similarly was applied to a wide range of skeletal morphologies having a bridge parallel to the minor axis. These usages developed partly from Lemmermann (1901), who gave the names *D. fibula* var. *aspera* and *Dictyocha fibula* var. *brevispina* to two of Ehrenberg's specimens that had bridges parallel to the minor axis. Bukry and Foster (1973) and Bukry (1976c) elevated these to species status and restricted the usage of *D. fibula* to morphologies that had a bridge parallel to the long axis.

More recently, the wide morphologic range of *D. fibula* (as used by Bukry and Foster) has been reduced with the application of *D. aculeata, D. messanensis* (or *D. stapedia*), *D. perlaevis, D. longa,* and other terms that have been applied to four-sided silicoflagellates with bridges parallel to the major axis. In the more recent deep-sea literature, *D. fibula* came to be used for skeletons that could not easily be placed in the developing taxonomy (e.g., Bukry, 1983, 1984; McCartney and Wise, 1990).

While *D. fibula* has been applied to skeletons having long-axis bridges by most workers that have contributed to the silicoflagellate deep-sea literature, the taxon has been used differently by Sigurd Locker and Erlend Martini. Locker (1974) reexamined Ehrenberg's type specimens and designated a large equant four-sided skeleton having a bridge parallel to the shorter spines as the lectotype for *D. fibula.* This specimen, which came from the middle Miocene of Oran in Algeria is similar to specimens illustrated by Lemmermann (1901) and Schulz (1928) as *D. fibula* var. *brevispina* and var. *aspera.* Thus, *D. brevispina* and *D. aspera* have become junior synonyms of *D. fibula,* and Locker and Martini (1986b; Martini and Müller, 1976; Martini, 1990) have built up a taxonomy based on *D. fibula*'s being a large, four-sided silicoflagellate with bridge parallel to the minor axis.

In previous work by the first author (see the discussion in McCartney and Harwood, 1992), the usage of "*Dictyocha fibula* s. l." was retained so that the work could be easily compared to the voluminous Bukry literature. However, here we accept the Locker usage for *D. fibula* and hope that this can be used as a basis for developing some standardization of silicoflagellate taxonomy. The taxon is applied to a group of medium- to large-sized silicoflagellates having a bridge that normally is parallel to the minor axis, and here has been divided into three subspecies. Because the terms "*aspera*" and *brevispina* now are considered junior synonyms, they are here replaced by "*fibula*" and *mutabilis,* respectively.

Dictyocha fibula ausonia (Deflandre) n. comb.
(Pl. 2, Figs. 2–4; Pl. 3, Fig. 11; Pl. 5, Fig. 4)

Dictyocha ausonia Deflandre, 1950, p. 195, fig. 194-196, 199-202.
Dictyocha brevispina ausonia (Deflandre), Bukry, 1978a, p. 697, pl. 1, figs. 17–19.

Remarks. *Dictyocha fibula ausonia* is characterized by an elliptical basal ring that is rounded at the major-axis corners and differs from *D. fibula fibula,* which has a more pointed major axis corner. The relationship between these two taxa appears to vary; in some samples, they are similar, except for the outline of the basal ring; while in other samples, the two are more distinctly different, with *D. fibula ausonia* usually having a smaller size than co-occurring *D. fibula fibula.*

The counts for Sample 138-844B-31X-5, 92-93 cm include three specimens that lack struts and have a bridge that is offset from the minor axis (Pl. 2, Fig. 4); similar specimens have been illustrated by Bukry (1980a, pl. 1, figs. 11-13). Bukry's specimens are of similar age.

Authorship of n. comb. McCartney, Churchill, and Woestendiek.

Dictyocha fibula fibula Ehrenberg
(Pl. 2, Fig. 1; Pl. 5, Fig. 5)

Dictyocha fibula Ehrenberg, Locker, 1974, p. 636, pl. 1, fig. 6 (= lectotype).
Dictyocha fibula fibula Ehrenberg, Locker and Martini, 1986b, p. 904, pl. 5, figs. 1, 2; pl. 11, figs. 8, 9.

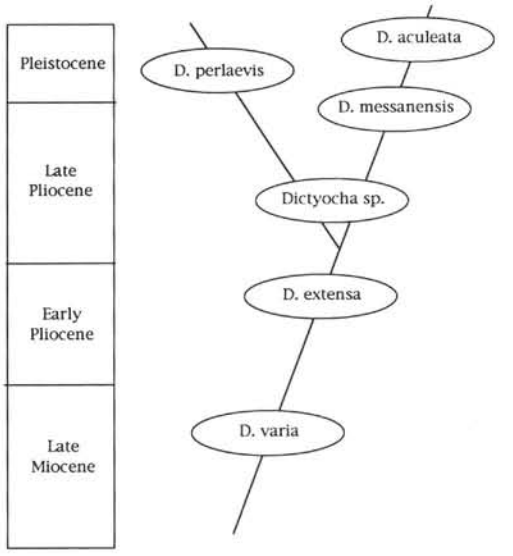

Figure 4. Simplified phylogeny showing the evolutionary relationships of important *Dictyocha* taxa as interpreted from Leg 138. *Dictyocha* sp. is a complex collection of intermediates between *D. extensa, D. messanensis,* and *D. perlaevis.*

Remarks. This is a group of generally large-sized dictyochid silicoflagellates having the bridge parallel to the minor axis and is commonly abundant in Miocene sediments of low and middle latitudes. The group has considerable diversity which workers have dealt with in a variety of ways. Skeletons having a relatively long bridge often have been generally classified as *Dictyocha brevispina,* while those having a shorter bridge usually have been classified as *D. aspera,* or sometimes in the older deep-sea literature (Bukry, 1973, 1975b), *D. rhombica.* In this study, we accept Locker's (1974) designation of a large skeleton with a long-axis bridge as the lectotype for *D. fibula.*

Dictyocha fibula mutabilis (Deflandre) n. comb.

Dictyocha mutabilis Deflandre, 1950, pl. 18, figs. 7–14.
Dictyocha brevispina (Lemmermann), Bukry, 1976c, p. 723.
Dictyocha brevispina brevispina (Lemmermann), Bukry, 1978b, p. 816, pl. 2, figs. 9, 10.

Remarks. *Dictyocha fibula mutabilis* here is used for skeletal morphologies that have previously been commonly referred to as *D. brevispina.* The basal ring of this taxon is somewhat more elongate than that of typical *D. fibula fibula.*

Authorship of n. comb. McCartney, Churchill, and Woestendiek.

Dictyocha lingii Dumitrica

Dictyocha lingi Dumitrica, 1973, p. 906, pl. 8, figs. 1–7.
Dictyocha lingii Dumitrica, Bukry, 1979a, p. 983, pl. 2, figs. 5–8.

Remarks. A single specimen similar to those illustrated by Bukry (1980b, pl. 3, figs. 3–5) was found in Sample 138-848B-6H-1, 120–121 cm.

Dictyocha messanensis Haeckel
(Pl. 3, Figs. 12–13)

Dictyocha fibula var. b Ehrenberg, 1843, p. 312, pl. 2, fig. IV 11.
Dictyocha messanensis Haeckel, *in* Peters (1860), p. 799–800.

Remarks. This taxon has considerable variability in the shape of its basal ring, the robustness of the skeletal elements and in the presence or absence of an apical spine. Locker and Martini (1986b) and other workers divided this taxon into several subspecies and forms, but these distinctions were found difficult to apply consistently, and thus, this taxon was not subdivided in this study.

Dictyocha perlaevis flexatella Bukry
(Pl. 2, Fig. 8)

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

Remarks. This taxon is generally rare, but is abundant in Sample 138-850B-6H-4, 120–121 cm.

Dictyocha perlaevis ornata Bukry
(Pl. 2, Fig. 6)

Dictyocha perlaevis ornata Bukry, 1977, p. 922, pl. 1, figs. 1–6; Bukry, 1978c, p. 644, pl. 1, fig. 8; Bukry, 1979a, p. 561,pl. 2, figs. 11–14.

Remarks. *Dictyocha perlaevis ornata* is found in Sample 138-849B-18X-1, 120–121 cm. A specimen found in Sample 138-849B-5H-1, 120–121 cm, was probably reworked.

Dictyocha perlaevis perlaevis Frenguelli
(Pl. 5, Fig. 1; Pl. 8, Fig. 4; Pl. 9, Fig. 3)

Dictyocha perlaevis Frenguelli, 1951, p. 279, figs. 4b, 4c.
Dictyocha fibula perlaevis (Frenguelli), Bukry, 1975c, p. 855, pl. 3, fig. 5.
Dictyocha perlaevis perlaevis Frenguelli, Bukry, 1979a, p. 984, pl. 3, fig. 6–11.

Remarks. *Dictyocha perlaevis* is most readily recognized by its large size. Smaller specimens that were otherwise similar to *D. perlaevis* were counted as *Dictyocha* sp.

Dictyocha subclinata Bukry
(Pl. 1, Figs. 5, 6, 8; Pl. 5, Figs. 8, 9)

Dictyocha sp., Ling, 1972 (in part), p. 164, pl. 26, figs. 7 and 8.
Dictyocha subclinata Bukry, 1981a, p. 546, 547, pl. 1, figs. 4–8; pl. 2, Figs. 1–10.

Remarks. This taxon is characterized by a moderate-sized apical bridge that is slightly inclined with respect to either the major or minor axis. The basal ring has long major-axis and short minor-axis spines. Both major- and minor-axis varieties are common in a brief interval of the early late Miocene, in Samples 138-850B-33X-1 120–121 cm., and -851B-25X-1, 120–121 cm. The group appears to be less abundant over a longer interval in DSDP Site 472 (Bukry, 1981a)

Dictyocha tamerae Bukry

Dictyocha tamerae Bukry, 1983, p. 338, figs. 7–11.

Dictyocha varia Locker
(Pl. 3, Fig. 1; Pl. 5, Fig. 2; Pl. 8, Fig. 6)

Dictyocha varia Locker, 1975, p. 99-101, figs. 3–7.
Dictyocha pulchella Bukry, 1975a, p. 687, pl. 4, figs. 1–3.

Remarks. This taxon has taken on two names in the DSDP and ODP literature. Bukry (1982a, 1982b, 1983) uses *Dictyocha pulchella,* while Locker and Martini (1986b) refer to it as *Dictyocha varia;* both terms were first described in 1975. Priority here is given to the Locker taxon, since it was described earlier in the year.

Dictyocha varia typically is small with a short-axis bridge, elliptical basal ring, and a generally robust construction. As the name suggests, considerable variation, particularly in the general size, exists in the shape of the basal ring and the structure of the apical axis. Major-axis morphologies that are similar to *D. varia* in the size and shape of the basal ring originally were described as *D. varia* forma *extensa;* this taxon has since been elevated to the species level. Cruxoid and deflandroid variants also can be common.

Introduction to *Dictyocha* sp.

Bukry (1982a, 1982b, 1983), in his investigations of silicoflagellates from equatorial sites, found abundant upper Miocene and lower Pliocene specimens of what he termed "*Dictyocha fibula* s. ampl." Bukry did not include photographs of this group but stated (Bukry, 1983) that Figures 8 and 9 of Loeblich et al. (1968) were used as a species concept for this taxon. These illustrations from Loeblich, which were reprinted from Ehrenberg, closely resemble *Dictyocha extensa.* However, Bukry's use of "s. ampl." and his reluctance to describe a new species suggest a group of *Dictyocha* with long-axis bridges that are not easily classified. We interpret a similar group, referred to as *Dictyocha* sp., in our investigations of Leg 138.

This group of *Dictyocha* are not readily amenable to species-level classification because of their wide variety, which is inconsistent enough from one sample to the next that it is difficult to apply a single set of identifying criteria. These generally middle-sized silicoflagellates frequently appear as intermediates between various species of the well-established *Dictyocha,* particularly *D. perlaevis, D. messanensis,*and *D. extensa;* this makes the interpretation into separate species a difficult undertaking. These skeletons were counted as *Dictyocha* sp. after several taxonomic approaches applied to this problem failed to separate the *Dictyocha* into distinct species that could be consistently identified.

The broad group of silicoflagellate morphologies represented here by *Dictyocha* sp. differs somewhat from Bukry's *Dictyocha fibula* s. ampl., although both groupings probably reflect similar difficulties in separating the *Dictyocha* into readily identifiable species. Bukry described (1982b) and used the taxon *Dictyocha perfecta,* which we were unable to recognize and apply consistently in our study. On the other hand, Bukry did not recognize *D. extensa,* which we counted as a separate species. Thus, Bukry's grouping includes *D. extensa,*while our grouping includes *D. perfecta.*

A possible explanation for this grouping is hybridization between several closely related species. Two important silicoflagellate species, *D. perlaevis* and *D. messanensis,* evolved during the interval in which the *Dictyocha* sp. morphologies are abundant. These species are distinct in the late Pliocene and Pleistocene sections, but appear to be less so in lower strata. Both taxa apparently evolved from *D. extensa,* which become less predominant and more variable in the interval in which *Dictyocha* sp. is abundant (Fig. 4).

Dictyocha sp.
(Pl. 3, Figs. 6–10)

Remarks. This is a broad group of dictyochids with a bridge parallel to the major axis, or slightly inclined from it. The group can best be understood as a collection of intermediates between *D. extensa, D. messanensis,*and *D. perlaevis.* Both the size and the shape of the basal ring vary considerably, but typical specimens are small to middle-sized. This grouping includes *D. perfecta* (Bukry, 1982b; 1983), but the boundaries between *D. perfecta* and other somewhat similar morphologies were difficult to place and varied from one sample to another, which made the broader grouping of *Dictyocha* sp. necessary.

Genus *DISTEPHANUS* Stöhr, 1880

Distephanus boliviensis boliviensis (Frenguelli) Bukry and Foster
(Pl. 6, Fig. 1; Pl. 10, Fig. 1)

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.

Remarks: Two specimens were found in Hole 844B that had an apical ring of moderate size subdivided into four small, rounded, symmetrical openings (Pl. 3, Fig. 1). These are listed in the counts as *D. boliviensis* (multiwindowed).

Distephanus crux carolae Bukry
(Pl. 2, Figs. 7, 8)

Distephanus crux carolae Bukry, 1982b, p. 315, pl. 5, figs. 4–11; Bukry, 1983, pl. 7, fig. 3.

Remarks. This taxon is small and has generally equant sides and long basal spines. The apical ring is square and has a small window. The apical structure often has a short bridge instead of an apical window; the bridge can be parallel to the major or minor axes. Bukry (1983) recorded this as a rare taxon over a large interval in the lower Pliocene and upper Miocene sediments of Hole 503A, but more abundant over a short interval of the lower Pliocene. Bukry (1982b) also found both ringed and bridged variants in Sample 68-503A-41-1, 34–35 cm, which is late Miocene in age. In the present study, this taxon occurs in Sample 138-850B-16H-1, 120–121 cm; the counts recorded in Table 3 include one specimen having a bridge.

Distephanus crux crux Ehrenberg
(Pl. 7, Figs. 1, 2, 5, 8, 9)

Distephanus crux Ehrenberg, 1840, p. 207; Ehrenberg, 1854, pl. 18, figs. 56; pl. 33(XV), fig. 9.

Remarks. Specimens counted as *Distephanus crux crux* may include cruxoid variants of other species. A bridged specimen is included in the counts for Sample 138-844B-15H-4, 120–121 cm.

Distephanus longispinus (Schulz) Bukry and Foster

Distephanus crux f. *longispinus* Schulz, 1928, p. 256, fig. 44.
Distephanus longispinus (Schulz), Bukry and Foster, 1973, p. 828, pl. 4, figs. 7, 8.

Distephanus polyactis (Ehrenberg)
(Pl. 6, Fig. 7)

Dictyocha polyactis Ehrenberg, 1840, p. 129.
Distephanus polyactis (Ehrenberg), Bukry, 1979a, p. 562, pl. 3; figs. 15, 16; pl. 4, fig. 1.

Remarks. One specimen found in Sample 138-844B-6H-4, 120–121 cm.

Distephanus pulchra (Schiller) Ling and Takahashi

Octactis pulchra Schiller, 1925, p. 67–68, fig. c.
Distephanus pulchra (Schiller), Ling and Takahashi, 1985, p. 80, pls. 1–2.

Remarks. The eight-sided *D. pulchra* is especially common in coastal waters (see Schrader et al., 1986). This taxon was consistently found throughout the Pleistocene section of Hole 847B; it was scattered at other Leg 138 sites. A single specimen was found in Sample 138-844B-2H-2, 120–121 cm.

Distephanus quinquangellus Bukry and Foster
(Pl. 8, Fig. 3; Pl. 10, Fig. 3)

Distephanus quinquangellus Bukry and Foster, 1973, p. 828, pl. 5, fig 4.

Remarks. This taxon has been used for five-sided distephanid morphologies that are larger than the co-occurring *Distephanus speculum.* The type specimen is from DSDP Site 157, where it often represented several percent of the total silicoflagellate counts from the Pleistocene and Pliocene sections; *Distephanus quinquangellus* specimens in this study were noticeably less abundant than those at Site 157.

A specimen having two apical windows was found in Sample 138-850B-18H-1, 120–121 cm.

Distephanus speculum giganteus Bukry
(Pl. 6, Fig. 4)

Distephanus speculum giganteus n. subsp. Bukry, 1976b, p.848, pl. 1, fig. 19; pl. 2, figs. 1,2.
Distephanus speculum giganteus Bukry, Bukry, 1981a, p. 550, pl. 4, figs. 1, 2.

Remarks: This taxon has a large basal ring that is hexagonal in shape, and a distinctly longer pair of major axis spines. The sides may be straight or slightly convex. Basal pikes are offset from the junctions of the struts and are small and blunt. The apical ring is rounded and only slightly smaller than the basal ring. It is distinguished from *D. speculum speculum* by its large size and large apical ring, and from *D. boliviensis boliviensis* by the disparity in axial spine length as well as by the large apical ring.

Distephanus speculum hemisphaericus (Ehrenberg) Bukry
(Pl. 6, Figs. 2, 5, 8; Pl. 7, Fig. 6)

Dictyocha hemisphaerica Ehrenberg, 1844, pl. 17, fig. 5.
Distephanus speculum hemisphaericus (Ehrenberg), Bukry, 1975c, p. 854.

Remarks. This taxonomy is used to describe those speculum-type morphologies displaying multiple apical windows, except for those specimens contained within the lectotype of *D. boliviensis boliviensis.*

Distephanus speculum minutus (Bachmann) Bukry
(Pl. 7, Fig. 3)

Dictyocha speculum f. *minuta* Bachmann *in* Ichikawa, et al., 1967, p. 161, pl. 7, figs. 12–15.
Distephanus minutus (Bachmann), Bukry and Foster, 1973, p. 828, pl. 4, figs. 10, 11.
Distephanus speculum minutus (Bachmann), Bukry, 1976a, p. 895, pl. 8, figs. 1–3.

Distephanus speculum patulus Bukry

Distephanus speculum patulus Bukry, 1982b, p. 433, pl. 5, figs. 7–10.

Remarks. Found in Sample 138-844B-29H-4, 120–121 cm. *D. speculum patulus* is moderately sized with semi-equant spines and a small to moderately sized apical ring.

Distephanus speculum pentagonus Lemmermann
(Pl. 7, Fig. 4)

Distephanus speculum var. *pentagona* Lemmermann, 1901, p. 264, pl. 11, fig. 19.
Distephanus speculum pentagonus Lemmermann, Bukry, 1976a, p. 895–896; McCartney and Wise, 1990, pl. 3, figs. 3–6.

Remarks. Although similar in appearance to *Distephanus quinquangellus,* having a five-sided basal structure with five semi-equant spines, this group is distinguished by its smaller size, which compares with that of *D. speculum speculum.* The counts include one specimen from Sample 138-844B-15H-4, 120–121 cm, that was similar to that illustrated by McCartney and Wise (1987, pl. 2, fig. 9).

Distephanus speculum speculum f. *pseudofibula* Schulz

Distephanus speculum f. *pseudofibula* Schulz, 1928, p. 262, figs. 51a, 51b.
Distephanus speculum speculum f. *pseudofibula* Schulz, Locker and Martini, 1986b, p. 907, pl. 7, fig. 5.

Remarks. One specimen was found in Sample 138-844B-12H-2, 120–121 cm.

Distephanus speculum speculum (Ehrenberg) Bukry and Foster
(Pl. 3, Fig. 3; Pl. 4, Fig. 7; Pl. 10, Fig. 7)

Dictyocha speculum Ehrenberg, 1840; Ehrenberg, 1854, pl. 18, fig. 57; pl. 19, fig. 41, pl. 21, fig. 44; pl. 22, fig. 47.
Distephanus speculum (Ehrenberg) Haeckel, 1887, p. 1565.
Distephanus speculum speculum (Ehrenberg), Bukry and Foster, 1973, p. 828, pl. 5, fig. 8.

Remarks. Specimens from the Pliocene section of Site 848 often were of small size. Considerable variation exists in the lengths of the basal spines, with some having short spines while others have spines longer than the diameter of the basal ring. Five-, seven- and eight-sided and multiwindowed variants are listed separately in the range charts, but have not been formally defined as separate forms; these morphologies are consistently uncommon. An unusual five-sided specimen (see McCartney and Wise, 1987, pl. 2, fig. 9) was found in Sample 138-851B-24X-1, 120–121 cm. Rare examples of the pseudofibulid morphologies (McCartney and Wise, 1990) also were found and are tabulated separately in the abundance charts.

Distephanus speculum tenuis Bukry
(Pl. 1, Figs. 9, 10; Pl. 5, Fig. 1; Pl. 10, Fig. 6)

Distephanus speculum tenuis Bukry, 1982b, p 316, pl. 6, figs. 5–11.

Remarks. This unusual silicoflagellate has an apical structure made up of very thin skeletal elements; in many cases, the skeleton lacks an apical structure entirely, but whether this is a primary feature or the result of breakage is uncertain. This taxon appears to be abundant in the late Miocene section only at sites very near the equator. These include Sites 503 (Bukry, 1982b), 849, 850, 851 and 847; all of these are within 5° of the equator. Sites farther away from the equator do not have this distinctive morphology. The absence of this morphology at Site 844 (latitude 9°N) or at Site 495 (latitude 12°N) shows that these morphologies have been restricted to near-equatorial waters and that they were not transported by surface waters for great distances away from the equator.

The apical structure of *Distephanus speculum tenuis* is similar to that of *D. pulchra,* which is from the Pleistocene and Holocene. *D. pulchra* is found typically in coastal regions and generally is uncommon in the open ocean (Poelchau, 1974). Schrader et al. (1986) thought that this taxon was indicative of long, persistent upwelling seasons. It is uncertain whether this information can be applied readily to the similar *D. speculum tenuis,* but its occurrence on the equator during the late Miocene may be indicative of especially persistent upwelling conditions.

A single seven-sided specimen of this taxon was found in -851B-18H-1, 120–121 cm, and was included within the general counts for that sample.

Distephanus pulchra (Schiller) Ling and Takahashi
(Pl. 10, Fig. 6)

Octactis pulchra Schiller, 1925, p. 67–68, fig. c.
Distephanus pulchra (Schiller), Ling and Takahashi, 1985, p. 80, pls. 1–2.

Remarks. This species is an eight-sided form of *Distephanus* and has an extremely delicate apical structure. With the exception of the number of sides it is similar to *Distephanus speculum tenuis,* although these species have markedly different geologic ranges and are probably independent of one another in development. The apical structure of this species often was broken or missing. It was present in the Pleistocene and upper Pliocene sediments in Hole 849B, but was not observed at all in Hole 852B.

Distephanus stauracanthus f. *stauracanthus* (Ehrenberg) Haeckel
(Pl. 6, Fig. 6)

Distephanus stauracanthus (Ehrenberg) Haeckel, 1887, v. 18, p. 1564.
Distephanus stauracanthus (Ehrenberg) Haeckel, Locker and Martini, 1986b, p. 907.

Distephanus stauracathus f. *octagonus* (Tsumara) Locker and Martini
(Pl. 6, Fig. 9)

Dictyocha fibula var. *octagona* Tsumara, 1963, pl. 2, fig. 4; pl. 10, figs. 11–13.; pl. 23, figs. 8–10.
Dictyocha octagona (Tsumara), Martini, 1971, p. 1697, pl 1., fig. 15.
Distephanus stauracanthus f. *octagonus* (Tsumara), Locker and Martini, 1986b, p. 907, pl. 6, fig. 8.

Remarks. This taxon is distinguished by its eight-sided basal ring, which displays eight equant spines. It differs from *D. stauracanthus stauracanthus* in having an inclined dictyochid bridge, rather than a cruxoid apical ring.

Distephanus xenus Bukry
(Pl. 10, Figs. 4, 5)

Distephanus xenus Bukry, 1984, p. 557, pl. 1, figs. 11, 12; Pl. 2, figs. 1–8.

Remarks. This species has a large hexagonal-shaped basal ring with a large apical ring. The basal ring either lacks spines or has only rudimentary spines. It has the overall skeletal appearance of *D. boliviensis* without basal spines.

Genus *NEONAVICULOPSIS* Locker and Martini, 1986

Neonaviculopsis neonautica neonautica (Bukry) Locker and Martini

Dictyocha navicula Ehrenberg, Bukry and Foster, 1973 (in part), p. 827, pl. 3, figs. 6, 7.
Dictyocha neonautica Bukry 1981b, p. 442.
Dictyocha neonautica neonautica Bukry, 1981a, p. 549, pl. 3, fig. 4.
Dictyocha neonautica Bukry, 1982b (in part), p. 316, pl. 2, fig. 10.
Neonaviculopsis neonautica Locker and Martini, 1986b, p. 909, pl. 10, figs. 6–11.

Remarks. *Neonaviculopsis neonautica* here is restricted to skeletal morphologies that are larger and more elongate than *Bachmannocena diodon nodosa.* The range of variation of *B. diodon nodosa* includes naviculopsid skeletons, but because we view these as the result of variation within the species, we are thus reluctant to place these within the separate genus *Neonaviculopsis.* The *Neonaviculopsis* morphologies generally occur within and immediately above the *B. diodon nodosa* Horizon, although they also occur just below the horizon in Sample 138-850B-17X-1, 120–121 cm.

Neonaviculopsis neonautica praenautica Locker and Martini
(Pl. 1, Fig. 7)

Neonaviculopsis neonautica praenautica Locker and Martini, 1986b, p. 909, pl. 10, figs. 1–5, 12.

Remarks. This skeletal morphology has the appearance of a *Dictyocha,* with a bridge parallel to the minor axis but without minor-axis spines. While members of this taxon are closely related to *Neonaviculopsis neonautica neonautica,* the general morphology is polyphyletic because very similar skeletons can occur within the range of variation of various *Dictyocha* and *Naviculopsis* taxa (see Perch-Nielsen, 1976; Bukry, 1976b). Praenauticid variants of *Dictyocha fibula ausonia* occur in Samples 138-850B-21H-1, 120–121 cm (Pl. 2, Figs. 3, 4).

Ebridians

Only Holes 844B, 848B, 850B and 851B were examined for ebridians. The absence of ebridians on the charts for the other sites does not necessarily mean that ebridians were not found to occur there.

Genus *AMMONOCHIUM* Hovasse, 1932

Ammonochium serotinum Locker and Martini

Ammonochium serotinum Locker and Martini, 1986a, p. 943, pl. 2, figs. 1,2.

Remarks. Specimens were found scattered in the middle Miocene section of Hole 844B and a single specimen was found in Sample 138-844B-14H-4, 120–121 cm.

Genus *EBRIOPSIS* Hovasse, 1932

Ebriopsis antiqua antiqua (Schulz) Ling

Ebria antiqua Schulz, 1928 (in part), pp. 273, 274, fig. 696.
Ebriopsis antiqua antiqua (Schulz), Ling, 1977, p. 215, pls. 17, 18.

Remarks. Single specimens of this taxon were found in Samples 138-850B-5H-1, 120–121 cm, and Sample 138-850B-12X-1, 120–121 cm.

Genus *HERMESINUM* Zacharias, 1906

Hermesinum adriaticum Zacharias

Hermesinum adriaticum Zacharias, 1906, p. 394, figs. a–d.

Remarks. This taxon was scattered in the upper Miocene and lower Pliocene sediments of Holes 844B, 850B and -851B.

Genus *PARATHRANIUM* Hovasse, 1932

Parathranium tenuipes (Hovasse), Ling

Thranium tenuipes Hovasse, 1932, p. 123, fig. 5.
Parathranium tenuipes (Hovasse), Ling, 1972, pp. 198–199.

Remarks. Specimens of this ebridian were scattered in the Miocene and Pliocene sediments of Hole 850B and in Sample 138-851B-12H-1, 34–35 cm. This species differs from the earlier *P. intermedium* in having relatively thinner skeletal elements (Ling and McPherson, 1974; Perch-Nielsen, 1975).

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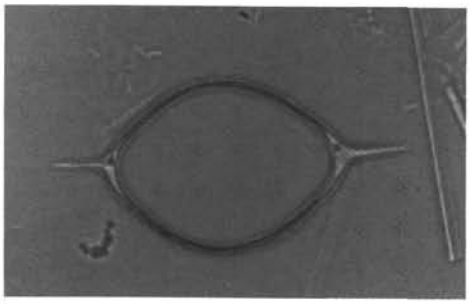
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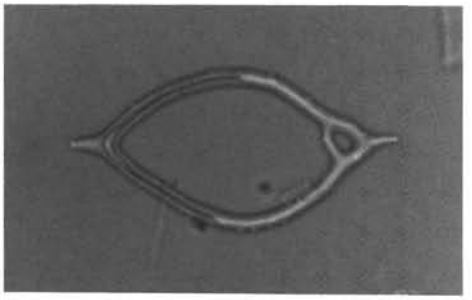
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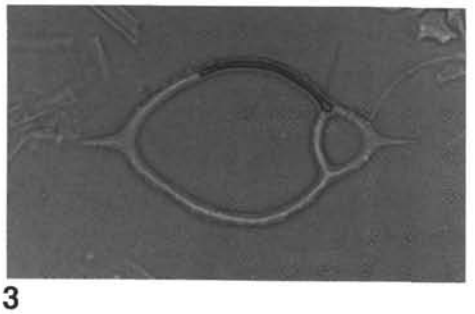
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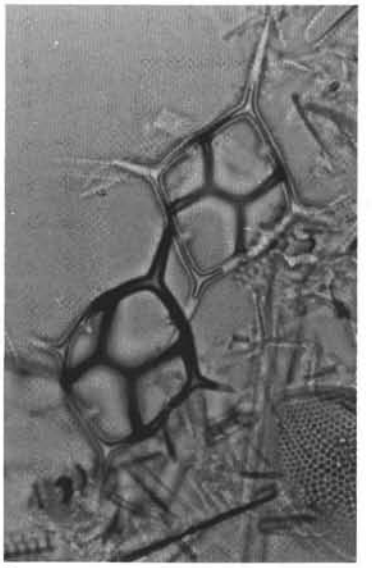
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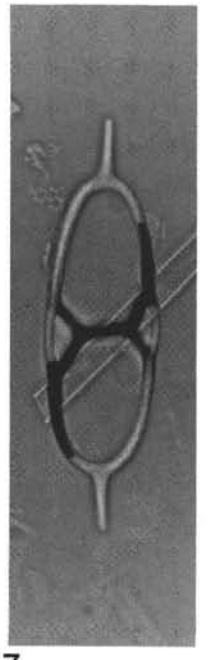
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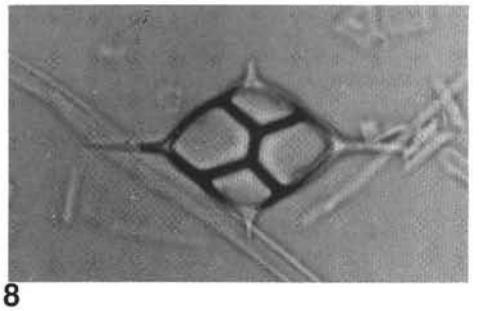
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Plate 1. Silicoflagellates from Sites 848, 850, and 851 (magnification 850×). **1.** *Bachmannocena diodon nodosa* (Bukry), Sample 138-848B-7H-4, 120–121 cm. **2, 3.** *Bachmannocena diodon nodosa* f. *transenna* (Bukry), Sample 138-848B-7H-4, 120–121 cm. **4.** *Bachmannocena diodon nodosa* f. *cocoensis* (Bukry), Sample 138-848B-7H-4, 120–121 cm. **5, 6.** *Dictyocha subclinata* Bukry, Sample 138-850B-33X-1, 120–121 cm. **7.** *Neonaviculopsis neonautica praenautica* Locker and Martini, Sample 138-850B-16H-1, 120–121 cm. **8.** *Dictyocha subclinata* Bukry, Sample 138-850B-33X-1, 120–121 cm. **9, 10.** *Distephanus speculum tenuis* Bukry; (9) Sample 138-850B-21X-1, 120–121 cm; (10) Sample 138-850B-19X-1, 120–121 cm.

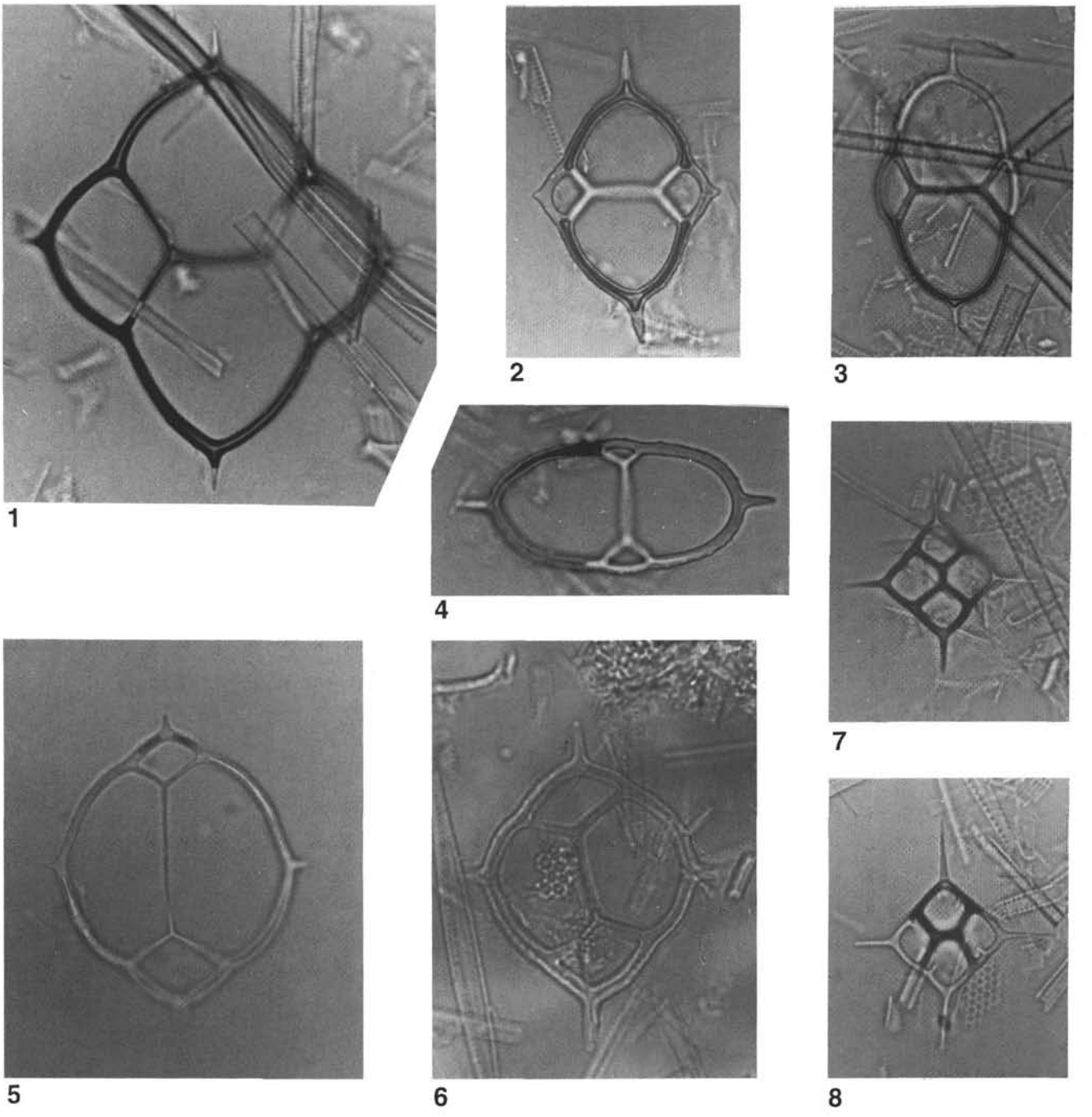
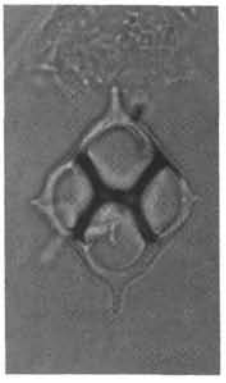


Plate 2. Silicoflagellates from Sites 848, 850, and 851 (magnification 850×). **1.** *Dictyocha fibula fibula* Ehrenberg, Sample 138-850B-25X-1, 120–121 cm. **2.** *Dictyocha fibula ausonia* (Deflandre), Sample 138-850B-21X-1, 120–121 cm. **3, 4.** *Dictyocha fibula ausonia* (Deflandre) (praenauticid), Sample 138-850B-21X-1, 120–121 cm. **5.** *Distephanus crux carolae* Bukry (bridged), Sample 138-850B-16X-1, 120–121 cm. **6.** *Dictyocha delicata bisecta* (Bukry), Sample 138-848B-6H-4, 120–121 cm. **7.** *Dictyocha perlaevis flexatella* Bukry, Sample 138-851B-6H-1, 120–121 cm. **8.** *Distephanus crux carolae* Bukry (bridged), Sample 138-850B-16X-1, 120–121 cm.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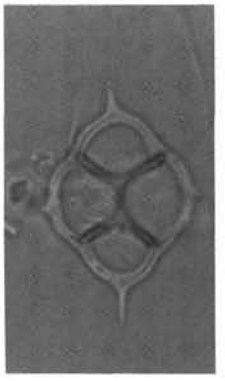
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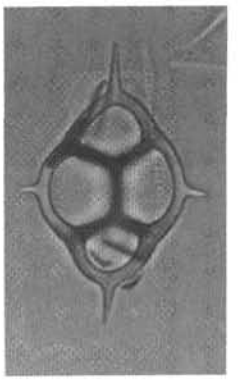
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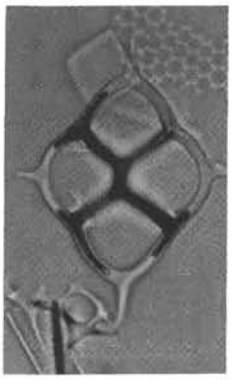
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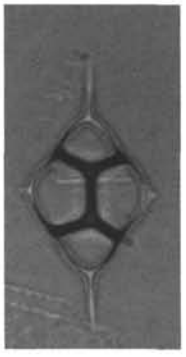
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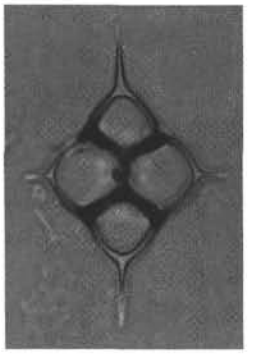
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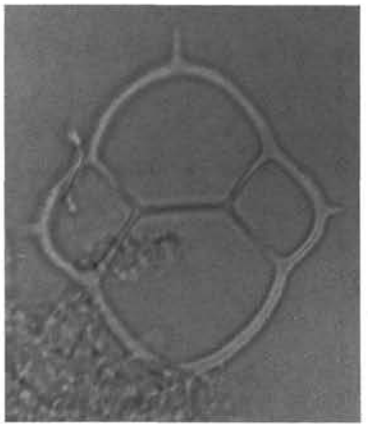
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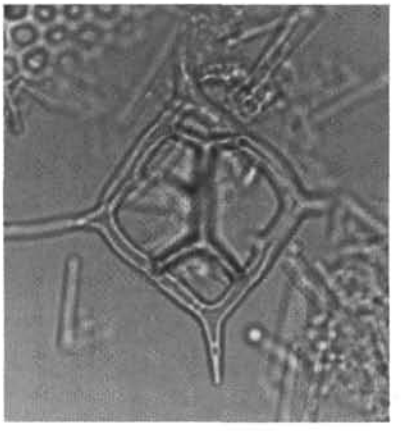
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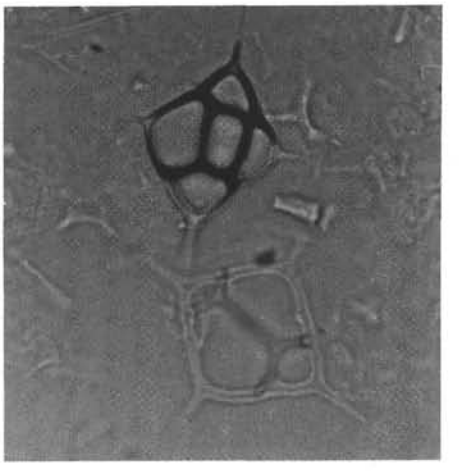
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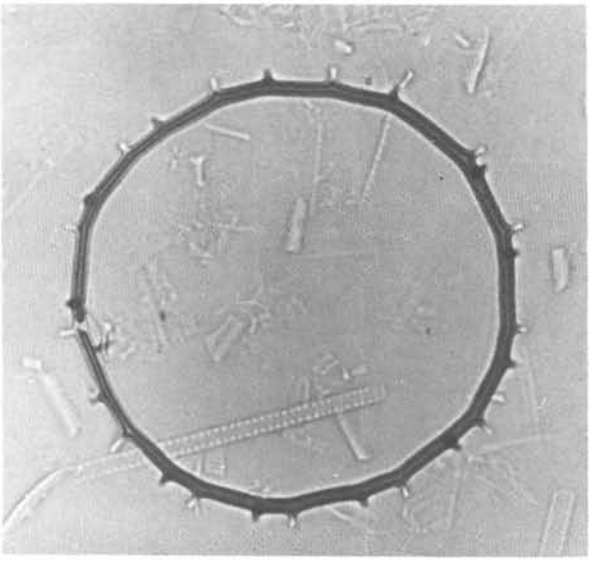
Plate 3. Silicoflagellates from Sites 848, 850, and 851 (magnification 850×). **1.** *Dictyocha varia* Locker, Sample 138-851B-10H-1, 120–121 cm. **2–5.** *Dictyocha extensa extensa* Locker (2) Sample 138-848B-6H-1, 120–121 cm; (3) Sample 138-851B-10H-1, 120–121 cm; (4) Sample 138-850B-23X-1, 120–121 cm; (5) Sample 138-850B-26X-1, 120–121 cm. **6–10.** *Dictyocha* sp., Sample 138-848B-4H-4, 120–121 cm. **11.** *Dictyocha fibula ausonia* (Deflandre), Sample 138-851B-11H-1, 120–121 cm. **12, 13.** *Dictyocha messanensis* Haeckel; (12) Sample 138-851B-3H-1, 120–121 cm; (13) Sample 138-848B-4H-4, 120–121 cm (top specimen is cruxoid).



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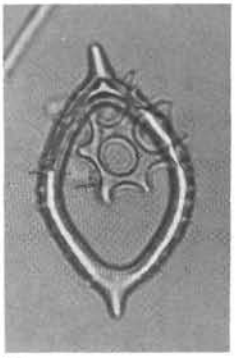

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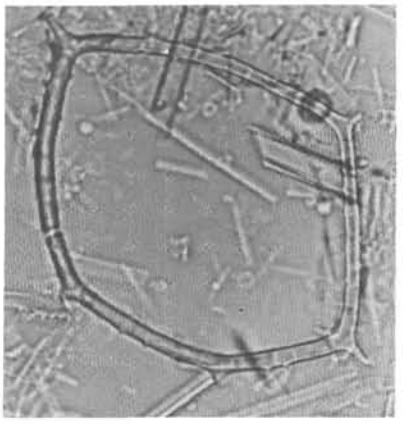

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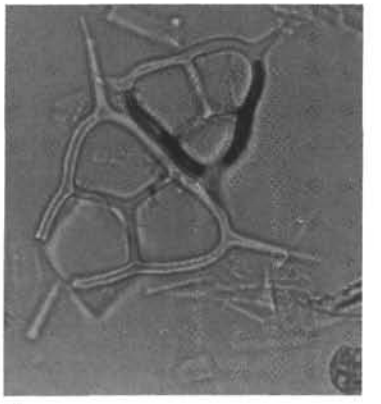

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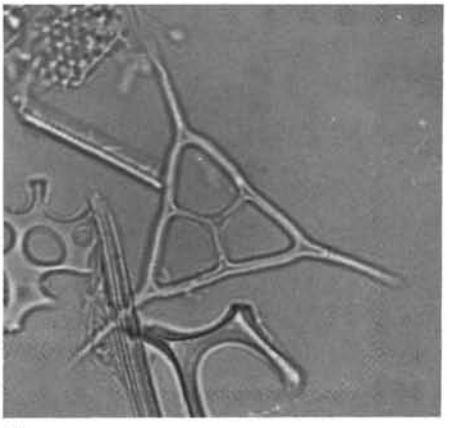

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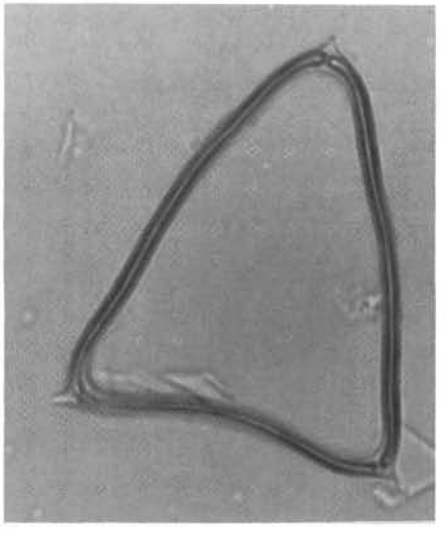

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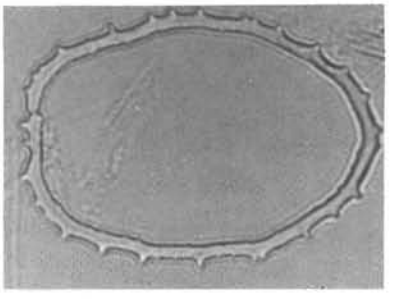

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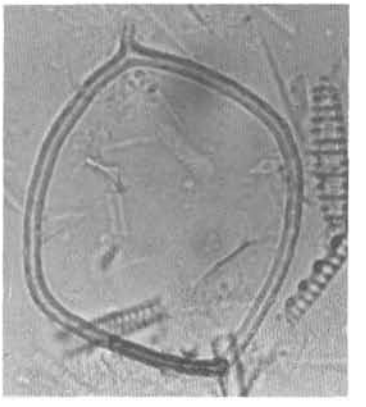

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Plate 4. Silicoflagellates from Sites 844 and 847 (magnification 850×). **1.** *Bachmannocena circulus* (Ehrenberg), Sample 138-847B-11H-1, 113–114 cm. **2.** *Bachmannocena diodon nodosa* (Ehrenberg), Sample 138-847B-22X-4, 123–124 cm. **3.** *Bachmannocena quadrangula* (Ehrenberg Ex Haeckel), Sample 138-844B-2H-4, 120–121 cm. **4, 5.** *Corbisema triacantha* (Bukry), Sample 138-844B-16H-2, 120–121 cm. **6.** *Bachmannocena apiculata curvata* Bukry, Sample 138-844B-26X-4, 120—121 cm. **7.** *Bachmannocena circulus* (Ehrenberg), Sample 138-847B-11H-1, 120–121 cm. **8.** *Bachmannocena diodon diodon* (Ehrenberg) Sample 138-844B-9H-4, 120–121 cm.

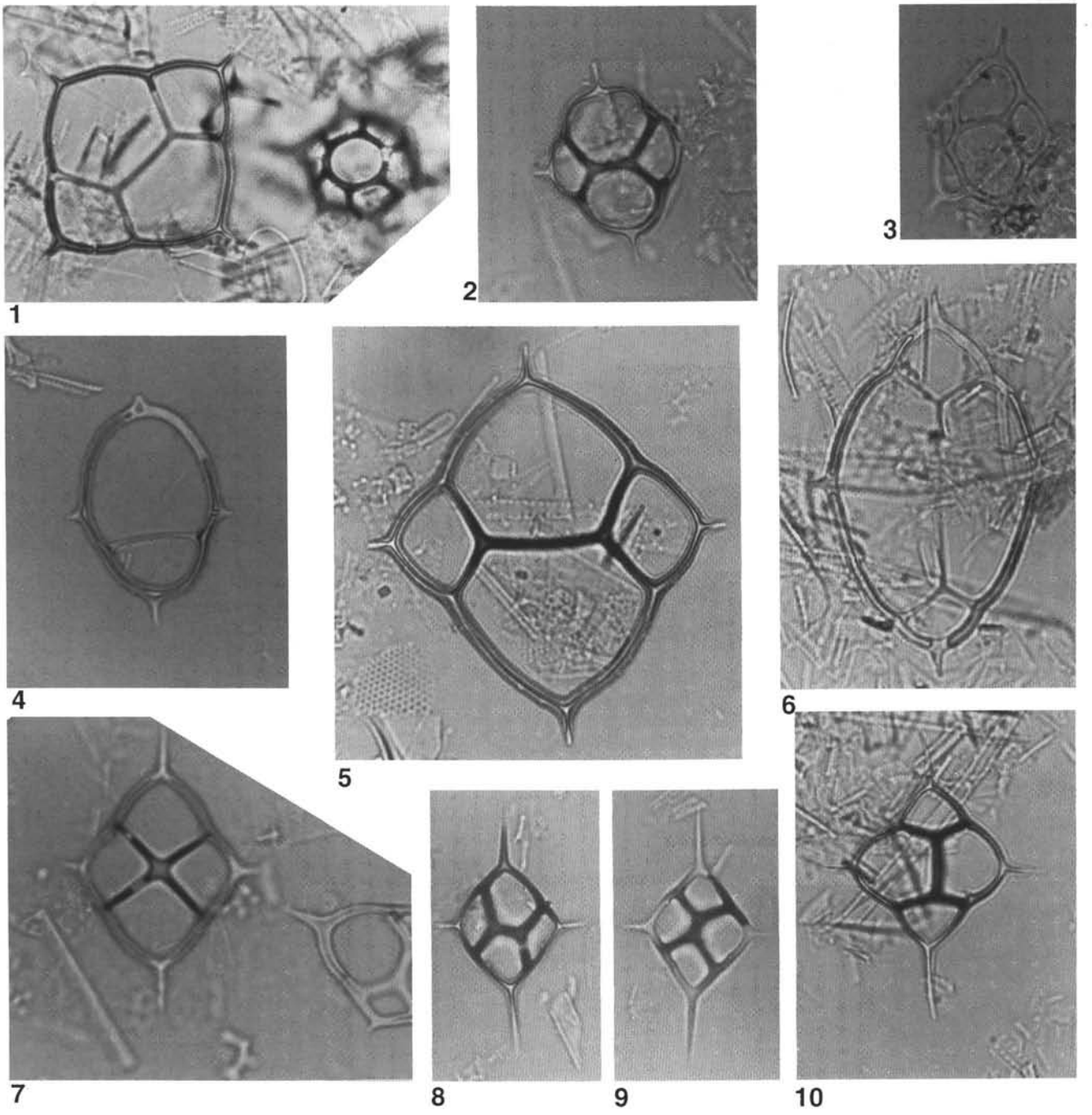


Plate 5. Silicoflagellates from Sites 844 and 847 (magnification 850×). **1.** *Dictyocha perlaevis* (Bukry) (with thin apical elements, left) and *Distephanus speculum tenuis* Bukry (right), Sample 138-847B-13H-1, 123–124 cm. **2.** *Dictyocha varia* (Locker), Sample 138-844B-31X-1, 92–93 cm. **3.** *Dictyocha extensa* Locker (five-sided), Sample 138-844B-3H-4, 120–121 cm. **4.** *Dictyocha fibula ausonia* (Deflandre) (naviculopsid), Sample 138-844B-31X-5, 92–93 cm. **5.** *Dictyocha fibula fibula* Ehrenberg, Sample 138-847B-17X-1, 123–124 cm. **6.** *Dictyocha delicata bisecta* (Bukry), Sample 138-847B-18X-4, 122–123 cm. **7.** *Dictyocha extensa extensa* f. *medusa* McCartney, Churchill, and Woestendiek, Sample 138-844B-22X-4, 120–121 cm. **8, 9.** *Dictyocha subclinata* (Bukry); (8) Sample 138-844B-7H-2, 120–121 cm, (9) Sample 138-844B-7H-2, 120–121 cm. **10.** *Dictyocha extensa longa* (Bukry), Sample 138-844B-21X-1, 120–121 cm.

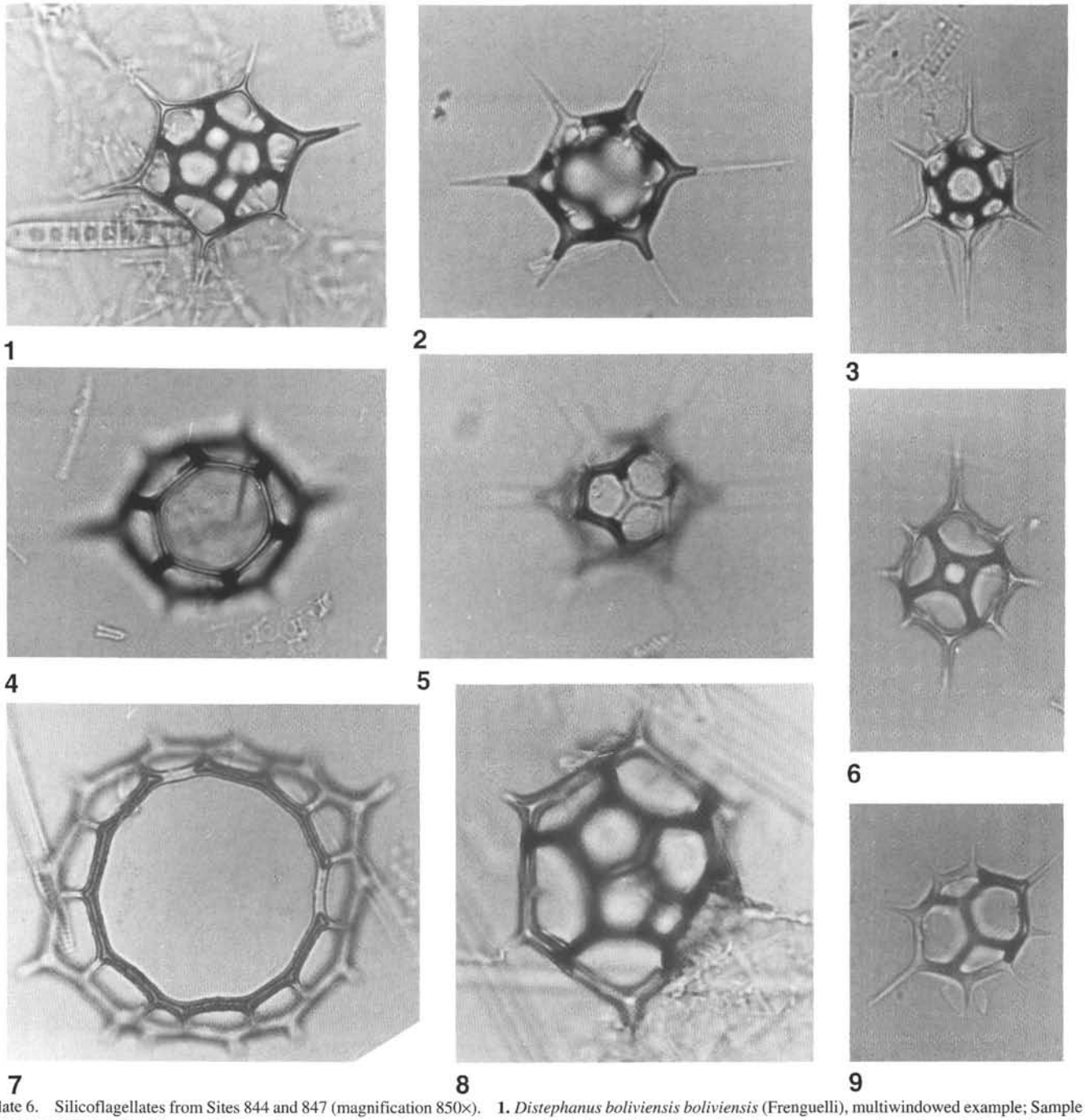
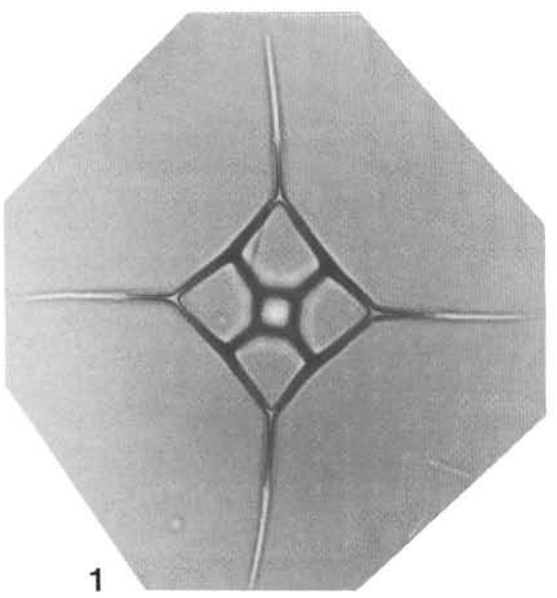
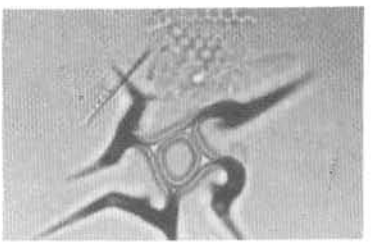
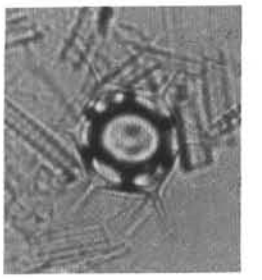
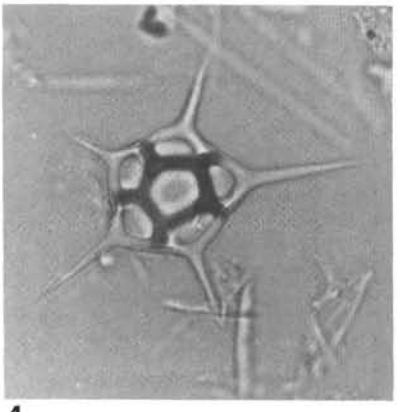


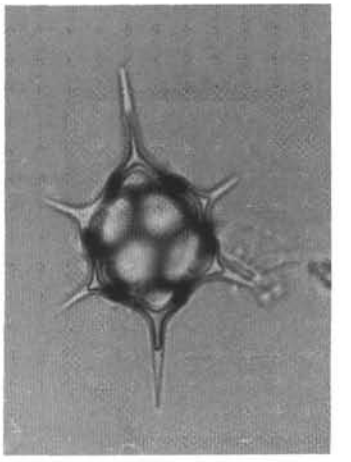
Plate 6. Silicoflagellates from Sites 844 and 847 (magnification 850×). **1.** *Distephanus boliviensis boliviensis* (Frenguelli), multiwindowed example; Sample 138-844B-9H-2, 120–121 cm. **2.** *Distephanus hemisphaericus* (Ehrenberg) (multiwindowed) (low focus, high focus of same specimen shown in Fig. 5), Sample 138-848B-6H-1, 120–121 cm. **3.** *Distephanus speculum speculum* Bukry, Sample 138-847B-16X-1, 123–124 cm. **4.** *Distephanus speculum giganteus* Bukry, Sample 138-844B-26X-4, 123–124 cm. **5.** *Distephanus speculum hemisphaericus* Bukry, Sample 138-847B-26X-4, 123–124 cm. **6.** *Distephanus stauracanthus* f. *stauracanthus* (Ehrenberg), Sample 138-844B-12H-1, 120–121 cm. **7.** *Distephanus polyactis* (Ehrenberg), Sample 138-844B-12H-4, 120–121 cm. **8.** *Distephanus speculum hemisphaericus* Bukry, Sample 138-847B-26X-4, 123–124 cm. **9.** *Distephanus stauracanthus* f. *octagonus* (Tsumara), Sample 138-844B-15H-2, 120–121 cm.

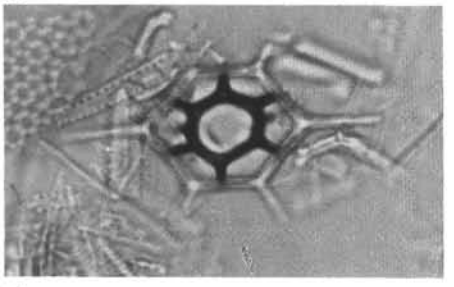


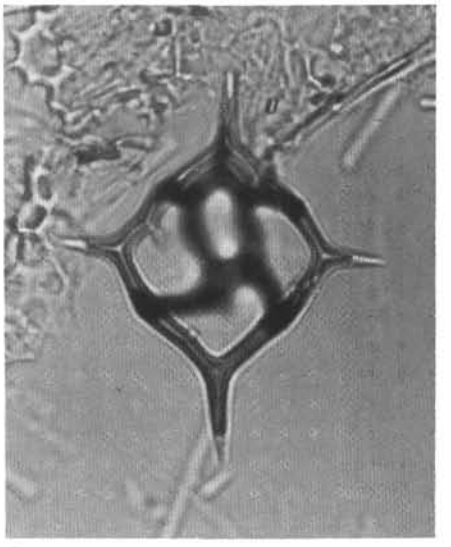












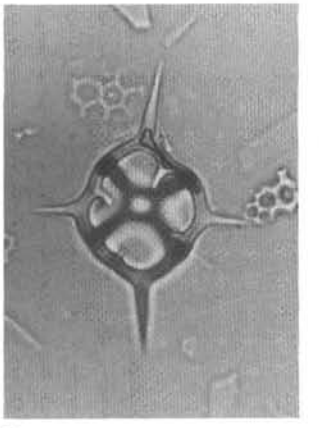


Plate 7. Silicoflagellates from Sites 844 and 847 (magnification 850×). **1.** *Distephanus crux crux* Ehrenberg, Sample 138-844B-12H-4, 120–121 cm. **2.** *Distephanus crux crux* Ehrenberg (aberrant), Sample 138-844B-12H-4, 120–121 cm. **3.** *Distephanus speculum minutus* (Bachmann), Sample 138-847B-18X-1, 123–124 cm. **4.** *Distephanus speculum pentagonus* Lemmermann, Sample 138-844B-7H-2, 120–121 cm. **5.** *Distephanus crux crux* Ehrenberg (aberrant), Sample 138-844B-28X-4, 120–121 cm. **6.** *Distephanus speculum hemisphaericus* (Ehrenberg), Sample 138-844B-18H-4, 120–121 cm. **7.** *Distephanus speculum speculum* (Ehrenberg), Sample 138-847B-15X-1, 120–121 cm. **8, 9.** *Distephanus crux crux* Ehrenberg; (8) aberrant, Sample 138-847B-16X-1, 123–124 cm, (9) Sample 138-844B-16H-4, 120–121 cm.

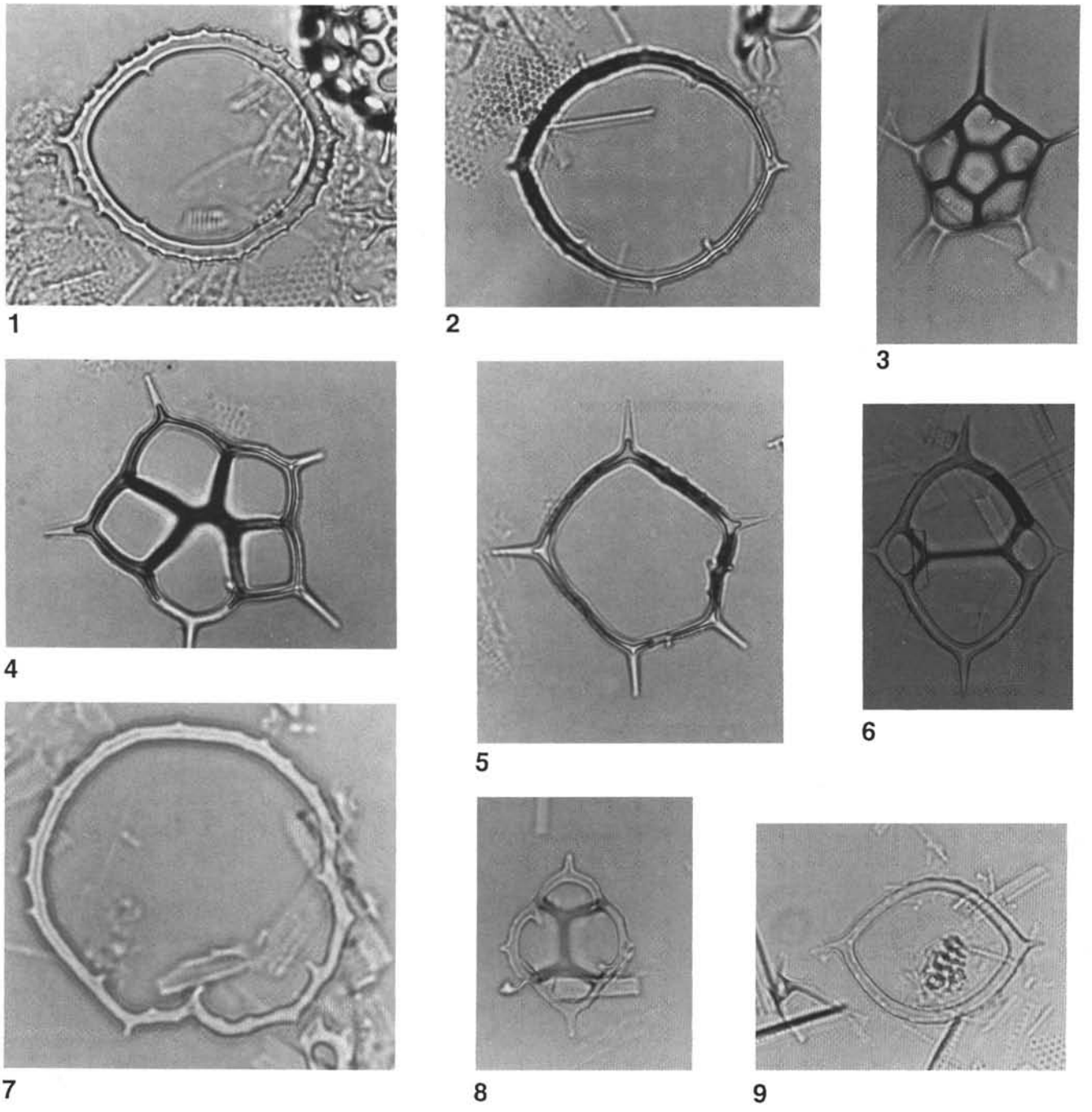
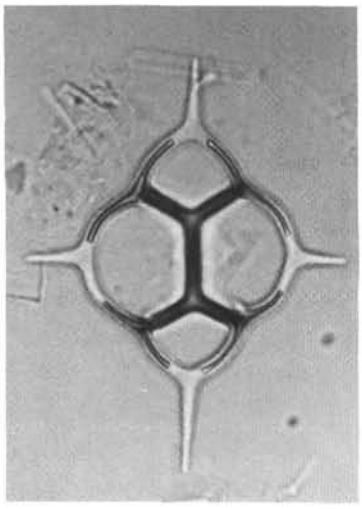


Plate 8. Silicoflagellates from Site 849 (magnification 850×). **1, 2.** *Bachmannocena diodon nodosa* (Bukry), Sample 138-849B-20X-1, 120–121 cm. **3.** *Distephanus quinquangellus* Bukry and Foster, Sample 138-849B-3H-4, 120–121 cm. **4.** *Dictyocha perlaevis perlaevis* Frenguelli (five-sided), Sample 138-849B-4H-1, 120–121 cm. **5.** *Bachmannocena quadrangula* Ehrenberg, Sample 138-848B-4H-1, 120–121 cm. **6.** *Dictyocha varia* Locker, Sample 138-852B-8H-1, 120–121 cm. **7.** *Bachmannocena circulus* (Ehrenberg), Sample 138-849B-15X-1, 120–121 cm. **8.** *Dictyocha extensa extensa* Locker, Sample 138-849B-17X-1, 120–121 cm. **9.** *Bachmannocena diodon nodosa* (Bukry), Sample 138-849B-3H-1, 120–121 cm.



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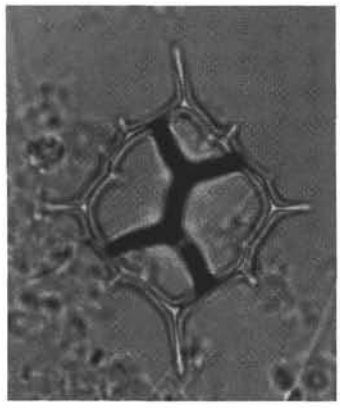

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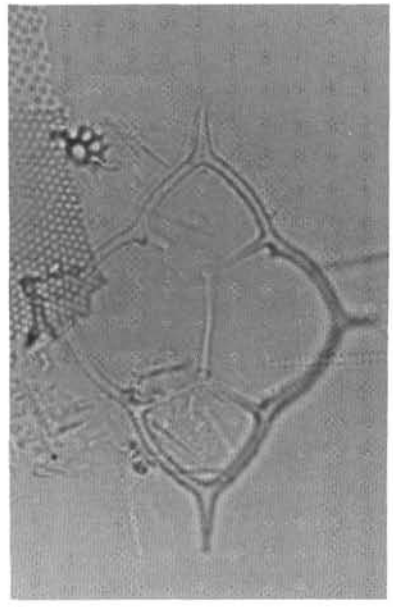

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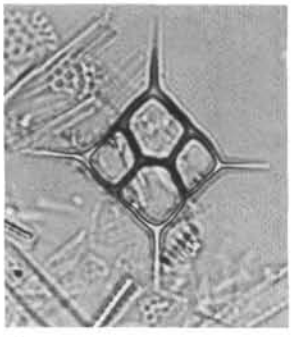

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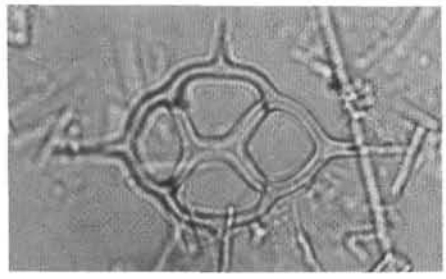

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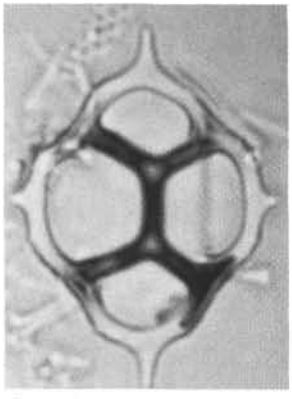

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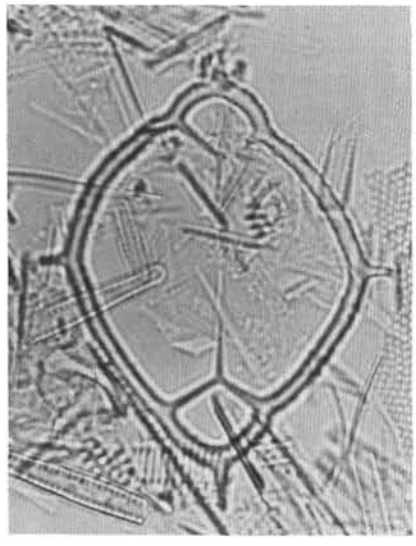

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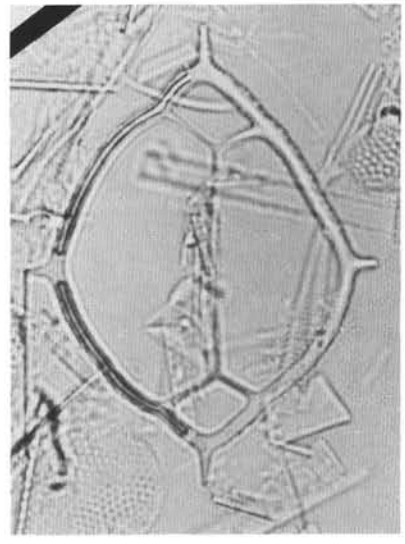

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Plate 9. Silicoflagellates from Site 849 (magnification 850×). **1.** *Dictyocha calida ampliata* Bukry, Sample 138-849B-8H-1, 120–121 cm. **2.** *Dictyocha aculeata aculeata* Lemmermann, Sample 138-849B-1H-1, 120–121 cm. **3.** *Dictyocha perlaevis perlaevis* Frenguelli (thin apical elements), Sample 138-849B-6H-1, 120–121 cm. **4.** *Dictyocha clinata* (Bukry), Sample 138-849B-20X-1, 120–121 cm. **5.** *Dictyocha angulata* Bukry, Sample 138-849B-15X-1, 120–121 cm. **6.** *Dictyocha perlaevis ornata* Bukry, Sample 138-849B-15X-1, 120–121 cm. **7, 8.** *Dictyocha bisecta delicata* Bukry, Sample 138-849B-16X-1, 120–121 cm.

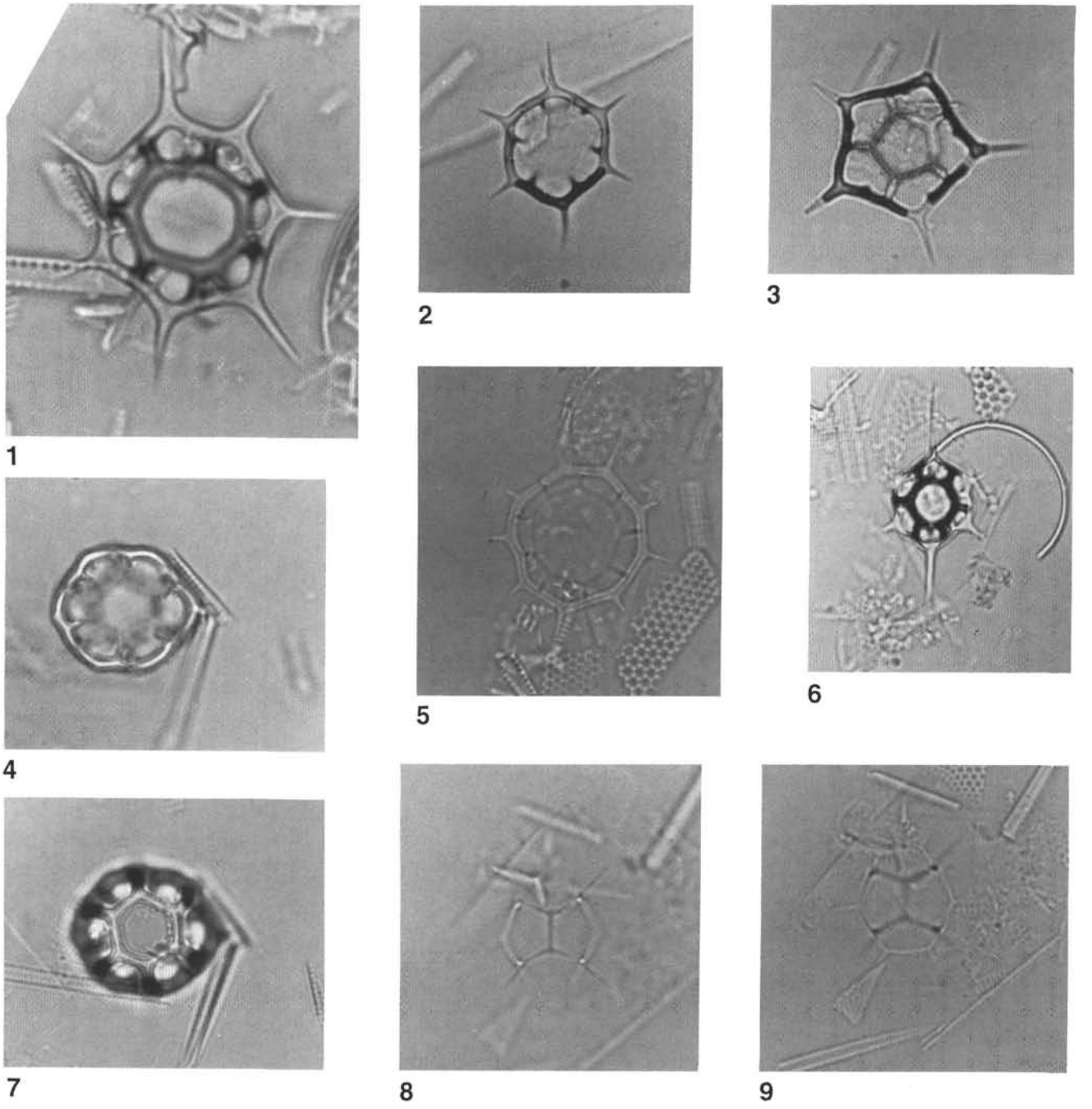

Plate 10. Silicoflagellates from Site 849 (magnification 850×). **1.** *Distephanus boliviensis* (Frenguelli), Sample 138-849B-25X-1, 120–121 cm. **2.** *Distephanus speculum tenuis* Bukry, Sample 138-849B-27X-1, 120–121 cm. **3.** *Distephanus quinquangellus* Bukry and Foster, Sample 138-849B-8H-1, 120–121 cm. **4, 5.** *Distephanus xenus* Bukry, Sample 138-849B-20X-1, 120–121 cm; (4) basal ring in focus, (5) apical ring in focus; **6.** *Distephanus pulchra* (Schiller), Sample 138-849B-2H-1, 120–121 cm. **7.** *Distephanus speculum speculum* (Ehrenberg), Sample 138-849B-15X-1, 120–121 cm. **8, 9.** Unidentified silicoflagellate (or radiolarian fragment?), Sample 138-849B-3H-4, 120–121 cm; (8) high focus, (9) low focus.