23. SILICOFLAGELLATE AND COCCOLITH STRATIGRAPHY, DEEP SEA DRILLING PROJECT, LEG 29

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INTRODUCTION

Leg 29 of the Deep Sea Drilling Project, in the southwest Pacific Ocean recovered 215 cores at 10 drilling sites, Sites 275-284 (Figure 1). Light-microscope techniques were used to study the silicoflagellates and coccoliths of 84 selected samples from Sites 275, 278, 280, and 283. An unusual abundance and diversity of silicoflagellates in certain intervals at these sites permits both correlation with other areas and evaluation of the status of biostratigraphy by silicoflagellates.

SILICOFLAGELLATE ZONATION

Silicoflagellate assemblages recovered on DSDP Leg 29 span much of the known stratigraphic record of this group of siliceous phytoplankton and therefore provide important references for the development of biostratigraphic zonation by silicoflagellates. The pre-middle Miocene silicoflagellates of Leg 29 are especially important in establishing a general biostratigraphic zonation. Previous silicoflagellate biostratigraphic models for the Cretaceous to lower Miocene have been based on less abundant and less consecutive samples (Ling, 1972; Bukry and Foster, 1974; Bukry, in press). These zonal systems, and the more detailed ones for the middle Miocene to Pleistocene (Figures 2 and 3) are discussed and related to the silicoflagellate assemblages of Leg 29. A zonal synthesis for the subantarctic is discussed (Figure 4).

Silicoflagellate zonation, unlike the one employed for coccoliths that relies exclusively on occurrence, requires quantitative data and more flexible definition. This is in part due to the less variable form of coccolith species and their greater abundance, which permits more ready recognition of indigenous first and last occurrences. Because of the larger size and dilution of silicoflagellates in siliceous sediment by other more abundant siliceous fossils, they must be counted to help assess the relative proportion of species. Stratigraphically significant presence and absence, at a reasonable degree of precision, has to be established by counts (Mandra, 1968). Then, when preparation inhomogeneity is eliminated, very rare occurrences can be evaluated in terms of possible reworking or mixing during deposition. Abundance trends from nearby samples also help in evaluating these effects. Consistency and abundance of species are generally more significant in silicoflagellate zonation than are absolute first and last occurrences. The apparent skeletal plasticity of silicoflagellate species, reflecting high ecologic responsiveness, also contributes to a need for lowered reliance on first or last occurrences, in favor of full-assemblage analysis and cosmopolitan-trend determination. Part of this necessary caution results from the present lack of multiple successions preventing determination of the regional versus cosmopolitan character of assemblages.

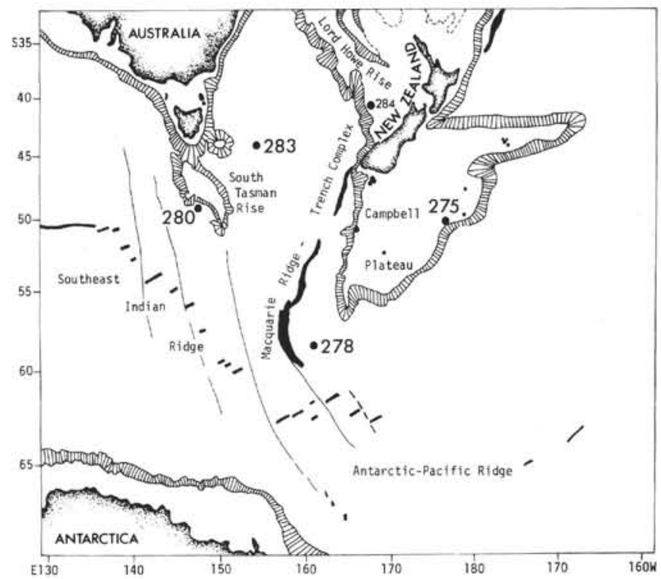

Figure 1. *Sketch map of sites drilled on Deep Sea Drilling Project Leg 29, that are discussed in this chapter.*

Techniques of individual investigators in sample preparation, identification, and counting provide additional reasons for caution in stratigraphic comparison. Variations in individual style have been predicated on different goals of the studies. The present study was done on smear slides of unprocessed sediment. All species identified were counted. Counts were done in bright-field illumination at magnifications of 390× or 500×. Tilted or obscured specimens were examined at 630× or 800× before accepting or dismissing them. Slides were systematically scanned by consecutive traverses using a mechanical stage. Traverses were balanced between thick and thin areas of smear slides for samples where counts of 300 could be achieved in only several traverses. Broken specimens of identifiable species were counted as fractional specimens to reflect the actual composition of the sediment as accurately as possible. For example, three fragments of *Mesocena apiculata*, each bearing an apex, were counted as one specimen of this simple triangular species.

Lyramula furcula Zone (Bukry and Foster, 1974)

The *Lyramula furcula* Zone is distinguished by the common to abundant occurrence of *Lyramula*, a genus that disappeared at the end of the Cretaceous. The

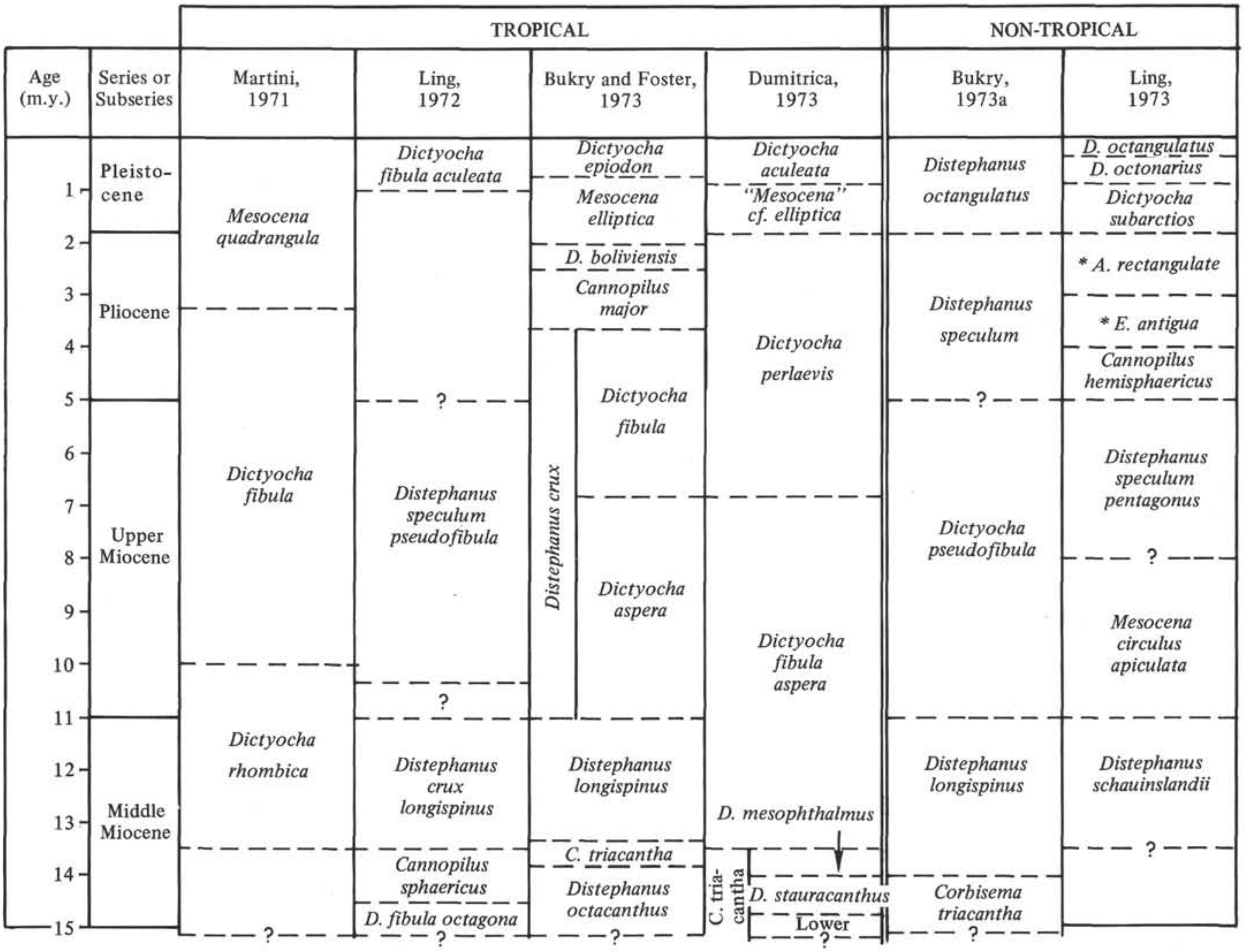

Figure 2. *Comparison of tropical and nontropical middle Miocene to Quaternary silicoflagellate zones in deep-sea sediment. *Ebridian zones.*

diversity of form in the zone of other important genera—*Corbisema* and *Vallacerta*—suggests that when older sections than those presently known are discovered, a sequential first occurrence pattern in these genera may be used for additional zonal refinement.

Current studies suggest considerable paleoecologic variation in *Lyramula furcula* Zone assemblages from various regions. Leg 29 assemblages from Cores 1 and 2 at Site 275 are quite consistent from sample to sample (Figure 5). Simple forms of *Lyramula furcula* predominate. Complex forms having one to three auxiliary spines, such as *Lyramula furcula minor,* constitute less than 5% of the *Lyramula* population and are tabulated as *L. furcula* s. ampl. Large, spineless *Lyramula simplex* is rare. In California, a detailed enumeration of silicoflagellates in the Maestrichtian part of the Moreno Formation shows a similar occurrence of *Lyramula* types in upper samples, whereas complex forms such as *L. furcula minor* predominate in lower samples (Cornell, 1972). Because of this relationship and that at DSDP Site 216 (1°28'N, 90°12'E), the Site 275 samples are considered late Maestrichtian.

A paleoecologic distinction between Site 275 and California assemblages is suggested by the distribution of species of *Vallacerta. Vallacerta tumidula* predominates and *V. hannai* is very rare at Site 275, whereas the California assemblages have *V. hortonii* dominant in the upper and lower parts of the section, *V. hannai* dominant in the middle, and *V. tumidula* missing throughout (Cornell, 1972). In addition to its occurrence at Site 275, *V. tumidula* is presently known from western Siberia and DSDP Site 216 in the eastern Indian Ocean. It is missing in the Arctic Basin where *V. hortonii (V. siderea* syn.?) predominates, not only within *Vallacerta* but also in the assemblage as a whole (Ling et al., 1973).

Corbisema hastata Zone (Bukry and Foster, 1974)

No assemblages of this zone were observed in Leg 29 samples. The absence of the first-occurrence marker

Series or Subseries	Silicoflagellate Zonation Tropical	Cosmopolitan	Nontropical
Quaternary	*Dictyocha epiodon*		*Distephanus octangulatus*
	Mesocena elliptica		*Distephanus octonarius*
Pliocene	*Distephanus boliviensis*		*Distephanus speculum speculum*
	Distephanus boliviensis major		
Upper Miocene	*Dictyocha fibula*		*Dictyocha pseudofibula*
	Dictyocha aspera		
Middle Miocene		*Distephanus longispinus*	
		Corbisema triacantha	
Lower Miocene		*?Distephanus octacanthus*	
		Naviculopsis quadrata	
Oligocene		*Distephanus speculum pentagonus*	
		Naviculopsis biapiculata	
		Dictyocha deflandrei	
Eocene		*Dictyocha hexacantha*	
		Naviculopsis constricta	
Paleocene		*Corbisema hastata*	
Upper Cretaceous		*Lyramula furcula*	

Figure 3. *Correlation of a composite of current tropical and nontropical silicoflagellate zonations. The lack of a thermally determined difference in the Upper Cretaceous and Paleogene may be natural to the fossil group, or may merely reflect a more limited amount of comparative data.*

species *Corbisema hastata* in the late Maestrichtian assemblages at Site 275 reconfirms the Paleocene and younger range of *C. hastata.*

Naviculopsis constricta Zone (Bukry and Foster, 1974)

No assemblages of this zone were observed in Leg 29 samples.

Dictyocha hexacantha Zone (Bukry and Foster, 1974)

Assemblages of this zone are identified in Core 8 at Site 283 by the common occurrence of *Dictyocha hexacantha* and the rare occurrence of *D. deflandrei* (Figure 6). The continuity of these assemblages to the next younger *Dictyocha deflandrei* Zone at Site 283 suggests that the upper part of the *Dictyocha hexacantha* Zone is present at Site 283. However, an uncored interval of 29 meters between Cores 7 and 8 may, in part, account for the sharp reversal in *Dictyocha deflandrei/D. hexacantha* dominance, as well as the smaller size of specimens of *Dictyocha aspera* and *D. fibula* in Core 8.

Dictyocha deflandrei Zone (Bukry and Foster, 1974)

Assemblages of the *Dictyocha deflandrei* Zone, recognized by the consistent occurrence of *Dictyocha deflandrei* above the latest common *Dictyocha hexacantha,* are present at Sites 280 (Hole 280A), and 283. Assemblages are known elsewhere at DSDP Site 274 (69°S, 173°E) in the Southern Ocean (Bukry, in press) and probably in the Oamaru section of New Zealand (Mandra et al., 1973). Although assemblages at these three DSDP sites can be readily assigned to this zone, they also possess other distinctive species suggesting possible division into subzones. The clearest example is the uppermost, or *Dictyocha frenguellii* Subzone (Bukry, in press) at Site 274 where the first common occurrence of *Dictyocha frenguellii* is noted. Two older Oligocene and late Eocene sections of the *Dictyocha deflandrei* Zone lack *D. frenguellii,* but a younger Oligocene section at Site 278, assigned to the *Naviculopsis biapiculata* Zone, does contain small numbers of *D. frenguellii.* In addition, both in the Site 278 *N. biapiculata* Zone and in an unzoned interval below the *N. biapiculata* Zone at DSDP Site 267 (59°16'S, 104°29'E) (Bukry, in press), the occurrence of *Corbisema archangelskiana* and *C. triacantha* indicates the late Oligocene position of the *Dictyocha frenguellii* Subzone.

In the same manner that the *Corbisema* association at DSDP Site 267 and Leg 29 Site 278 suggests the position of the *D. frenguellii* Subzone, the distribution of species of *Naviculopsis* at Sites 280 (Hole 280A) and 283, suggests the position of the *Mesocena apiculata* Subzone above the *Naviculopsis trispinosa* Subzone. The *M. apiculata* Subzone (Bukry, in press) is characterized by the common to abundant occurrence of *Dictyocha deflandrei* and *Mesocena apiculata* at Site 280 (Hole 280A) (Figure 7). *Naviculopsis trispinosa* is an important auxiliary species ranging from 1% to 10%, but *N. constricta* is not present. In the *N. trispinosa* Subzone, *N. constricta* is the predominant species and *N. trispinosa* is sparse but consistent (Figure 6). Because *N. constricta* is the older of the two species in Leg 29 cores and elsewhere (Bukry and Foster, 1974), the *M. apiculata*

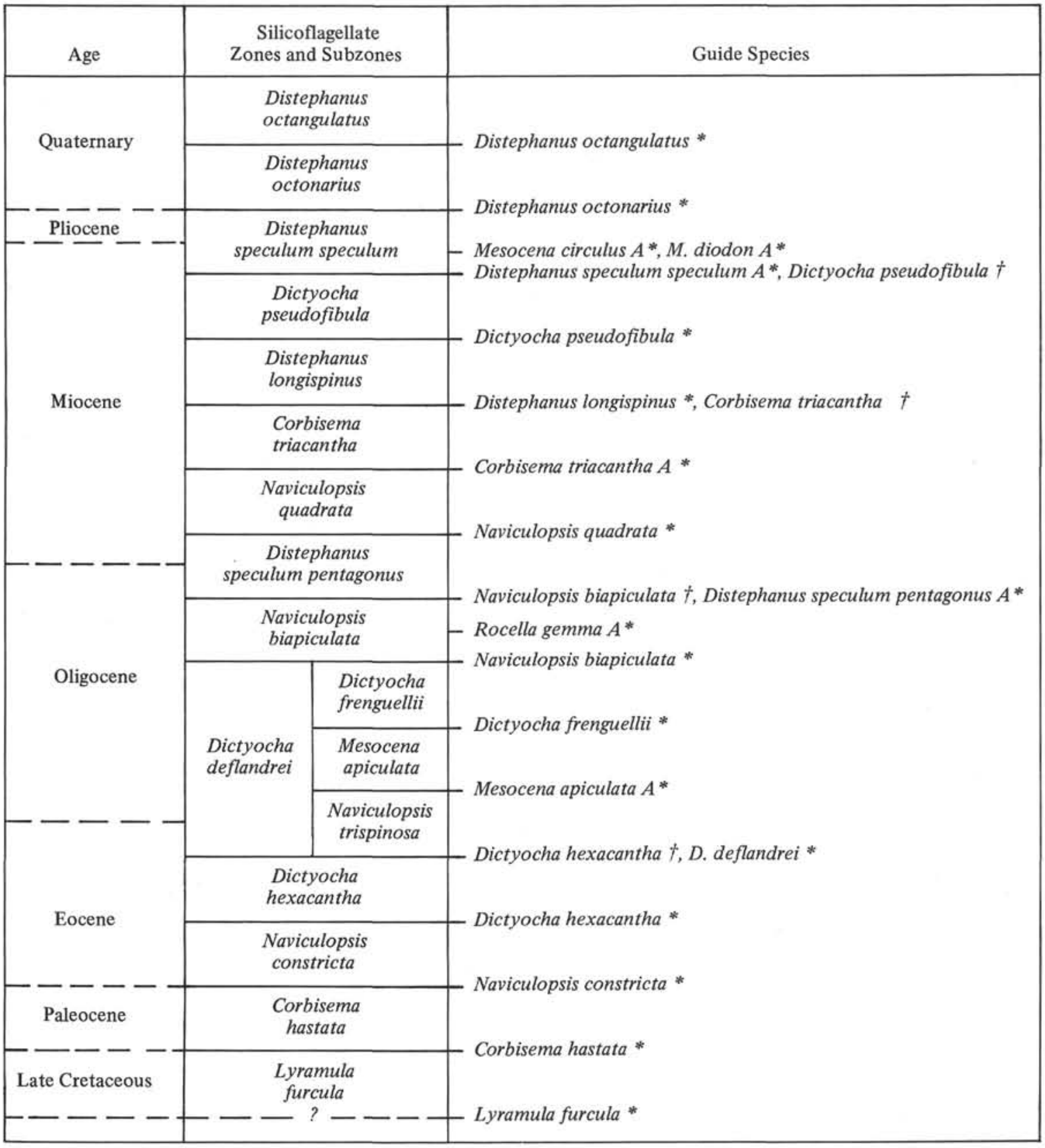

Figure 4. *Silicoflagellate zones for the subantarctic region showing first common occurrence (*), last common occurrence (†), and beginning of acme (A*) of guide species.*

Subzone at Site 280 (Hole 280A) is considered younger than the *N. trispinosa* Subzone at Site 283. The *Naviculopsis trispinosa* Subzone is herein defined as the lower interval of the *Dictyocha deflandrei* Zone, wherein *N. constricta* predominates over *M. apiculata* above the last common occurrence of *Dictyocha hexacantha*. The earliest *N. trispinosa* appears near the base of the *N. trispinosa* Subzone. Cores 3 to 7 from Site 283 provide the type section.

Naviculopsis biapiculata Zone (Bukry, in press)

The *Naviculopsis biapiculata* Zone is present in Cores 30 to 32 at Site 278. It is characterized by common to abundant *Naviculopsis biapiculata* and *Distephanus crux crux*. *Rocella gemma* is predominant in Sample 278-31-2, but is missing in older samples where *Corbisema archangelskiana*, *C. triacantha*, *Dictyocha deflandrei*, *D. frenguellii*, and *Naviculopsis trispinosa* suggest the base of the *N. biapiculata* Zone (Figure 8). *N. trispinosa* does not range above the zone at Site 278. The *Rocella gemma* acme is very brief at Site 278 compared to its longer range at DSDP Site 206 (Hole 206C) lat 32°1′S, long 165°27′E (Bukry, 1973b; Dumitrica, 1973). *Naviculopsis biapiculata* provides a more cosmopolitan zonal marker and is most likely a true silicoflagellate. The *N. biapiculata* Zone is associated with late Oligocene coc-

Age	Zone	Sample	Depth (m)	*Corbisema archangelskiana*	*C. geometrica geometrica*	*C. geometrica lateradiata*	*Cornua aculeifera*	*C. trifurcata*	*Dictyocha quadralta*	*Lyramula furcula* s. ampl.	*L. simplex*	*Vallacerta hannai*	*V. hortonii*	*V. tumidula*	Total Specimens
Late Cretaceous	*Lyramula furcula*	275-1-2, 75 cm	1		6	4				83	1		1	4	300
		275-1-3, 75 cm	3	<1	3	7				78	1		1	10	300
		275-1-4, 75 cm	5	<1	4	6	<1			82	1		<1	6	300
		275-2-1, 75 cm	6		3	6		1		86	1	<1	1	2	300
		275-2-2, 75 cm	8	<1	8	8		1		76			2	4	300
		275-2-3, 25 cm	9	<1	4	12	<1	1		79	1		2	2	300
		275-2-4, 75 cm	11	<1	5	5	<1	1		83	<1		<1	4	300
		275-2-5, 75 cm	13		3	5		1	<1	86	<1	<1	<1	4	300

Figure 5. *Occurrence of Cretaceous silicoflagellates at Site 275 tabulated as percent.*

coliths of the *Sphenolithus distentus* Zone or *S. ciperoensis* Zone in DSDP Site 206 (Hole 206C) and in Alvin 2698 (Bukry, in press).

Distephanus speculum pentagonus Zone (new zone)

The *Distephanus speculum pentagonus* Zone in Cores 28 and 29 at Site 278 is characterized by the common to abundant occurrence of *Distephanus speculum pentagonus, D. crux crux,* and *Mesocena apiculata.* It is herein defined as the interval of abundant *D. speculum pentagonus* above the last common *Naviculopsis biapiculata* and *N. trispinosa,* and below the first common *N. quadrata* and *Distephanus crux hannai.* On the basis of previously known correlations of the zones above and below, the *D. speculum pentagonus* Zone corresponds to the *Triquetrorhabdulus carinatus* Zone and possibly the *Sphenolithus belemnos* Zone of coccoliths.

Although the name *Distephanus speculum pentagonus* Zone has been previously applied to an upper Miocene interval in the North Pacific (Ling, 1973), use of the name for a lower Miocene interval seems more appropriate in the subantarctic region because of the great abundance of the name-giving species. The North Pacific Zone is defined by at least five regional disappearances (at DSDP Sites 183 and 192) of *Mesocena circulus, Dictyocha pseudofibula, Distephanus crux crux, Dictyocha fibula fibula,* and *Distephanus speculum pentagonus.* Therefore, no similarity in definition, stratigraphic position, or locality exists. The *D. speculum pentagonus* Zone is probably equivalent to part of the *Naviculopsis lata* Zone (Martini, 1972), but the guide species for that zone is rare and sporadic at Site 278.

Because of the ecologic sensitivity of silicoflagellates, distinguishing cosmopolitan zones from regional zones will require examination of many more sections. On the basis of the recognition of this zone and of the variation in the *Lyramula furcula* Zone, it appears that silicoflagellates, although biostratigraphically useful at high latitude, have significant regional variation.

Naviculopsis quadrata Zone (Bukry and Foster, 1974)

The *Naviculopsis quadrata* Zone has been recognized in the Atlantic and California by the restricted occurrence of *Naviculopsis quadrata* s. ampl. and *Distephanus crux hannai,* associated with the upper lower Miocene coccolith marker species *Helicopontosphaera ampliaperta.* At Site 278 the coccolith assemblages are less definitive, however, the presence of *N. quadrata* and *D. crux hannai* in the context of the assemblages above and below at Site 278, indicates assignment of Cores 25 to 27 to this zone. For example, certain California samples that contain assemblages of the next higher middle Miocene *Sphenolithus heteromorphus* Zone of coccoliths also contain the silicoflagellates *Corbisema triacantha, Distephanus speculum hemisphaericus,* and common *D. crux crux,* just as do the next higher samples at Site 278 in Cores 21 to 24.

Although a correlation with younger coccoliths is suggested here, the *Naviculopsis quadrata* Zone is essentially equivalent to the *Naviculopsis navicula* Zone (Martini, 1972). The name-giving taxa in the broad sense are considered partly synonymous. There is general stratigraphic agreement that, where present, the *Naviculopsis quadrata-N. navicula* group indicates a later part of the early Miocene than does the antecedent *Naviculopsis lata.*

Corbisema triacantha Zone (Martini, 1971)

A rather cosmopolitan acme of *Corbisema triacantha* in the lower middle Miocene is the principal criterion for identifying this zone. Because the genus *Corbisema* favors warm conditions, this middle Miocene acme corroborates a thermal high (Douglas and Savin, 1973) that seems to be marked worldwide. Following this acme at high and low latitude, *Corbisema* occurs only rarely and sporadically, probably reworked.

Martini's (1972) use of the last occurrence of *Naviculopsis rectangularis* (syn. *N. quadrata* s. ampl.) to

Age	Zone and Subzone	Sample	Depth (m)	Corbisema apiculata	C. bimucronata	C. flexuosa	C. hastata	C. triacantha	Dictyocha aspera aspera	D. aspera martinii	D. deflandrei	D. fibula fibula	D. fibula fornicata	D. hexacantha	D. pentagona	D. fibula perlaevis	Distephanus crux crux	D. speculum pentagonus	D. speculum speculum	Mesocena apiculata	M. oamaruensis oamaruensis	M. oamaruensis quadrangula	Naviculopsis biapiculata s. ampl.	N. constricta s. ampl.	N. cf. foliacea	N. trispinosa	Total specimens
Eocene or Oligocene	*Dictyocha deflandrei* Zone	283-3-1, 30 cm	29	4	1		4	3	4	1	4	7		2		1	3		<1	11	1	1	5	47		1	300
		283-5-1, 44 cm	86	1		<1	1	10	1	1	9	11					3	1		3	<1		1	54		2	300
		283-5-2, 90 cm	88	3			3	9	3	3	7	5		<1			3		<1	3		1	1	55	2	3	300
Late Eocene	*Naviculopsis trispinosa* Subzone	283-6-1, 125 cm	124	2		1	7	7	4	1	18	2		<1			3	<1		2			<1	50	1	1	300
		283-6-2, 86 cm	125	<1	<1		4	7	1	3	12	2		<1		<1	5	<1		1	<1	<1		61	1	1	300
		283-7-1, 32 cm	153	2		1	2	3	2		4	8					4	1		2	1	<1	3	68	<1	<1	300
		283-7-6, 125 cm	159	3		1	4	7	3		4	8		1	<1	<1	8	1		5		<1		55		<1	300
Middle or late Eocene	*Dictyocha hexacantha* Zone	283-8-1, 75 cm	191	9		3	1	3	8	<1		4	<1	22			4			6	1	1	1	37			300
		283-8-3, 75 cm	194	1			<1	3	11	<1	3	19	<1	23	1		3			2	<1	<1	3	24	1		300

Figure 6. Occurrence of Eocene and Eocene or Oligocene silicoflagellates at Site 283 tabulated as percent.

define the base of the *Corbisema triacantha* Zone in Europe is a good choice based on the evolutionary record of *Naviculopsis*. However, in practice, the cosmopolitan acmes of *Corbisema triacantha* and *Distephanus speculum hemisphaericus* provide more evident markers in California and in the subantarctic region.

Because of deterioration in the preservation of silicoflagellate assemblages in the middle Miocene at Site 278, *Corbisema triacantha* is noted in only one sample; however, auxiliary marker species such as *Distephanus speculum hemisphaericus* help to confirm assignment of Cores 21 to 24 to this zone.

Distephanus longispinus Zone (Bukry and Foster, 1973)

No assemblages of this zone were recognized in Leg 29 samples.

Dictyocha pseudofibula Zone (Bukry, 1973a)

No assemblages of this zone were recognized in Leg 29 samples.

The *Dictyocha pseudofibula* Zone is partly equivalent to the warm-water *Dictyocha fibula* Zone (Martini, 1971), which is associated with the upper Miocene *Discoaster quinqueramus* Zone of coccoliths in California.

Distephanus speculum speculum Zone (Bukry, 1973a)

The *Distephanus speculum speculum* Zone was defined for cool-water silicoflagellate assemblages characterized by great abundances of *Distephanus speculum speculum* and related *D. speculum minutus*, occurring between the latest common *Dictyocha pseudofibula* and the earliest *Distephanus octangulatus*. It is recognized in Cores 8 to 14 at Site 278 above a barren interval between Cores 14 and 21, and below the first common occurrence of *Distephanus octonarius* which is a marker for the next younger *Distephanus octonarius* Zone (Ling, 1973) here and in the North Pacific. An abundant occurrence of *Mesocena circulus* in Cores 9 and 10 is indicative of an interval near the Miocene-Pliocene boundary at high latitude (Stadum and Burckle, 1973). Although this stratigraphic evidence is less diagnostic at low latitude (Bukry and Foster, 1973), it does provide a convenient marker at Site 278 suggesting that this acme is widespread in the Southern Ocean and may be used to identify a *Mesocena circulus* Subzone. In addition, a general limitation of *Mesocena diodon*, at low to middle latitudes, to the Miocene suggests that the lower part of the interval assigned to the *Distephanus speculum speculum* Zone (the *M. circulus* Subzone) at Site 278 is late Miocene. Additional subantarctic sections will be required to substantiate this.

As a result of the recognition of the *Distephanus octonarius* Zone at Site 278, the upper boundary of the *D. speculum speculum* Zone is herein emended to be the first common occurrence of *Distephanus octonarius*.

Distephanus octonarius Zone (Ling, 1973)

The *Distephanus octonarius* Zone was defined in the North Pacific as the interval marked by the last *Dictyocha subarctios* at the base, and the last *Distephanus octonarius* at the top. *D. subarctios* was not recognized in

Age	Zone and Subzone	Sample	Depth (m)	*Corbisema apiculata*	*C. hastata* s. ampl.	*C.* sp.	*Dictyocha deflandrei*	*D. deflandrei* (trigonal)	*D. deflandrei* (pentagonal)	*D. deflandrei* (hexagonal)	*D.* aff. *D. fibula fibula*	*Distephanus crux crux*	*D. speculum binoculus*	*D. speculum pentagonus*	*D. speculum speculum*	*Mesocena apiculata*	*M. oamaruensis oamaruensis*	*M. oamaruensis quadrangula*	*Naviculopsis biapiculata* s. ampl.	*N. trispinosa*	Total specimens
Early? Oligocene	*Dictyocha deflandrei* Zone *Mesocena apiculata* Subzone	280A-1-1, 107 cm	38	6			68		1		<1	14		1	2	7				<1	300
		280A-1-3, 75 cm	41	1	<1		54				3	16				23	<1			2	300
		280A-2-2, 75 cm	56	2			55		1		1	22		1		7			1	10	135
		280A-3-2, 75 cm	75	1			56			2	<1	21	<1	1	5	3	<1	1	<1	3	280
		280A-3-4, 75 cm	78	3	1	<1	46		1	<1		27		1	5	8	<1	<1		8	300
		280A-4-4, 75 cm	86	2	2		33		1	<1		20		2	3	30	<1	<1	2	8	300
		280A-5-1, 75 cm	92	7	2		27		<1		<1	15		4	<1	31	<1	1		10	285
		280A-6-1, 130 cm	102	7	5		27		<1		1	20		5	2	26	1	1		3	300
		280A-6-2, 80 cm	103	10	3		38			<1	1	16		2	3	19	1	1	<1	6	300
		280A-7-1, 115 cm	121	9	4		31	<1			<1	23		<1	3	22	1	<1	1	4	300
		280A-7-4, 75 cm	125	13	1		32		<1		4	25		1	5	16		1	2	1	303

Figure 7. *Occurrence of Oligocene silicoflagellates at Hole 280A tabulated as percent.*

Leg 29 samples. The zone is characterized by the common occurrence of *D. octonarius* (syn. *Distephanus polyactis,* 8-spined) in the early Pleistocene. The boundaries are herein emended to the first common *D. octonarius* at the base and the first common *Distephanus octangulatus* at the top. When available, first-occurrence markers are believed to offer the best means of testing an extraregional zonation. Because both *D. subarctios* and *D. octangulatus* are missing at Site 278, the common occurrence of *D. octonarius* (8- to 11-spined) in Cores 6 and 7 is used to recognize the zone.

The *Distephanus polyactis* specimens tabulated for Core 6 at DSDP Site 173 (Bukry, 1973a) are 8-spined and can be referred to *Distephanus octonarius,* thus placing the assemblage in the *Distephanus octonarisus* Zone. Core 6 is assigned to the base of the early Pleistocene North Pacific Diatom Zone III (Schrader, 1973). This would corroborate Ling's (1973) age determination for the *D. octonarius* Zone and is consistent with the biostratigraphy at Site 278.

Distephanus octangulatus Zone (Bukry, 1973a)

The name-giving species which provides a convenient guide to this zone in the North Pacific is not recognized in DSDP Leg 29 samples, but *Octactis pulchra,* a Pleistocene marker in the equatorial Pacific, is present in Cores 3 and 4 at Site 278. *Distephanus octonarius* (syn. *Distephanus polyactis,* 8-spined), an early Pleistocene marker in the North Pacific, is common below in Cores 6 and 7. The assemblages of Cores 1 to 5 are so dominated by *Distephanus speculum speculum* having both large and small apical rings, that assignment to this zone is circumstantial and therefore queried.

COCCOLITH STRATIGRAPHY

Site 275 (lat 50°26.34'S, long 176°18.99'E, depth 2827 m)

Site 275 is on the southeast slope of the Campbell Plateau, south of New Zealand. The only coccoliths present in eight samples from Cores 1 and 2 (0-15 m) are rare Neogene drilling contaminants, such as *Cyclococcolithina leptopora.*

Site 278 (lat 56°33.42'S, long 160°04.29'E, depth 3698 m)

Site 278 is in the Emerald Basin between the Campbell Plateau and Macquarie Rise. Coccoliths are common to abundant in 29 of 41 samples examined from Cores 1 to 33 (0-424 m), but specimens are strongly etched, and diversity is very low. Coccoliths are meager or absent in 12 samples, especially in Cores 27 to 29 (339-358 m).

Sample 278-1-2, 75 cm (2 m) contains abundant *Cyclococcolithina leptopora, ?Emiliania huxleyi,* and *Helicopontosphaera kamptneri,* in addition to meager *Coccolithus pelagicus, C. pliopelagicus,* and *Gephyrocapsa ericsonii.* This assemblage is assigned to the late Pleistocene or Holocene *Emiliania huxleyi* Zone. Cores 3 to 5 (111-139 m) are considered Quaternary, although diversity is low. *Cyclococcolithina leptopora* is abundant throughout (Burns, 1972), *Coccolithus pelagicus* is common; in Core 3 *Emiliania ovata* is common; and rare *Gephyrocapsa oceanica* is present in Core 5.

Samples from Core 9 (168-177 m) contain a coccolith hash dominated by placolith species *Coccolithus pelagicus, Cyclococcolithina leptopora, C. macintyrei,* and *Reticulofenestra pseudoumbilica.* Rare specimens of *Discoaster* sp. cf. *D. prepentaradiatus, D. variabilis,* and *Sphenolithus neoabies* suggest a probable late Miocene or early Pliocene age. Coccolith assemblages in Cores 10 to 14 (177-225 m) could be middle or late Miocene. They are predominated by *Reticulofenestra pseudoumbilica* s. ampl. Rare specimens of *Cyclococcolithina macintyrei* in these cores indicate the assemblages are no older than middle Miocene.

Cores 17 to 23 (244-310 m) contain abundant *Cyclicargolithus floridanus* and rare to meager *Discoaster deflandrei,* suggesting the early Miocene, because late Oligocene guide species *Chiasmolithus altus* and *Dictyococcites bisectus* are lacking. The early

Age	Zone	Sample	Depth (m)	*Corbisema archangelskiana*	*C. triacantha*	*Dictyocha deflandrei*	*D. frenguellii*	*Distephanus boliviensis major*	*D. crux crux*	*D. speculum hemisphaericus*	*D. speculum pentagonus*	*D. speculum speculum*	*Mesocena apiculata*	*Naviculopsis biapiculata* s. ampl.	*N.* cf. *trispinosa* (no apical bar)	*N. trispinosa*	*Distephanus speculum binoculus*	*D. speculum quintus*	*Mesocena oamaruensis oamaruensis*	*Naviculopsis lata*	*Rocella gemma*	*Distephanus crux hannai*	*Dictyocha aspera*	*D. fibula fibula*	*Cannopilus sphaericus*	*Corbisema flexuosa*	*Dictyocha pseudofibula*	*Naviculopsis quadrata* s. ampl.	*Pseudorocella corona*	*Mesocena circulus*	*Distephanus polyactis*	*Mesocena diodon*	*M. triangula*	*Octactis pulchra*	*Distephanus speculum variants*	Total specimens
Quaternary	*Distephanus octangulatus?*	278-1-2, 75 cm	2								<1	99												<1											<1	300
		278-3-2, 75 cm	113									99																			1			<1		300
		278-4-1, 75 cm	121								1	91					1				1			2							1			6		200
		278-5-5, 75 cm	136									97												3							<1					200
	Distephanus octonarius	278-6-5, 75 cm	146									92																			8					300
		278-7-5, 75 cm	155					<1			<1	87									<1			<1							12		<1			300
Pliocene or late Miocene	*Distephanus speculum speculum*	278-8-2, 75 cm	160								1	99																								300
		278-9-2, 75 cm	170								2	40												1						41		14	2			100
		278-9-5, 75 cm	174							1	2	52																		28	1	16				100
		278-10-5, 75 cm	184					1			37	37									1		5	19												75
		278-14-5, 75 cm	222						8		36	8																		48						50
Middle Miocene	*Corbisema triacantha*	278-21-2, 114 cm	284		3	1		5	15	1	5	57	5	1			4				4						1	1								140
		278-23-2, 145 cm	302			<1		2	20	6	2	40	27				1				2					<1										300
		278-24-4, 75 cm	315					2	15	6	3	39	27							<1	4							3								300
Early Miocene	*Naviculopsis quadrata*	278-25-2, 75 cm	321						14	1	5	38	17	1							6	1			2			11	4							100
		278-26-6, 75 cm	337					1	15	2	8	29	25							1	6	9					1	3								100
		278-27-4, 96 cm	344						2	2	1	16	42				<1				<1	33			1	2										300
Early Miocene or late Oligocene	*Distephanus speculum pentagonus*	278-28-1, 75 cm	348			1	<1	1	28		42	6	22				<1							<1												300
		278-28-5, 75 cm	354					1	24		53	4	16							2																300
		278-29-2, 75 cm	359					3	1	1	25	7	60				<1	2		1																300
		278-29-4, 30 cm	362			<1			6	3	25	11	53	<1			<1	1		1	<1															300
Late Oligocene	*Naviculopsis biapiculata*	278-30-1, 113 cm	378					1	36		1	10	37	13							1		<1													300
		278-31-1, 72 cm	396			<1		3	20	2	39	6	12	13	<1	<1	1	<1			3	2														600
		278-31-2, 75 cm	397	<1		<1	2		5	2	7	7	1	20					<1	1	54															300
		278-31-3, 75 cm	398	1			10		63		4	12	1	6		2	<1	2																		400
		278-32-5, 75 cm	412	1	4	2	7	1	9		3	4	9	33	9	17	1																			100

Figure 8. *Occurrence of late Oligocene to Quaternary silicoflagellates at Site 278 tabulated as percent.*

Miocene diatom *Raphidodiscus marylandicus* is present in Core 20 (272-282 m).

Cores 24 and 25 (310-329 m) contain an ooze of *Coccolithus pelagicus* and its rim fragments. Rare auxiliary species such as *Cyclicargolithus floridanus, Discoaster deflandrei,* and *Sphenolithus* sp. cf. *S. dissimilis* support an early Miocene age in the context of adjacent cores.

Definitive Oligocene assemblages, identified by the common occurrence of *Chiasmolithus altus* and *Dictyococcites bisectus,* in addition to *Cyclicargolithus floridanus* and *Discoaster deflandrei,* are present in Cores 31 to 33 (396-424 m).

Site 280 (lat 48°57.44'S, long 147°14.08'E, depth 4181 m)

Site 280 is south of the South Tasmanian Ridge. Only 3 of 14 samples from Cores 1 to 8 (38-149 m) contain any coccoliths. Sample 280A-1-1, 107 cm (38 m) contains only sparse *Cyclicargolithus floridanus,* a cosmopolitan and long-ranging middle Tertiary species. Diagnostic coccoliths from Core 5 (92-101 m) indicate an early or early late Oligocene age equivalent to the *Helicopontosphaera reticulata* Zone, or *Sphenolithus predistentus* Zone of low latitude. An absence or paucity of low-latitude taxa such as *Discoaster* and *Sphenolithus* prevents precise correlation. Species present in Core 5 include *Chiasmolithus altus, C. expansus, C. oamaruensis, Coccolithus eopelagicus, C. pelagicus, Dictyococcites bisectus, D. scrippsae, ?Discoaster tanii* (fragment), *Reticulofenestra gartneri, ?R.* sp. cf. *R. hillae,* and *Transversopontis ponticulus.*

Site 283 (lat 43°54.60'S, long 154°16.96'E, depth 4756 m)

Site 283 is in the central Tasman Sea east of Tasmania. Coccoliths occur in only four of nine samples examined from Cores 3 to 8 (29-200 m). Late Eocene assemblages of the *Discoaster barbadiensis* Zone, *Reticulofenestra reticulata* Subzone, are indicated in Core 7 (153-162 m) by the occurrence of *Chiasmolithus oamaruensis, Coccolithus eopelagicus, C. pelagicus, Dictyococcites bisectus, D. scrippsae, Discoaster barbadiensis, D. saipanensis, Reticulofenestra hillae, R. reticulata, R. umbilica, Sphenolithus moriformis,* and *Transversopontis* sp. Placolith species greatly outnumber the few specimens of *Discoaster* and *Sphenolithus. Coccolithus formosus,* a common species in low-latitude assemblages of this age, is absent.

Samples from Core 6 (124-134 m) contain similar assemblages, although specimens are more etched and *Zygolithus dubius* is present, also suggesting Eocene age (Edwards, 1971).

SYSTEMATIC PALEONTOLOGY OF SILICOFLAGELLATES

Genus CORBISEMA Hanna, 1928

Corbisema apiculata (Lemmermann)
(Plate 1, Figure 2)

Dictyocha triacantha apiculata Lemmermann, 1901, Deutsch Bot. Ges., Ber., v. 19, p. 259, pl. 10, fig. 19, 20.
Dictyocha triacantha apiculata Lemmermann, Schulz, 1928 (in part), Bot. Archiv., v. 21, no. 2, p. 247, fig. 27, 28, 29a.
"Corbisema" apiculata (Lemmermann) Hanna, 1931, Mining Calif., v. 27, no. 2, p. 198, pl. D., fig. 2.

Remarks: Excellent photographs of this structurally central form of the genus *Corbisema* are presented in Ling (1972). This species is common through the Oligocene of Leg 29 and is characterized by equilateral shape, short radial spines, and slightly indented sides. It is distinguished from *Corbisema triacantha* by its consistently larger size and proportionally narrower body ring.

Corbisema archangelskiana (Schulz)

Dictyocha triacantha archangelskiana Schulz, 1928, Bot. Archiv., v. 21, no. 2, p. 250, fig. 33a-c; fig. 77, 78.
Corbisema archangelskiana (Schulz), Bukry, in press, Initial Reports of the Deep Sea Drilling Project v. 28, pl. 1, fig. 2, 3; pl. 3, fig. 4.

Remarks: This species is distinguished mainly by the elongate and bluntly terminating apices of the body spine. The slightly rounded blunt apices may or may not possess a short spine. Oligocene specimens at Site 278 are more typical than Cretaceous specimens at Site 275, which resemble *Corbisema geometrica lateradiata.*

Corbisema bimucronata Deflandre
(Plate 1, Figure 3)

Corbisema bimucronata Deflandre, 1950, Microscopie, v. 2, p.63/82, fig. 174-177.
Corbisema bimucronata Deflandre, Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 153, pl. 24, fig. 1.
Corbisema bimucronata Deflandre, Bukry and Foster, 1974, U.S. Geol. Surv. J. Res., v. 2, no. 3, fig. 1a.

Remarks: The rare Oligocene specimens of DSDP Leg 29 do not have as pronounced pikes at the body-ring apices, as do Eocene specimens.

Corbisema flexuosa (Stradner) n. comb.
(Plate 1, Figures 4, 5)

Corbisema triacantha flexuosa Stradner, 1961, Erdöl Kohle, v. 14, no. 2, p. 89, pl. 1, fig. 1-8.
Corbisema triacantha flexuosa Stradner, Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 157, pl. 24, fig. 14-17.

Remarks: This small angular species is characterized by a distinctly indented equal-sided body ring and a broad triangular apical plate. The apical plate attachment divides each side of the body ring unequally. Spines at the body-ring apices are long. The combination of these characters serve to distinguish *Corbisema flexuosa* from *C. triacantha.*

Corbisema geometrica geometrica Hanna
(Plate 1, Figures 6, 7)

?*Dictyocha triacantha inermis* Lemmermann, 1901, Deutsch Bot. Ges., Ber., v. 19, p. 259, pl. 10, fig. 21.
Corbisema geometrica Hanna, 1928, J. Paleont., v. 1, no. 4, p. 261, pl. 41, fig. 1, 2.

Remarks: This large species has a smooth, rounded body ring that can be circular or trilobate. The apical structure generally features a triangular, hyaline, central plate, but three apical bars can also have a simple juncture. Specimens with three radial spines on the body ring are present, but not common at Site 275. This species is primarily Late Cretaceous, although Paleocene and Eocene specimens have been reported.

Corbisema geometrica lateradiata (Schulz) n. comb.
(Plate 1, Figure 8)

Dictyocha triacantha apiculata late-radiata Schulz, 1928, Bot. Archiv., v. 21, no. 2, p. 281, fig. 73.
Corbisema geometrica apiculata Jousé, 1949, fide Loeblich and others, 1968, Geol. Soc. Am. Mem., p. 76, pl. 5, fig. 15.

Remarks: This small- to medium-sized species was described from the Upper Cretaceous of Poland and is a consistent member of the Cretaceous assemblages at Site 275. It has a large triangular apical plate similar to *Corbisema geometrica geometrica,* but is distinguished by a less-rounded, more triangular outline. Spines at the body-ring apices are a consistent feature.

Corbisema hastata hastata (Lemmermann)
(Plate 1, Figure 9)

Dictyocha triacantha hastata Lemmermann, 1901, Deutsch Bot. Ges., Ber., v. 19, p. 259, pl. 10, fig. 16, 17.

Dictyocha triacantha hastata Lemmermann, Schulz, 1928 (in part), Bot. Archiv., v. 21, no. 2, p. 249, fig. 31a, b.

Dictyocha triacantha hastata Lemmermann, Glezer, 1966 (in part), Cryptogamic plants USSR, v. 7, p. 231, pl. 6, fig. 6; pl. 7, fig. 1, 3, 5, 7, 8; pl. 31, fig. 9.

Corbisema hastata (Lemmermann), Bukry, 1973, Initial Reports of the Deep Sea Drilling Project, v. 21, p. 892, pl. 1, fig. 1.

Remarks: Although originally described as Holocene subspecies this isosceles form, having a distinctive indented basal side, is most characteristic of the early Paleocene (Glezer, 1966; Bukry, 1973b). The radial spines at the end of the basal side are typically aligned with the long sides of body ring. *Corbisema hastata hastata* is larger and less rounded than *C. hastata minor.* Although it ranges into the Oligocene of DSDP Leg 29, it is much less abundant than *C. hastata minor* above the Paleocene. For purposes of tabulation, both subspecies are enumerated as *Corbisema hastata* for Leg 29.

Corbisema hastata minor (Schulz) n. comb.
(Plate 1, Figure 10)

Dictyocha triacantha apiculata minor Schulz, 1928 (in part), Bot. Archiv., v. 21, p. 249, fig. 29b.

Dictyocha triacantha hastata Schulz, 1928 (in part), ibid., p. 249, fig. 31c.

Dictyocha triacantha hastata Lemmermann, Glezer, 1966 (in part), Cryptogamic plants USSR, v. 7, p. 231, pl. 6, fig. 7, 8; pl. 7, fig. 2, 4, 6; pl. 31, fig. ?8.

Corbisema hastata (Lemmermann) Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 155, pl. 24, fig. 5.

Remarks: This subspecies is distinguished from *Corbisema hastata hastata* by having an essentially straight basal side to the rounded isosceles outline. The two spines at the ends of the basal side are almost perpendicular to this side. *Corbisema hastata minor* is distinctly smaller than *C. hastata hastata* and much more common in the Eocene and Oligocene than is *C. hastata hastata.*

Corbisema inermis (Glezer) n. comb.

Not *Dictyocha triacantha inermis* Lemmermann, 1901, Deutsch. Bot. Ges., Ber., v. 19, p. 259, pl. 10, fig. 21.

Dictyocha triacantha inermis Lemmermann, Schulz, 1928, Bot. Archiv., v. 21, no. 2, pl. 248, fig. 30b.

Dictyocha triacantha inermis Lemmermann *inermis* Glezer, 1966, Cryptogamic plants USSR, v. 7, p. 230, pl. 8, fig. 1, 2; pl. 32, fig. 1.

Corbisema inermis (Lemmermann) Dumitrica, 1973, Initial Reports of the Deep Sea Drilling Project, v. 21, p. 845, pl. 12, fig. 7-9.

Remarks: The regular crenulation of the large, thick body ring of this Paleocene species is distinctive. Excellent photographs by Dumitrica (1973) show a variety of forms assigned to this species at DSDP Site 208. Although not present at Leg 29 sites, forms resembling *C. inermis* occur in the Paleocene *Corbisema hastata* Zone at DSDP Site 214 (lat 11°20'S, long 88°43'E). These specimens were tabulated as *Corbisema geometrica,* because they are much less crenulate than the specimens at DSDP Site 208.

Corbisema triacantha (Ehrenberg)
(Plate 1, Figures 11, 12)

Dictyocha triacantha Ehrenberg, 1844, König. Preuss. Akad. Wiss. Berlin, Ber. Verh., p. 80.

Corbisema triacantha (Ehrenberg), Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 156, pl. 24, fig. 8-13.

Remarks: Forms resembling *Corbisema triacantha* are known from Paleocene to Holocene strata, but the species in a strict sense is most common in upper Oligocene to middle Miocene strata. A short-spined variety having a rounded body ring—*Corbisema triacantha minor*—has been distinguished (see Ling, 1972). The ranges of the two varieties appear to be similar, and they are all listed as *Corbisema triacantha* for DSDP Leg 29.

Genus DICTYOCHA Ehrenberg, 1837

Dictyocha aspera aspera (Lemmermann)
(Plate 2, Figures 2-4)

Dictyocha fibula aspera Lemmermann, 1901, Deutsch Bot. Ges., Ber., v. 19, p. 260, pl. 10, fig. 27, 28.

Dictyocha aspera (Lemmermann) Bukry and Foster, 1973, Initial Reports of the Deep Sea Drilling Project, v. 16, p. 826, pl. 2, fig. 4-6.

Dictyocha aspera martinii n. ssp.
(Plate 2, Figures 5-8)

Description: *Dictyocha aspera martinii* has elevated spines at the distal ends of the apical struts that extend beyond and above the margin of the basal ring. The apical bar is transverse to the long axis of the typically rhomboid basal ring.

Remarks: *Dictyocha aspera martinii* is distinguished from *D. aspera aspera* by the apical strut spines. It is distinguished from other taxa having apical strut spines, such as *Dictyocha fibula formicata, D. frenguellii, D. hexacantha,* and *D. spinosa,* by its transverse apical bar.

Size: Basal-ring length 30-70μ; holotype 30μ.

Holotype: USNM 207364 (Plate 2, Figure 6).

Paratypes: USNM 207365 to 207367.

Type locality: South Tasman Sea, Sample 283-8-1, 75 cm (191 m).

Dictyocha deflandrei Frenguelli ex Glezer
(Plate 2, Figures 9-13)

Dictyocha deflandrei Frenguelli, 1940, Rev. Mus. La Plata, ser. 2, v. 2, Paleontol., no. 7, p. 65, fig. 14a-d.

Dictyocha deflandrei Frenguelli ex Glezer, 1966, Cryptogamic plants USSR, v. 7, p. 244.

Dictyocha deflandrei completa completa Glezer, 1966, ibid., p. 244, pl. 12, fig. 14, 15.

Dictyocha deflandrei completa producta Glezer, 1966, ibid., p. 245, pl. 12, fig. 17-19.

Dictyocha deflandrei deflandrei Glezer, 1966, ibid., p. 244, pl. 12, fig. 13, 16; pl. 32, fig. 4.

Dictyocha deflandrei Frenguelli ex Glezer, Bukry, in press, Initial Reports of the Deep Sea Drilling Project, v. 28 pl. 1, fig. 7-10.

Remarks: Pentagonal and hexagonal variants of this basically quadrate species are noted at DSDP Site 280 (Hole 280A). In deep-sea cores the species ranges from late Eocene to late Oligocene and is typically distinguished by a square apical plate.

Dictyocha fibula fibula Ehrenberg
(Plate 3, Figures 2, 3)

Dictyocha fibula Ehrenberg, 1839, fide Loeblich et al., 1968, Geol. Soc. Am. Mem. 106, p. 90, pl. 9, fig. 7-12.

Dictyocha fibula Bukry and Foster, 1973, Initial Reports of the Deep Sea Drilling Project, v. 16, pl. 3, fig. 12.

Remarks: Both rhomboid and smooth elliptic shapes are indicated for the basal ring of *Dictyocha fibula fibula* by Ehrenberg (see Loeblich et al., 1968; Ehrenberg, 1854). All but one of the original drawings has the apical bar along the long axis of the basal ring. This concept for *D. fibula fibula* has been in use for over 100 years and should therefore be conserved for nomenclatural stability. A recent suggestion to alter the species concept of *D. fibula fibula* (Dumitrica, 1973) is not used in this study.

The axial alignment of the apical bar may not be obvious in specimens with equilateral frames. For such specimens, the length of the radial spines can be used as an auxiliary criterion. For such specimens the longer pair of radial spines will be aligned with the apical bar. *D. fibula fibula* is distinguished from *Hannaites quadrina* (Plate 3, Figure 1) by its narrow pointed spines.

Dictyocha fibula formicata n. ssp.
(Plate 3, Figures 7, 8)

Description: This subspecies of the *Dictyocha fibula* group has elevated spines at the distal ends of the apical struts that extend beyond and above the margin of the basal ring.

Remarks: *Dictyocha fibula formicata* is distinguished from other silicoflagellates having distal extensions of the apical struts (lateral rods) and by the presence and axial alignment of an apical bar. *Dictyocha aspera martinii* has a transverse apical bar; *Dictyocha frenguellii* a modified apical plate; *Dictyocha spinosa* a simple, central, strut juncture; and *Dictyocha hexacantha* a simple, central, strut juncture that may bear a vertical spine.

Size: Basal-ring length 30-40μ; holotype 30μ.

Holotype: USNM 207369 (Plate 3, Figure 8).

Paratype: USNM 207370.

Type locality: South Tasman Sea, Sample 283-8-1, 75 cm (191 m).

Dictyocha fibula perlaevis (Frenguelli) n. comb.
(Plate 3, Figure 5)

Dictyocha perlaevis Frenguelli, 1951, Physis (Buenos Aires), v. 20, p. 279, fig. 4b, c.
Dictyocha fibula Ehrenberg, Bukry and Foster, 1973, Initial Reports of the Deep Sea Drilling Project, v. 16, pl. 3, fig. 1.
Dictyocha perlaevis Frenguelli, Dumitrica, 1973, ibid., v. 21, pl. 3, fig. 9; pl. 4, fig. 1, 2.

Remarks: This species has the same structural elements as *Dictyocha fibula fibula.* It is distinguished from *D. fibula fibula* by the pronounced four-lobed basal ring, more obtuse angle between apical bar and supporting struts, larger size, and relatively shorter radial spines. The most obvious distinction is the lobed outline and simple apical bar; compare the type specimen to *Dictyocha fibula fibula* (Ehrenberg, 1854, pl. 18, fig. 54b, c, 55; pl. 19, fig. 43; pl. 20, fig. 45; or pl. 33 [16], fig. 10).

Dictyocha frenguellii Deflandre
(Plate 3, Figures 10, 11)

Dictyocha frenguellii Deflandre, 1950, Microscopie, v. 2, p. 194, fig. 188-193.
Dictyocha frenguellii Deflandre *frenguellii* Glezer, 1966, Cryptogamic plants USSR, v. 7, p. 240, pl. 11, fig. 9.
Dictyocha frenguellii Deflandre, Bukry, in press, Initial Reports of the Deep Sea Drilling Project v. 28, pl. 1, fig. 11, 12.

Remarks: This small, rounded to quadrate species has a modified apical plate that is generally not as large or well defined as that of *Dictyocha deflandrei.* Spines at the distal ends of the apical struts extend beyond and above the basal ring. By its stratigraphic distribution in cores from DSDP Legs 28 and 29, it appears to have developed from *D. deflandrei.*

Dictyocha hexacantha Schulz
(Plate 4, Figures 1, 2)

Dictyocha hexacantha Schulz, 1928, Bot. Archiv., v. 21, no. 2, p. 255, fig. 43.

Remarks: This middle and upper Eocene species could include two forms. The dominant early variety has a small rounded basal ring with a triradiate apical structure that is pegged to the basal ring and extends beyond it. This early form has been distinguished from younger *Dictyocha hexacantha* s. str. by Deflandre (1932; fig. 178-187) as a distinct species, *Corbisema spinosa.* It was later transferred to *Dictyocha* by Glezer (1966). *D. spinosa* should be distinguished from *D. hexacantha,* because they may prove to have a different stratigraphic range. *D. spinosa* s. str. is most common in the middle Eocene (see *D. hexacantha* s. ampl. of Bukry and Foster, 1974), whereas *D. hexacantha* s. str. is dominant in the late middle or late Eocene.

Dictyocha hexacantha s. str. is the larger of the two and has a more polygonal outline. The apical structure forms an unbroken unit with the basal ring. The basal ring has six sides and six spines, but is essentially triangular in form. Some specimens at Site 283 have a central spine atop the apical structure.

Genus DISTEPHANUS Stöhr, 1880

Distephanus crux hannai n. ssp.
(Plate 4, Figures 4-6)

?*Distephanus crux crux* (Ehrenberg), Glezer, 1966 (in part), Cryptogamic plants USSR, v. 7, p. 279, fig. 14 (5), pl. 18, fig. 3.
?*Distephanus crux* Ehrenberg, Ling, 1973 (in part), Initial Reports of the Deep Sea Drilling Project, v. 19, pl. 1, fig. 18.

Description: *Distephanus crux hannai* is basically a rounded rhomboid form, but can have a slightly four-lobed outline. The apical ring is small and the spines are of moderate length, the principal-axis spines being longer.

Remarks: The small apical ring and large, rounded or lobate basal ring serve to distinguish *Distephanus crux hannai* from other members of the *Distephanus crux* group. It is distinguished from *Distephanus schauinslandii* by its more moderate spine proportions and wider basal ring. It differs from *D. schauinslandii stradneri* (Plate 4, Figure 7) by its lack of a square body ring (see Loeblich et al., 1968, pl. 7, fig. 7, 8; pl. 25, fig. 6, 7). *D. crux hannai* is most common in the upper lower Miocene of California and at Site 278.

Site: Basal-ring length 35-50μ; holotype 50μ.
Holotype: USNM 207371 (Plate 4, Figure 5).
Paratypes: USNM 207372 to 207373.
Type locality: Southern California Borderland, Kelez sample 73100227, lat 33°23.7′N, long 119°02.5′W.

Distephanus speculum binoculus (Ehrenberg) n. comb.

Dictyocha binoculus Ehrenberg, 1844, König. Preuss. Akad. Wiss. Berlin, Ber. Verh., p. 63, 79.

Distephanus speculum hemisphaericus (Ehrenberg) n. comb.
(Plate 4, Figure 8)

Dictyocha hemisphaerica Ehrenberg, 1844, König. Preuss. Akad. Wiss. Berlin, Ber. Verh., pl. 17, fig. 5.
Dictyocha speculum Ehrenberg, Tynan, 1957, Micropaleontology, p. 132, pl. 1, fig. 13-19.
Dictyocha hemisphaerica Ehrenberg, Loeblich et al., 1968, Geol. Soc. Am. Mem. 106, p. 100, pl. 17, fig. 5.
Cannopilus hemisphaericus (Ehrenberg) Haeckel; Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 147, pl. 23, fig. 1-4.

Remarks: This fossil is most common in lower and middle Miocene assemblages. The basal ring is polygonal, typically six-, sometimes seven-sided. The apical structure is generally a framework having three to seven rounded openings. This framework is connected to the basal ring by short struts. Regular apical structures have three, four, or seven equant openings that are symmetrically arranged. *Distephanus speculum hemisphaericus* is distinguished from *Distephanus boliviensis major* by having rounded instead of angular apical openings (see Plate 1 of Bukry and Foster, 1973). It is distinguished from *Cannopilus*? *schulzii* by having less than eight radial spines.

Distephanus speculum quintus (Bukry and Foster) n. comb.

Dictyocha variabilis Hanna, 1931 (in part), Mining Calif., p. 200, pl. E., fig. 5-7. (Invalid by ICBN art. 32.)
Cannopilus quintus Bukry and Foster, 1973, Initial Reports of the Deep Sea Drilling Project v. 16, p. 826, pl. 1, fig. 8, 9; pl. 2, fig. 1.

Remarks: Pentagonal varieties of the *Distephanus speculum* group that have subdivided apical rings are included in *Distephanus speculum quintus.*

Distephanus speculum speculum (Ehrenberg)
(Plate 4, Figure 12; Plate 5, Figures 1, 2)

Dictyocha speculum Ehrenberg, 1839, König. Preuss. Akad. Wiss. Berlin, Ber. Verh., p. 150; 1854, Mikrogeologie, pl. 18, fig. 57; pl. 19, fig. 41; pl. 21, fig. 44; pl. 22, fig. 47.

Remarks: A broad species concept is employed for this hexagonal species in this report. Many varieties distinguished by relative proportions of apical to basal rings, basal ring and spine symmetry, or size, could be recognized. The basic species ranges from Eocene to Recent, being especially abundant in cool regions of the upper Neogene. Forms having large apical rings are most abundant in cooler environments (Bukry, 1973a).

Subdivision of the apical ring is recognized at the subspecific level in this study.

Genus LYRAMULA Hanna, 1928

Lyramula furcula Hanna
(Plate 5, Figure 4)

Lyramula furcula Hanna, 1928, J. Paleontol., v. 1, p. 262, pl. 41, fig. 4, 5.
Lyramula furcula minor Deflandre, 1940, C. R. Acad. Sci. Paris, v. 211, p. 509, fig. 7-10.
Lyramula furcula Hanna, Deflandre, 1950, Microscopie, v. 2, p. 61/82, fig. 163, 167-169.

Remarks: A majority of specimens assigned to this species are simple wishbone-shaped forms. Minor varieties with accessory spines are included in the tabulation of *Lyramula furcula* s. ampl. Such varieties, occurring in assemblages of DSDP Legs 22 and 29, have been well illustrated by Deflandre (1950) from California assemblages.

Genus MESOCENA Ehrenberg, 1843

Mesocena apiculata (Schulz)
(Plate 5, Figures 6-9)

Mesocena oamaruensis apiculata Schulz, 1928, Bot. Archiv., v. 21, no. 2, p. 240, fig. 11.
"Mesocena" apiculata Schulz, Hanna, 1931, Mining California, v. 27, no. 2, pl. D., fig. 3.
Mesocena apiculata (Schulz), Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 173, pl. 28, fig. 2-4.

Remarks: This species is a consistent and often common member of late Eocene to early Miocene assemblages. Oligocene specimens may lack septae or may have them at one, two, or all three of the apices. Some specimens have solid hyaline apices, only the sides being tubular. The form is variable, being equilateral or isosceles triangles with sides that are straight or bowed-out. Bizarre forms that have four or five irregular sides and apices are very rare, two or three per thousand.

Genus NAVICULOPSIS Frenguelli, 1940

Remarks: The species concepts in *Naviculopsis* have had a tendency to overlap in part. Although there may be some technical question involving the priority of the names selected, the species concepts outlined below are an attempt to exclusively discriminate the specimens encountered in DSDP Leg 29 cores.

A typical stratigraphic sequence of dominant associations of *Naviculopsis* species beginning in the lower Eocene and ending in the lower Miocene would be the following: (1) *Naviculopsis constricta*, (2) *N. constricta-N. foliacea*, (3) *N. constricta-N. trispinosa*, (4) *N. constricta-N. trispinosa-N. biapiculata*, (5) *N. biapiculata-N. trispinosa*, (6) *N. biapiculata-N. lata*, and (7) *N. lata-N. quadrata*.

Naviculopsis biapiculata (Lemmermann)
(Plate 6, Figures 5-8)

?*Dictyocha navicula biapiculata* Lemmermann, 1901, Deutsch Bot. Ges., Ber., v. 19, p. 258, pl. 10, fig. 14, 15.
?*Dictyocha regularis* Carnevale, 1908, R. Inst. Veneto Sci. Lett. Arti, Mem., v. 28, no. 3, p. 35, pl. 4, fig. 28.
Naviculopsis biapiculata (Lemmermann), Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 181, pl. 30, fig. 1-4.
Naviculopsis regularis (Carnevale), Ling, 1972, ibid., p. 188, pl. 31, fig. 3-5.
Naviculopsis biapiculata (Lemmermann), Dumitrica, 1973 (in part), Initial Reports of the Deep Sea Drilling Project, v. 21, p. 847, pl. 1, fig. 4, 5, 9.

Remarks: Specimens classified as *Naviculopsis biapiculata* have narrow, essentially tubular, crossbars. Spines are equal to or longer than the body ring. Lower Oligocene *N. biapiculata* are smaller and rarer than typical upper Oligocene specimens.

Naviculopsis constricta (Schulz)
(Plate 7, Figures 1, 2)

Dictyocha navicula biapiculata constricta Schulz, 1928, Bot. Archiv., v. 21, no. 2, p. 246, fig. 21.
Dictyocha navicula minor Schulz, 1928, ibid., v. 21, no. 2, p. 246, fig. 22.
Naviculopsis biapiculata minor (Schulz), Glezer, 1966 (in part), Cryptogamic plants USSR, v. 7, p. 274, pl. 16, fig. 6-8; pl. 17, fig. 1, 2, 6.
Naviculopsis biapiculata constricta (Schulz), Glezer, 1966, ibid., p. 276, pl. 17, fig. 4.
Naviculopsis constricta (Schulz), Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 183, pl. 30, fig. 5-8.
Naviculopsis biapiculata (Lemmermann), Dumitrica, 1973 (in part), Initial Reports of the Deep Sea Drilling Project, v. 21, p. 847, pl. 1, fig. 8, ?10.
Naviculopsis foliacea Deflandre, Dumitrica, 1973 (in part), ibid., v. 21, p. 847, pl. 1, fig. 7.
Naviculopsis constricta (Schulz), Bukry, 1973, ibid., v. 21, p. 892, pl. 1, fig. 4, 5.

Remarks: *Naviculopsis constricta* is typified by a broad apical band across the body ring that occupies up to a third of the length of the body-ring opening. The body ring is parallel sided or slightly concave where the apical band is attached. Two axial spines are equal to or longer than the body ring.

Naviculopsis constricta differs from *N. foliacea* in having an apical band occupying less than a third of the body opening, and spines that are generally equal to or longer than the body length.

Naviculopsis constricta is a typically small form that ranges through the Eocene to the upper Oligocene. It is especially abundant near the Eocene-Oligocene boundary at Site 283. Large specimens are rare.

Naviculopsis foliacea Deflandre

Naviculopsis foliacea Deflandre, 1950, Microscopie, v. 2, p. 76/82, fig. 235-239.
Naviculopsis biapiculata minor (Schulz), Glezer, 1966 (in part), Cryptogamic plants USSR, v. 7, p. 274, pl. 17, fig. 3.
Naviculopsis foliacea Deflandre, Glezer, 1966, ibid., v. 7, p. 277, pl. 7, fig. 5.
Naviculopsis biapiculata (Lemmermann) Mandra, 1968 (in part), Calif. Acad. Sci., Proc., v. 36, no. 9, p. 264, fig. 22.
Naviculopsis foliacea Deflandre, Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 184, pl. 30, fig. 9-11.
Naviculopsis foliacea Deflandre, Dumitrica, 1973 (in part), Initial Reports of the Deep Sea Drilling Project, v. 21, p. 847, pl. 1, fig. 6.
Naviculopsis foliacea Deflandre, Bukry 1973, ibid., p. 892, pl. 1, fig. 6, 7.

Remarks: Easily identified specimens of *Naviculopsis foliacea* possess a distinctive set of characters. Such typical specimens have an apical band that occupies more than a third of the body-ring opening, spines that are shorter than the body-ring length and that are canted away from the body-ring axis. Some specimens may have spines as long as the body ring, but the very wide apical band distinguishes such specimens as *N. foliacea*. *N. foliacea* appears to be restricted to the Eocene.

Naviculopsis lata (Deflandre)
(Plate 7, Figure 4)

Dictyocha biapiculata lata Deflandre, 1932, Soc. Bot. France, Bull., v. 79, p. 500, fig. 30, 31.
Naviculopsis robusta Deflandre, 1950, Microscopie, v. 2, p. 74, fig. 227-229.
Naviculopsis robusta Deflandre, Glezer, 1966, Cryptogamic plants USSR, v. 7, p. 273, pl. 16, fig. 1; pl. 33, fig. 3-6.
Naviculopsis lata (Deflandre), Ling, 1972 (in part), Am. Paleontol. Bull., v. 62, no. 273, p. 185, pl. 30, fig. 12-14.
Naviculopsis lata (Deflandre), Martini, 1972, Senckenb. Lethaea, v. 53, p. 120, fig. 1.

Remarks: *Naviculopsis lata* has the widest body ring, proportional to length, of any species of *Naviculopsis*. The apical bar is narrow, and the spines are typically shorter than the body length. The outline of the body ring ranges from hexagonal to rounded. *Naviculopsis lata* is distinguished from similar *N. quadrata* by the more equal length and width of its body ring, and by a less quadrate outline. *N. lata* is most common in the lower Miocene.

Naviculopsis quadrata (Ehrenberg)

Dictyocha quadrata Ehrenberg, 1844, König. Preuss. Akad. Wiss. Berlin, Ber. Verh., p. 258, 267.
Dictyocha navicula rectangulare Schulz, 1928, Bot. Archiv., v. 21, no. 2, p. 243, fig. 17a, b.
Naviculopsis lata (Deflandre), Ling, 1972 (in part), Am. Paleontol. Bull., v. 62, no. 273, p. 185, pl. 30, fig. 15, 16.
Naviculopsis quadrata (Ehrenberg), Ling, 1972 (in part), ibid., v. 62, no. 273, p. 187, pl. 30, fig. 2.
Naviculopsis rectangularis (Schulz), Martini, 1972, Senckenb. Lethaea, v. 53, p. 120, fig. 3.
Naviculopsis quadrata pacifica Dumitrica, 1973, Initial Reports of the Deep Sea Drilling Project, v. 21, p. 846, pl. 1, fig. 12-14.
?*Naviculopsis* sp., Dumitrica, 1973, ibid., v. 21, p. 847, pl. 1, fig. 15.

Remarks: The intraspecific variation indicated by Schulz (1928) is accepted for this report. *Naviculopsis quadrata* is distinguished by its rectangular to rounded rectangular outline and by its short but obvious spines. *Naviculopsis navicula* s. str. is distinctly navicular (boat shaped) and lacks spines (see Schulz, 1928; Martini, 1972). The range of intermediate forms between these two species concepts is assigned to *N. quadrata*.

Naviculopsis trispinosa (Schulz)
(Plate 7, Figures 5-7)

Dictyocha navicula trispinosa Schulz, 1928, Bot. Archiv., v. 21, no. 2, p. 246, fig. 23a, b.

Naviculopsis trispinosa (Schulz), Glezer, 1966, Cryptogamic plants USSR, v. 7, p. 277, pl. 17, fig. 7.

Naviculopsis trispinosa (Schulz), Ling, 1972, Am. Paleontol. Bull., v. 62, no. 273, p. 190, pl. 31, fig. 7, 8.

Remarks: This upper Eocene to upper Oligocene species is distinguished by a spine that projects from the middle of the apical bar. The spine can be perpendicular to the plane of the body ring or at an angle, and it can be as long or shorter than the body-ring spines. Definite identification is easiest in side view, its preferred orientation on slides of strewn specimens.

OTHER SPECIES

Illustration references to silicoflagellate species cited without discussion are indicated in Figure 9. Several of these species from Leg 29 are also illustrated in Plates 1-7.

ACKNOWLEDGMENT

I am grateful to Dorothy Blackstock, U.S. Geological Survey, for careful attention to detail and assistance in designing the figures, and in proofing the original manuscript. Harald S. Poelchau, Scripps Institution of Oceanography, and George W. Moore, U.S. Geological Survey, provided excellent scientific and philosophical advice in their reviews of the paper which is deeply appreciated.

REFERENCES

Bukry, D., 1973a. Coccolith and silicoflagellate stratigraphy, Deep Sea Drilling Project Leg 18, eastern North Pacific. *In* Kulm, L. D., von Huene, R., et al., Initial Reports of the Deep Sea Drilling Project, Volume 18: Washington (U.S. Government Printing Office), p. 817-831.

———, 1973b. Coccolith and silicoflagellate stratigraphy, Tasman Sea and southwestern Pacific Ocean, Deep Sea Drilling Project Leg 21. *In* Burns, R. E., Andrews, J. E., et al., Initial Reports of the Deep Sea Drilling Project, Volume 21: Washington (U.S. Government Printing Office), p. 885-893.

———, in press. Coccolith and silicoflagellate stratigraphy near Antarctica, Deep Sea Drilling Project Leg 28. *In* Hayes, D., Frakes, L. A., et al., Initial Reports of the Deep Sea Drilling Project, Volume 28: (Washington (U.S. Government Printing office).

Bukry, D. and Foster, J. H., 1973. Silicoflagellate and diatom stratigraphy, Leg 16, Deep Sea Drilling Project: *In* van Andel, T. H., Heath, G. R., Initial Reports of the Deep Sea Drilling Project, Volume 16, Washington (U.S. Government Printing Office), p. 815-871.

———, 1974. Silicoflagellate zonation of Upper Cretaceous to lower Miocene deep-sea sediment: U.S. Geol. Surv. J. Res., v. 2, no. 3.

Burns, D. A., 1972. The latitudinal distribution and significance of calcareous nannofossils in the bottom sediments of the South-west Pacific Ocean (Lat. 15-55°S) around New Zealand: Oceanography of the South Pacific 1972. New Zealand National Commission, Wellington, p. 221-228.

References / Silicoflagellates	Loeblich et al., 1968	Ling, 1972	Dumitrica, 1973	Bukry and Foster, 1973
Cannopilus sphaericus Gemeinhardt	X	X		
Cornua aculeifera Deflandre	X			
C. trifurcata Schulz	X			
Dictyocha pentagona (Schulz)				X
D. pseudofibula (Schulz)				X
D. quadralta Hanna	X			
D. subarctios Ling		X		
Distephanus boliviensis major Frenguelli	X			
D. crux crux (Ehrenberg)	X			
D. octangulatus Wailes	X			
D. octonarius Deflandre		X		
D. polyactis (Ehrenberg)			X	X
D. speculum pentagonus Lemmermann	X			
D. speculum varians (Gran and Braarud)	X			
Lyramula simplex Hanna	X	X		
Mesocena circulus (Ehrenberg)		X		X
M. diodon Ehrenberg				X
M oamaruensis oamaruensis Schulz	X	X		
M. oamaruensis quadrangula Schulz	X			
M. triangula (Ehrenberg)	X			X
Octactis pulchra Schiller	X			X
Pseudorocella corona Deflandre	X			
Rocella gemma Hanna	X	X	X	
Vallacerta hannai Deflandre	X			
V. hortonii Hanna	X	X		
V. tumidula Glezer	X			

Figure 9. *Illustration references to reports by other authors for silicoflagellate species.*

Cornell, W. C., 1972. Chrysomonad cysts and silicoflagellates from the Marca Shale Member, Moreno Formation (Maestrichtian), Fresno County, California: Univ. Calif., Los Angeles, Ph. D. dissertation, p.1-235. (Univ. Microfilm order no. 72-25, 766.)

Deflandre, G., 1932. Sur la systématique des silicoflagellés: Soc. Bot. France, Bull., v. 79, p. 494-506.

———, 1950. Contribution a l'étude des silicoflagellidés actuels et fossiles: Microscopie, v. 2, p. 72-108, 117-142, and 191-210.

Douglas, R. G. and Savin, S. M., 1973. Oxygen and carbon isotope analyses of Cretaceous and Tertiary Foraminifera from the central North Pacific. *In* Winterer, E. L., Ewing, J. I., et al., Initial Reports of the Deep Sea Drilling Project, Volume 17: Washington (U.S. Government Printing Office), p. 591-605.

Dumitrica, P., 1973. Paleocene, late Oligocene and post-Oligocene silicoflagellates in southwestern Pacific sediments cored on DSDP Leg 21: *In* Burns, R. E., Andrews, J. E., et al., Initial Reports of the Deep Sea Drilling Project, Volume 21: Washington (U.S. Government Printing Office), p. 837-883.

Edwards, A. R., 1971. A calcareous nannoplankton zonation of the New Zealand Paleogene: Plankt. Conf. 2nd Proc., p. 381-419.

Ehrenberg, C. G., 1854. Mikrogeologie: Leipzig (Leopold Voss), p. 1-374.

Glezer, Z. I., 1966. Silicoflagellatophyceae. *In* Gollerbakh, M. M. (Ed.), cryptogamic plants of the USSR: Moscow (Nauka). (Translated from Russian by Israel Program for Scientific Translations Ltd., Jerusalem, 1970).

Ling, H. Y., 1972. Upper Cretaceous and Cenozoic silicoflagellates and ebridians: Am. Paleontol. Bull., v. 62, p. 135-229.

———, 1973. Silicoflagellates and ebridians from Leg 19: *In* Creager, J. S., Scholl, D. W., et al., Initial Reports of the Deep Sea Drilling Project, Volume 19: Washington (U.S. Government Printing Office), p. 751-775.

Ling, H. Y., McPherson, L. M., and Clark, D. L., 1973. Late Cretaceous (Maestrichtian?) silicoflagellates from the Alpha Cordillera of the Arctic Ocean: Science, v. 180, p. 1360-1361.

Loeblich, A. R., 3d, Loeblich, L. A., Tappan, H., and Loeblich, A. R., Jr., 1968. Annoted index of fossil and recent silicoflagellates and ebridians with descriptions and illustrations of validly proposed taxa: Geol. Soc. Am. Mem. 106.

Mandra, Y. T., 1968. Silicoflagellates from the Cretaceous, Eocene, and Miocene of California, U.S.A.: Calif. Acad. Sci. Proc., v. 36, p. 231-277.

Mandra, Y. T., Brigger, A. L., and Mandra, H., 1973. Preliminary report on a study of fossil silicoflagellates from Oamaru, New Zealand: Calif. Acad. Sci. Occasional Papers no. 107, p. 1-11.

Martini, E., 1971. Neogene silicoflagellates from the equatorial Pacific: *In* Winterer, E. L., Riedel, W. R., et al., Initial Reports of the Deep Sea Drilling Project, Volume 7: Washington (U.S. Government Printing Office), p. 1695-1708.

———, 1972. Silicoflagellate zones in the late Oligocene and early Miocene of Europe: Senckenb. Lethaea, v. 53, p. 119-122.

Schrader, H.-J., 1973, Cenozoic diatoms from the northeast Pacific, Leg 18: *In* Kulm, L. D., von Huene, R., et al., Initial Reports of the Deep Sea Drilling Project, Volume 18: Washington (U.S. Government Printing Office), p. 673-797.

Schulz, P., 1928. Beiträge zur Kenntnis fossiler und rezenter Silicoflagellaten: Bot. Archiv., v. 21, p. 15-292.

Stadum, C. J. and Burckle, L. H., 1973. A silicoflagellate ooze from the east Falkland Plateau: Micropaleontology, v. 19, p. 104-109.

PLATE 1

Silicoflagellates from DSDP Leg 29.
Figures 1-6, 8-12 magnified 800×, scale bar equals 10μ;
Figure 7 magnified 500×, scale bar equals 10μ.

Figure 1	*Cannopilus sphaericus* Gemeinhardt; Sample 278-27-4, 96 cm (344 m).
Figure 2	*Corbisema apiculata* (Lemmermann); Sample 280A-7-1, 115 cm (121 m).
Figure 3	*Corbisema bimucronata* Deflandre; Sample 283-6-2, 86 cm (125 m).
Figures 4, 5	*Corbisema flexuosa* (Stradner), 4. Sample 283-5-1, 44 cm (86 m). 5. Sample 283-8-1, 75 cm (191 m).
Figures 6-7	*Corbisema geometrica geometrica* Hanna. 6. Sample 275-2-3, 25 cm (9 m). 7. Sample 275-2-4, 75 cm (11 m).
Figure 8	*Corbisema geometrica lateradiata* (Schulz); Sample 275-2-2, 75 cm (8 m).
Figure 9	*Corbisema hastata hastata* (Lemmermann); Sample 283-6-1, 125 cm (124 m).
Figure 10	*Corbisema hastata minor* (Schulz); Sample 283-6-1, 125 cm (124 m).
Figures 11, 12	*Corbisema triacantha* (Ehrenberg). 11. Sample 283-6-2, 86 cm (125 m). 12. Sample 283-8-3, 75 cm (194 m).

PLATE 1

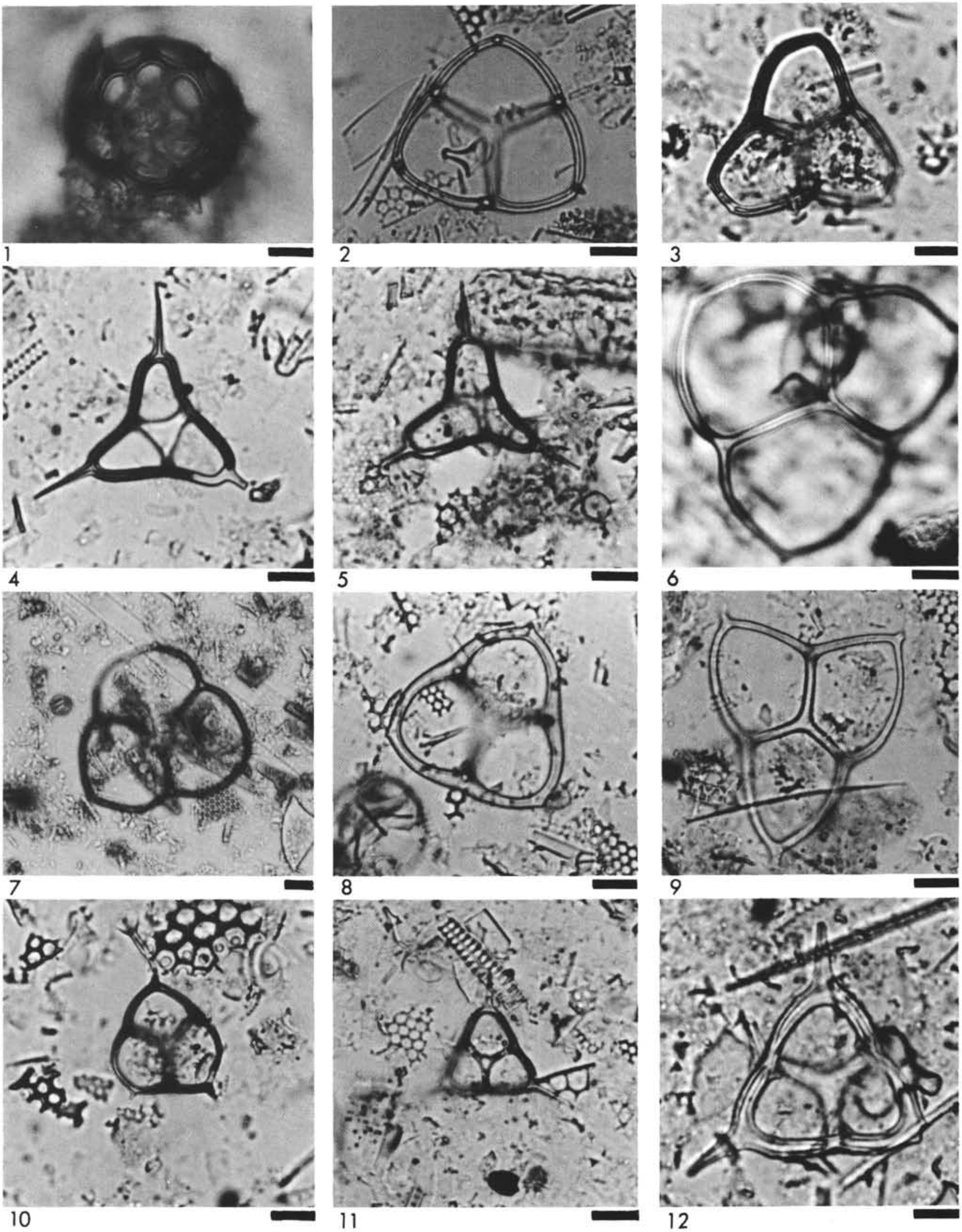

PLATE 2

Silicoflagellates from DSDP Leg 29,
Magnification 800×, scale bar equals 10μ.

Figure 1	*Cornua trifurcata* Schulz; Sample 275-2-4, 75 cm (11 m).
Figures 2-4	*Dictyocha aspera aspera* (Lemmermann); 2. Sample 283-8-3, 75 cm (194 m). 3, 4. Sample 283-5-1, 44 cm (86 m).
Figures 5-8	*Dictyocha aspera martinii* Bukry. 5. USNM 207365, Sample 283-5-1, 44 cm (86 m). 6. Holotype, USNM 207364, Sample 283-8-1, 75 cm (191 m). 7. USNM 207366, Sample 283-6-1, 125 cm (124 m). 8. USNM 207367, Sample 283-6-2, 86 cm (125 m).
Figures 9-13	*Dictyocha deflandrei* Frenguelli ex Glezer. 9, 10. Sample 280A-2-2, 75 cm (56 m). 11. Sample 278-31-1, 72 cm (396 m). 12. Sample 283-5-1, 44 cm (86 m). 13. Sample 280A-7-1, 115 cm (121 m).

PLATE 2

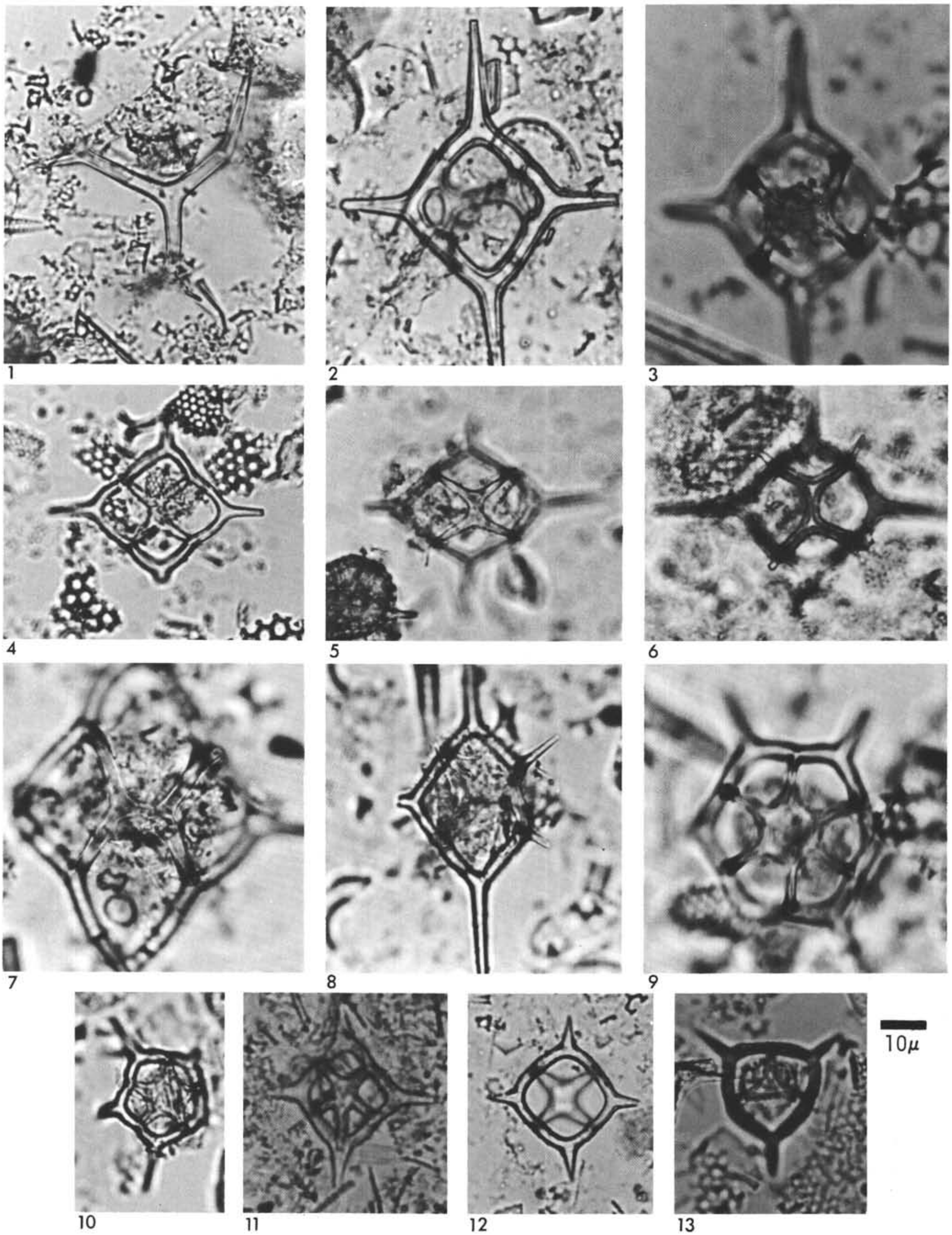

PLATE 3

Silicoflagellates from DSDP Leg 29.
Figure 1 magnification 1000×, scale bar equals 10μ;
Figures 2-6, 10, 11 magnification 800×, scale bar equals 10μ;
Figures 7-9 magnification 500×, scale bar equals 10μ.

Figure 1	*Hannaites quadria* Mandra; Sample 283-6-1, 125 cm (124 m).
Figures 2, 3	*Dictyocha fibula fibula* Ehrenberg. 2. Sample 278-10-5, 75 cm (184 m). 3. Sample 283-8-3, 75 cm (194 m).
Figures 4, 6	*Dictyocha* sp. aff. *D. fibula fibula* Ehrenberg. 4. Sample 283-6-2, 86 cm (125 m). 6. Sample 280A-3-4, 75 cm (78 m).
Figure 5	*Dictyocha fibula perlaevis* (Frenguelli); Sample 283-7-6, 125 cm (159 m).
Figures 7, 8	*Dictyocha fibula formicata* Bukry. 7. USNM 207370, Sample 283-8-1, 75 cm (191 m). 8. Holotype, USNM 207369, Sample 283-8-1, 75 cm (191 m).
Figure 9	*Dictyocha quadralta* Hanna; Sample 275-2-5, 75 cm (13 m).
Figures 10, 11	*Dictyocha frenguellii* Deflandre. 10. Sample 278-31-2, 75 cm (397 m). 11. Sample 278-31-3, 75 cm (398 m).

PLATE 3

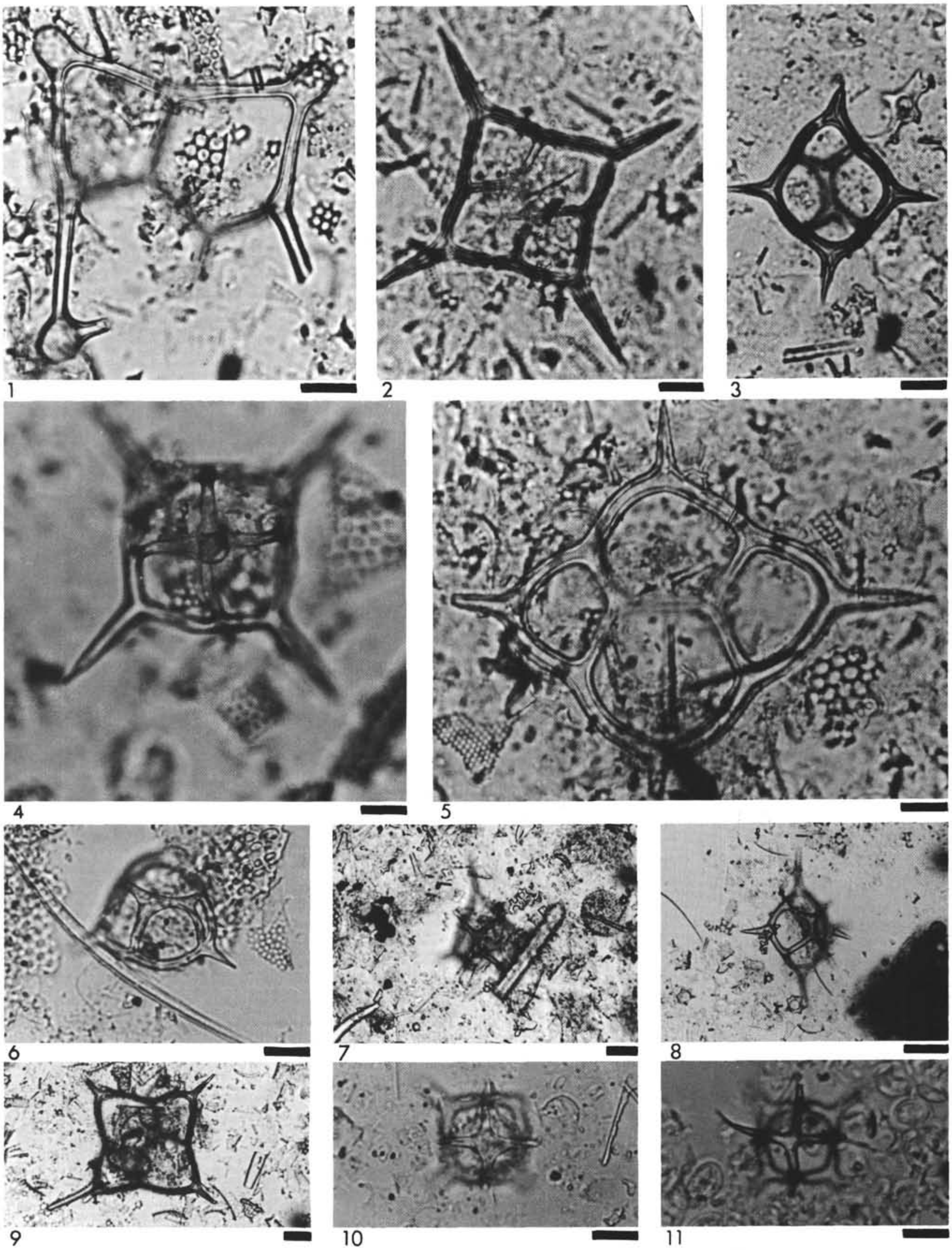

PLATE 4

Silicoflagellates from DSDP Leg 29 and Southern California Borderland.
Magnification 800×, scale bar equals 10μ.

Figures 1, 2	*Dictyocha hexacantha* Schulz. 1. Sample 283-6-2, 86 cm (125 m). 2. Sample 283-8-3, 75 cm (194 m).
Figure 3	*Distephanus crux crux* (Ehrenberg); Sample 280A-7A-1, 115 cm (121 m).
Figures 4-6	*Distephanus crux hannai* Bukry. 4. USNM 207372, Sample Kelez 73100227. 5. Holotype, USNM 207371, Sample Kelez 73100227. 6. USNM 207373, Sample 278-26-6, 75 cm (337 m).
Figure 7	*Distephanus schauinslandii stradneri* Jerkovic; Sample 278-30-1, 113 cm (378 m).
Figure 8	*Distephanus speculum hemisphaericus* (Ehrenberg); Sample 278-31-2, 75 cm (397 m).
Figures 9-11	*Distephanus speculum pentagonus* (Lemmermann). 9, 10. Sample 278-28-5, 75 cm (354 m). 11. Sample 278-1-2, 75 cm (2 m).
Figure 12	*Distephanus speculum speculum* (Ehrenberg); Elongate apical ring; Sample 278-8-2, 75 cm (160 m).

PLATE 4

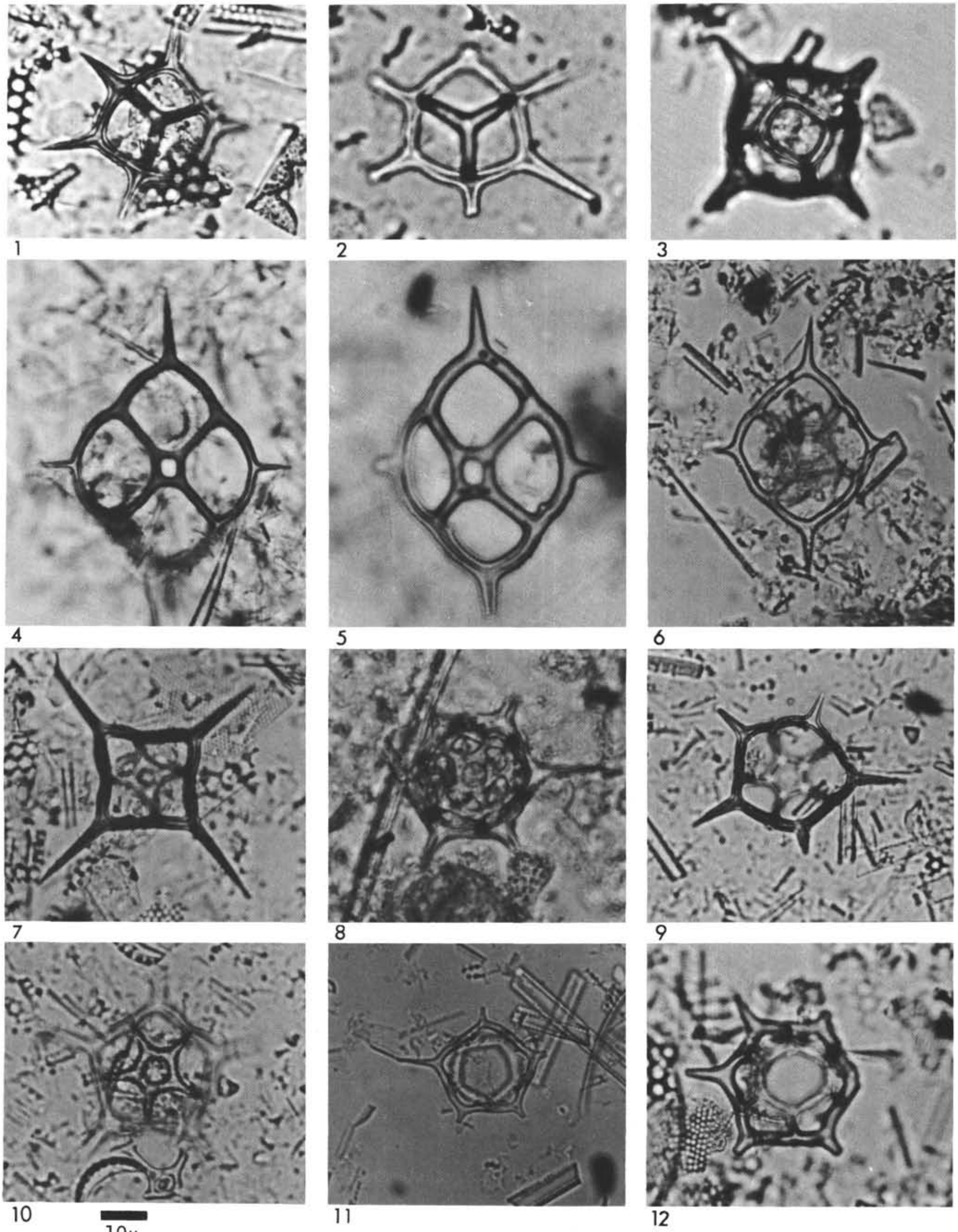

PLATE 5

Silicoflagellates from DSDP Leg 29,
Magnification 800×, scale bar equals 10μ.

Figures 1, 2	*Distephanus speculum speculum* (Ehrenberg). 1. Sample 278-1-2, 75 cm (2 m). 2. Sample 280A-4-4, 75 cm (86 m).
Figure 3	*Distephanus speculum varians* (Gran and Braarud); Sample 278-1-2, 75 cm (2 m).
Figure 4	*Lyramula furcula* Hanna; Sample 275-2-4, 75 cm (11 m).
Figure 5	*Lyramula* sp.?; Sample 275-2-4, 75 cm (11 m).
Figures 6-9	*Mesocena apiculata* (Schulz). 6. Sample 280A-4-4, 75 cm (86 m). 7. Sample 278-31-2, 75 cm (397 m). 8. Sample 283-8-1, 75 cm (191 m). 9. Sample 280A-6-1, 130 cm (102 m).

PLATE 6

Silicoflagellates from DSDP Leg 29.
Magnification 800×, scale bar equals 10μ.

Figures 1, 2	*Mesocena circulus* (Ehrenberg). 1. Sample 278-14-5, 75 cm (222 m). 2. Sample 278-9-5, 75 cm (174 m).
Figure 3	*Mesocena diodon* Ehrenberg; Sample 278-9-5, 75 cm (174 m).
Figure 4	*Mesocena oamaruensis quadrangula* Schulz; Sample 280A-3-2, 75 cm (75 m).
Figures 5-8	*Naviculopsis biapiculata* (Lemmermann). 5. Sample 280A-3-2, 75 cm (75 m). 6. Sample 283-6-1, 125 cm (124 m). 7. Sample 278-30-1, 113 cm (378 m). 8. Sample 278-31-3, 75 cm (398 m).

(See p. 870)

PLATE 5

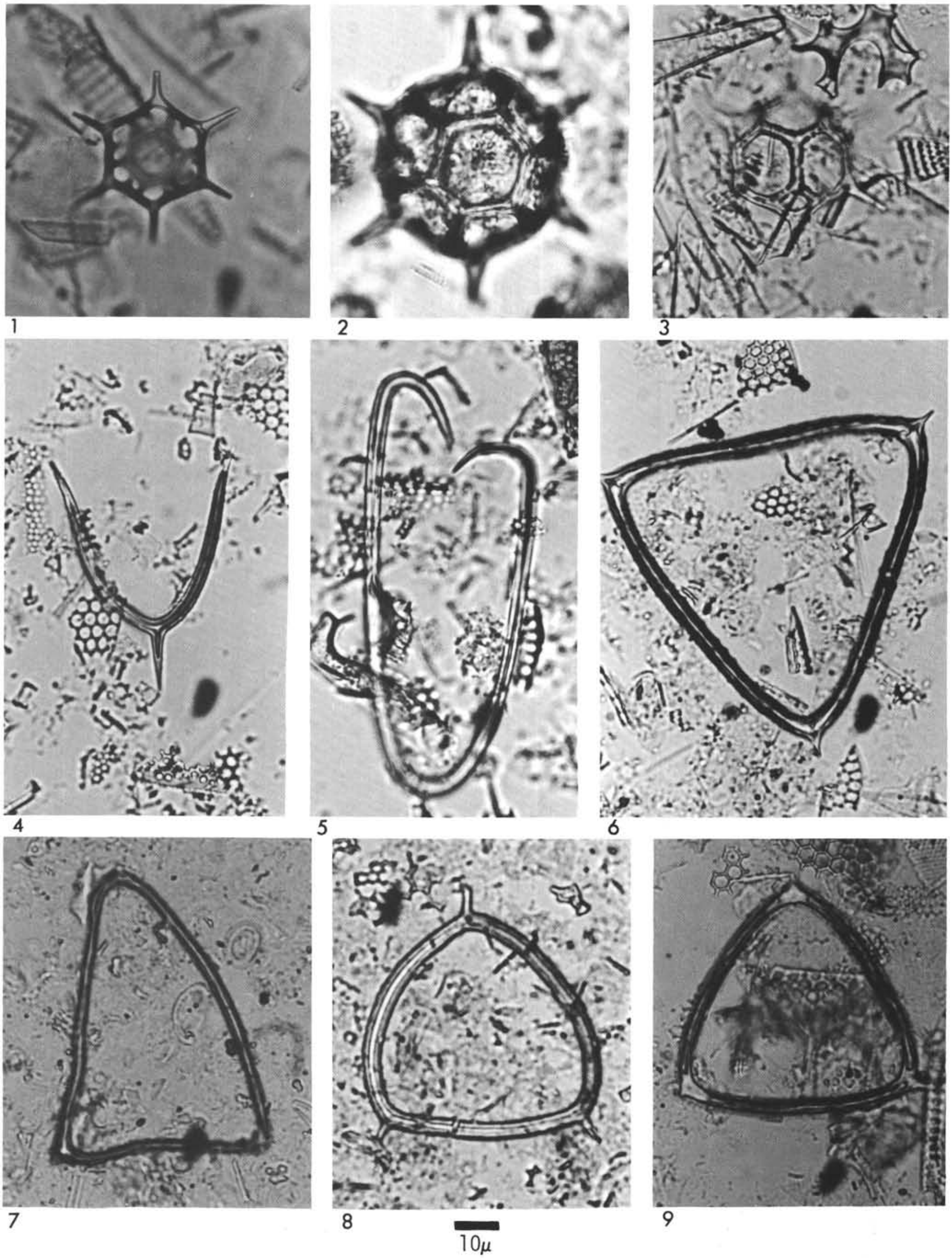

PLATE 6

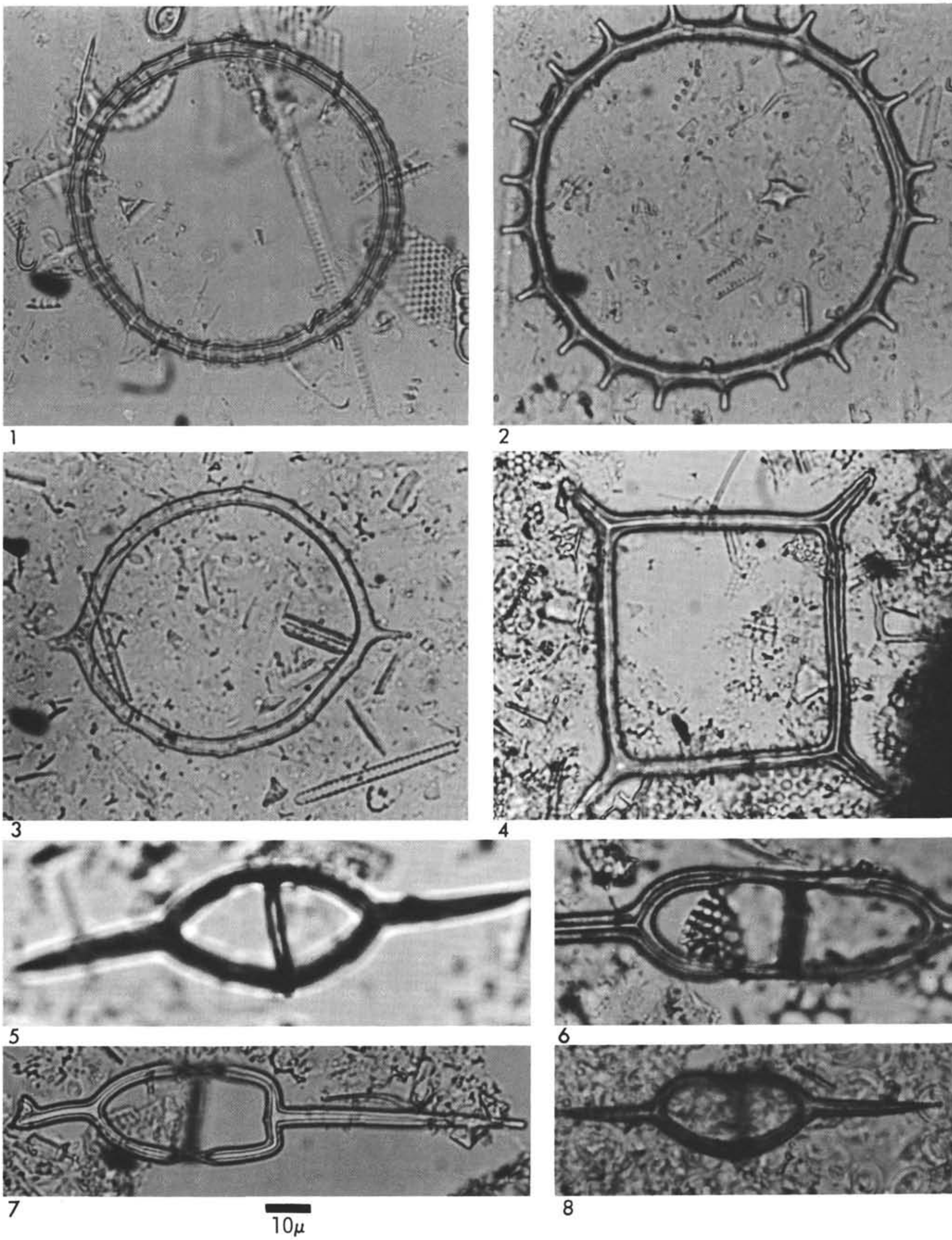

PLATE 7

Silicoflagellates from DSDP Leg 29.
Magnification 800×, scale bar equals 10μ.

Figures 1, 2	*Naviculopsis constricta* (Schulz); Sample 283-6-2, 86 cm (125 m).
Figure 3	*Naviculopsis* sp. cf. *N. constricta* (Schulz); Sample 283-5-2, 90 cm (88 m).
Figure 4	*Naviculopsis lata* (Deflandre); Sample 278-29-2, 75 cm (359 m).
Figures 5-7	*Naviculopsis trispinosa* (Schulz). 5, 6. Sample 280A-3-4, 75 cm (78 m). 7. Sample 280A-6-2, 80 cm (103 m).
Figures 8, 9	*Pseudorocella corona* Deflandre; Sample 278-25-2, 75 cm (321 m).

(See p. 872)

PLATE 7