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41. *DATA REPORT:* OLIGOCENE AND MIOCENE SILICOFLAGELLATES FROM THE NORTHERN EMPEROR SEAMOUNT CHAIN, SITE 883[1]

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ABSTRACT

Changes in silicoflagellate abundances at Detroit Seamount identify four new floras. *Naviculopsis lata* var. *obliqua* is abundant in the lower Miocene and it is possibly an endemic species in the North Pacific Ocean.

INTRODUCTION

Late Oligocene and early Miocene silicoflagellates are common to abundant and moderately well preserved in Ocean Drilling Program (ODP) Cores 145-883B-66X through 68X from Detroit Seamount at the northern end of the Emperor Seamount Chain (Fig. 1). Because this cored interval is near the Paleogene/Neogene boundary, systematic species counts (n = 50–300) were made for 29 samples from throughout the 23-m interval (Table 1). The 31 taxa in six genera are assigned to the two zonal units that have been used to identify the Oligocene/Miocene boundary by silicoflagellates: *Naviculopsis biapiculata* Zone and *N. lata* Zone (Bukry, 1981). Prior reports on North Pacific Oligocene/Miocene boundary silicoflagellates have been limited to Japan (Sawamura and Nakajima, 1980) or Deep Sea Drilling Project (DSDP) sites (Bukry 1982, 1985).

Most of the Hole 883B samples studied were prepared for diatom studies (Barron and Gladenkov, this volume). Some were prepared as silicoflagellate acid residues (Bukry, 1983) for light-microscope study. Counting techniques followed those previously described in DSDP reports and the totals are presented as percentages (Bukry, 1985). Although fragmentation of specimens is evident in all three cores, there are no signs of dissolution.

SILICOFLAGELLATE OCCURRENCES

The succession of silicoflagellate species (Table 1) and genera (Table 2) at Hole 883B is characterized by two major changes in Core 67X and by a minor change in Core 66X. The oldest flora, Flora A in Core 68X and lower Core 67X, is distinguished from overlying Flora B by changes in several generic abundance patterns that coincide in Section 67X-4 (Table 2).

	Flora A (%)	Flora B (%)
Bachmannocena	<9	14–23
Corbisema	1–11	0
Dictyocha	3–49	<3
Distephanus (quad.)	19–52	48–65
Naviculopsis	9–22	<4

Because the core log does not show any prominent physical break, the A/B floral change could be a rapid regional current shift with essentially no time missing in the sediment record. But the floral change above Flora B is more abrupt and suggests an important break in the sediment record. The contrast between Flora B and Flora C is shown by the following changes:

	Flora B (%)	Flora C (%)
Caryocha	0–1	2–33
Distephanus (quad.)	50 or 60	10–30
Naviculopsis	<4	20–40

The dark greenish-gray diatom coccolith chalk in Core 67X changes in color to light greenish gray coccolith chalk immediately above in Core 66X according to the core logs. This supports the between-core break in the sediment record that is indicated by the sharp changes in generic abundances between Floras B and C.

Within Core 66X a minor change is shown at the species level by several abundance transitions:

1. Most prominently, the predominance among *Naviculopsis* changes from *N. lata* to *N. lata* var. *obliqua* upward from Sections 66X-5 through 66X-4.
2. The last significant occurrences of *Distephanus quinquangellus* is in Section 66X-5.
3. Also diminished at this level are *Caryocha* sp. and *Distephanus schauinslandii.*

Core photographs of Sections 66X-5 and 66X-4 show a single uniform lithologic unit. Therefore, Flora C1 and Flora C2, below and above this transition are ecostratigraphic units reflecting nonsedimentary changes that favored different species within the same genus. In the case of *Naviculopsis lata* var. *obliqua,* the transition apparently became permanent (evolutionary). The record from Japan (Sawamura and Nakajima, 1980) shows *N. lata* var. *obliqua* achieved dominance over *N. lata* and then survived beyond the extinction of *N. lata*.

COMPARISON OF HOLE 883B FLORA TO OTHER AREAS

The most similar silicoflagellate flora to that of Hole 883B was reported from the Boso Peninsula in Japan (Flora A1 and A2, Sawamura and Nakajima, 1980). *Corbisema flexuosa, C. triacantha triacantha, Distephanus crux scutulatus, D. schauinslandii, Naviculopsis la-*

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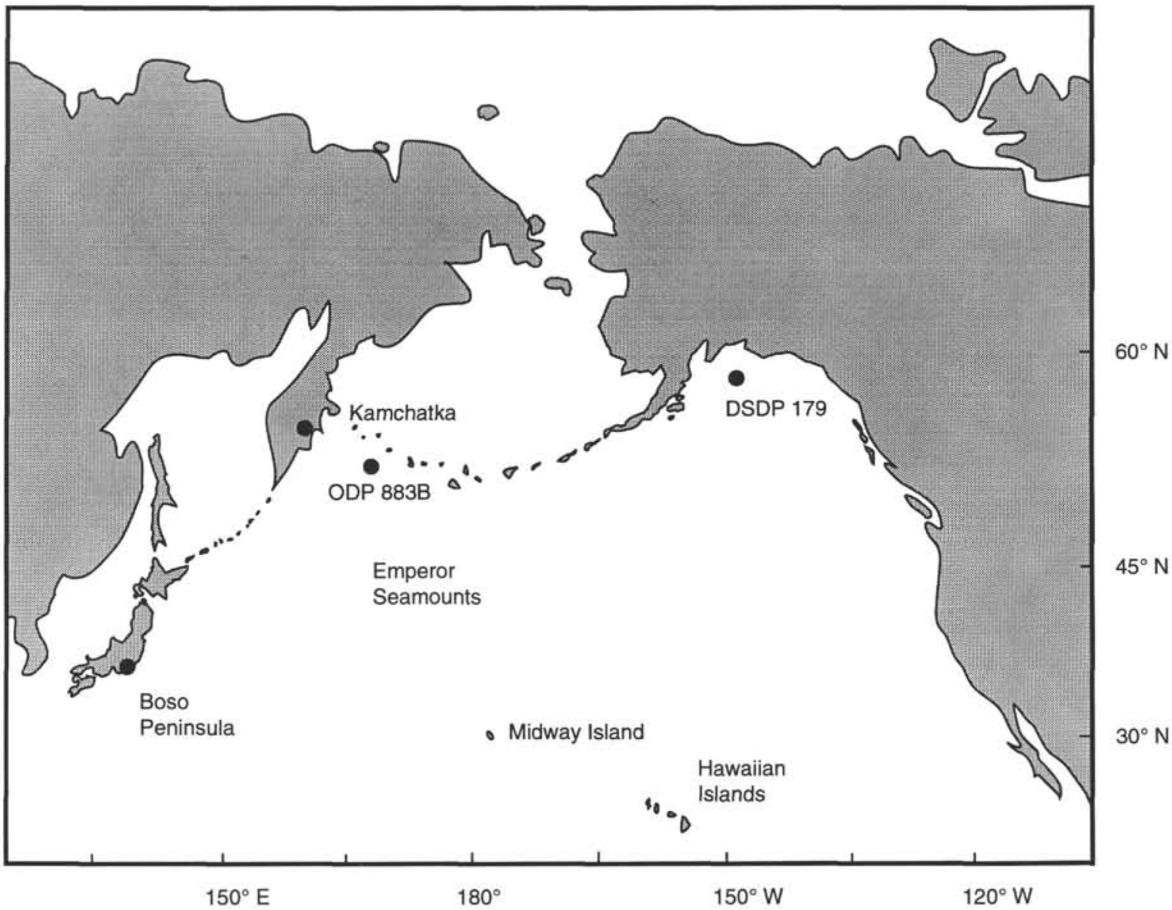

Figure 1. Sketch map of North Pacific region showing locations of reported occurrences of *Naviculopsis lata* var. *obliqua*. The Kamchatka occurrence was reported by A. Gladenkov (pers. comm., 1993).

ta, and *N. lata* var. *obliqua* were illustrated from strata assigned to the lowermost Miocene in Japan. This flora resembles that from Core 145-883B-66X, except for the more common occurrence of *C. triacantha triacantha* and the lack of *Caryocha* sp. The sparseness of *C. triacantha triacantha* at Hole 883B suggests cooler waters than for Japan at that time. The older *Naviculopsis biapiculata* Zone floras of Cores 67X and 68X, with prominent *C. flexuosa, Dictyocha deflandrei, N. biapiculata*, and *N. constricta* are not recorded at the Japanese sections.

Warm-water silicoflagellate floras of the early Miocene *N. lata* Zone at Japan and on the flanks of the Mid-Pacific Rise (Bukry, 1982, 1985) contain species of *Corbisema* and *Dictyocha* that are essentially absent at Hole 883B. Also, the cool-water taxa *Dictyocha deflandrei* and *Distephanus raupii* are missing in the older *N. biapiculata* Zone of tropical DSDP Hole 575A (Bukry, 1985).

In the Atlantic, warm-water floras of the late Oligocene and early Miocene at DSDP Holes 369A and 667A (Bukry, 1978b, 1989) are distinguished from those at Hole 883B by the distinctly more common and persistent occurrence of *Corbisema* and by the lack of *Caryocha* at the former holes.

At cooler high-latitude sites in the South Pacific, coeval floras contain *D. deflandrei* (four-sided, 95% to 99%), *D. raupii*, and *Naviculopsis trispinosa* in the uppermost Oligocene (Bukry, 1975). Of these, only *D. deflandrei* (five-sided, 98%) occurs at Hole 883B. The late Oligocene *N. biapiculata* Zone at ODP Hole 774A in the Southern Ocean has a cool-water flora with taxa that are missing from the North Pacific, such as *Dictyocha fischeri, Distephanus crux darwinii*, and *D. raupii* (Bukry, 1991).

Therefore, the *N. biapiculata* Zone at Hole 883B can be correlated by cosmopolitan taxa such as *C. flexuosa, D. schauinslandii, D. speculum haliomma*, and *N. biapiculata* and more restricted taxa like *D. deflandrei*. The low frequency of *Corbisema* indicates that this is not a warm-water flora. For the early Miocene *N. lata* Zone, the transition of *N. lata* to *N. lata* var. *obliqua* appears to be a regional characteristic in the North Pacific; again, the paucity of *Corbisema* and the prominence of *Caryocha* indicates a cooler-water regime than what existed to the south in the region of Japan.

OLIGOCENE/MIOCENE BOUNDARY CORRELATION AND AGE

The Oligocene/Miocene boundary is traditionally drawn at the base of the Aquitanian Stage in Europe (Ewing et al., 1969). Many fossil groups have provided one or more species events to approximate this boundary away from the type area. For silicoflagellates the first *Naviculopsis lata* has been widely used. Numerous coccolith events indicated near the boundary include the following († = extinction, * = appearance): *Dictyococcites bisectus*,† *Discoaster druggii*,* *Helicosphaera carteri*,* *H. recta*,† *Sphenolithus capricornutus*,† *S. ciperoensis*,† *S. delphix*,† *Triquetrorhabdulus carinatus*,† and *Zygrhablithus bijugatus*† (Bukry, 1978a; Gartner, 1992). A comparable list of silicoflagellate coeval events would include *C. flexuosa*,† *D. deflandrei*,† *N. biapiculata*,† *N. constricta*,† and *N. lata** (Martini and Müller, 1976; Bukry, 1981). New studies (Gartner, 1992; Wei and Peleo-Alampay, 1993; S. Cande and D.V. Kent, unpubl. data) have

Table 1. Occurrence of silicoflagellates in samples from Hole 883B, shown as percentages.

Age	Zone (subzone)	Hole 883B sample (interval in cm)	Sub-bottom depth (m)	Total specimens	*Bachmannocena apiculata apiculata*	*B. apiculata curvata*	*B. apiculata evexa*	*B. apiculata glabra*	*Caryocha* sp.	*Corbisema flexuosa*	*C. triacantha mediana*	*C. triacantha* var. *nuda*	*C. triacantha triacantha*	*Dictyocha deflandrei* (pentagonal)	*Distephanus crux crux* s. ampl.	*D. crux parvus*	*D. crux scutulatus*	*D. longispinus*	*D. quinquangellus*	*D. quintus*	*D. schauinslandii*	*D. speculum binoculus*	*D. speculum diommata*	*D. speculum haliomma*	*D. speculum minutus*	*D. speculum speculum*	*D. speculum triommata*	*D. staurodon*	*Naviculopsis biapiculata*	*N. constricta*	*N. eobiapiculata*	*N. lata*	*N. lata* var. *obliqua*	*N.* sp. aff. *N. navicula* (spines)	*N. ponticula ponticula*	Flora
		66X-1, 22-23	626.5	200	5	8		9	2						16	5	11				4				3	9						2	29		1	
		66X-1, 104-105	627.3	300	5	8	1	7	10			<1	<1		15		11		1		<1				12							2	27	1	<1	
		66X-2, 22-23	628.0	300	2	8		2	15						17	2	7		<1	1	1				11	1						1	31			
		66X-2, 104-105	628.8	300	4	5		3	18						15	1	10		1					<1		17							26			
		66X-3, 22-23	629.5	177	3	18		7	12						8	1	9									10						<1	32			C2
		66X-3, 104-105	630.3	300	3	15		2	7						16		3									8		<1					45			
early Miocene	*Naviculopsis lata*	66X-4, 22-23	631.0	300	4	9		12	19						13	<1	6				<1			<1		4							32	<1		
		66X-4, 104-105	631.8	150	7	19	3	5	0						7	11	3		<1		<1				5	5						7	24	2		
		66X-5, 22-23	632.5	300	9	10	1	4	9						5	16	1		7		5				2	8						18	5			
		66X-5, 104-105	633.3	150	1	5		5	15						3	<1	7	1	5						3	11	<1		1			42	<1		<1	
		66X-6, 22-23	634.0	50	2	4		10	8						4		10				4				16							36	6			C1
		66X-6, 104-105	634.8	300	4	14	3	2	25					<1	1	1	3		2		1	<1			<1	2			1		<1	34	5	1		
		66X-7, 22-23	635.5	300		10	1	1	33						9	3	6		1		3	<1		1	2							27	1	<1		
		67X-1, 19-20	636.2	100	6	14		2						1	2		35		3		28					8			1							
		67X-1, 104-105	637.0	300	5	16	1	1						1	9		29	1	12		10				3	11	1		<1							
		67X-2, 19-20	637.7	200		14	1	4	1					1	9	4	30		8		5	2	1		6	17	1		1							
		67X-2, 104-105	638.5	250		9	<1	5						1	8		30		6		19	2	1		3	12	2		2							B
late Oligocene	*Naviculopsis biapiculata* (*Distephanus speculum haliomma*)	67X-3, 19-20	639.2	300	4	8	1	5							7	1	31	2	6		7	1	1		16	9	1									
		67X-3, 104-105	640.0	200	4	9		3						1	8	1	40		4	1	14	1	1	1	8	5	1		3							
		67X-4, 19-20	640.7	300	6	6		4						2	16		36		3		8			1	8	8	<1		1	<1						
		67X-4, 104-105	641.5	300	4	4				5	2			7	5		16	2	2		16	1		1	18	8	<1		9							
		67X-5, 19-20	642.2	300	2	3		2		3				3	8		28	3	1	<1	6	1			9	13	1		18							
		67X-5, 104-105	643.0	300	3	2								27	10		8		3		13	1	1		4	9	<1		20							
		67X-6, 19-20	643.7	300	3	2		1						37	5		5		2		9	1			7	17	1		8	1						
		67X-7, 19-20	645.2	300	2			1		<1			<1	49	10		7		1		3			1	3	9			13							
		68X-2, 22-23	646.8	300	1	<1				9	2			30	7		13		1		5				1	7	<1		20	2						A
		68X-3, 22-23	648.3	250	3	1				6				6	6		19	3	2		18	<1		<1	15	7	2		11					<1		
		68X-3, 104-105	649.1	300	2	4	1			5				8	16		22		1		14	1	<1		3	8	1		14							
		68X-4, 22-23	649.8	300	3			3		1				15	14		19		4		8	1	<1		7	10	1		13	2						

focused on using paleomagnetic Chron C6CN.2n as a cosmopolitan boundary with an age of about 23.7 to 23.8 Ma.

Cross-correlation of coccolith and silicoflagellate ranges has indicated that much of early Miocene Zone CN1 (coccoliths) belongs to the *N. lata* Zone and most of late Oligocene Subzone CP19b belongs to the *N. biapiculata* Zone/*Distephanus speculum haliomma* Subzone (Bukry, 1981; von Salis, 1993). Note that the late Oligocene age of the upper *N. biapiculata* Zone at Hole 883B is in conflict with diatom results that date Core 145-883B-68X at about 20.1 Ma, well above the Oligocene/Miocene boundary (J.A. Barron, pers. comm., 1993).

The general best-fit relation of these fossil events to an appropriate paleomagnetic event should be developed. For this report, the *N. biapiculata* Zone is assigned to the Oligocene and the *N. lata* Zone entirely to the early Miocene, especially because of the apparent gap in the silicoflagellate succession at this boundary. The discontinuity in occurrences between Cores 67X and 66X of Hole 883B suggests missing section in the lower part of the *N. lata* Zone.

CONCLUSION

Silicoflagellates are common to abundant and moderately well preserved near the Oligocene/Miocene boundary interval of Hole 883B on Detroit Seamount. Distinct shifts in silicoflagellate abundances at the *N. biapiculata*/*N. lata* zonal boundary suggest that the actual Oligocene/Miocene boundary section is missing here. The abundant occurrence of the Oligocene guide species *Dictyocha deflandrei* in Core 145-883B-68X conflicts with early Miocene diatom correlations.

The presence of *N. lata* var. *obliqua* in Core 145-883B-66X indicates the upper part of the *N. lata* Zone and correlates to Japanese floras at the Boso Peninsula. The high abundance of *N. lata* var. *obliqua* at Hole 883B and its absence in coeval beds in the South Pacific and Southern Oceans suggest that it may be an endemic early Miocene guide taxon for the northern Pacific floras.

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B. apiculata glabra (Schulz, 1928) Bukry, 1987
Caryocha sp. Bukry and Monechi, 1985
Corbisema flexuosa (Stradner, 1961) Bukry, 1975
C. triacantha mediana Bukry, 1978
C. triacantha var. *nuda* Bukry, 1982
C. triacantha triacantha (Ehrenberg, 1844) Hanna, 1931
Dictyocha deflandrei Frenguelli, 1940 ex Glezer, 1966
D. fischeri Bukry, 1976
Distephanus crux crux (Ehrenberg, 1840) Haeckle, 1887
D. crux darwinii Bukry, 1976
D. crux parvus (Bachmann in Ichikawa et al., 1967) Bukry, 1982
D. crux scutulatus Bukry, 1982
D. longispinus (Schulz, 1928) Bukry and Foster, 1973
D. quinquangellus Bukry and Foster, 1973
D. quintus (Bukry and Foster, 1973) Bukry, 1981
D. raupii Bukry, 1976
D. schauinslandii Lemmermann, 1901
D. speculum binoculus (Ehrenberg, 1844) Bukry, 1975

Table 2. Summations of generic percents showing main shifts in silicoflagellate abundances at Hole 883B.

Age	Zone (subzone)	Hole 883B sample (interval in cm)	Sub-bottom depth (m)	Total specimens	*Bachmannocena*	*Caryocha*	*Corbisema*	*Dictyocha*	*Distephanus* (quadrangular)	*Distephanus* (hexagonal)	*Distephanus* (pentagonal)	*Naviculopsis*	Flora
early Miocene	*Naviculopsis lata*	66X-1, 22-23	626.5	200	22	2			36	12		32	C2
		66X-1, 104-105	627.3	300	21	10	1		26	12	1	30	
		66X-2, 22-23	628.0	300	12	15			27	12	1	32	
		66X-2, 104-105	628.8	300	12	18			26	17	1	26	
		66X-3, 22-23	629.5	177	28	12			18	10		32	
		66X-3, 104-105	630.3	300	20	7			19	8		45	
		66X-4, 22-23	631.0	300	25	19			20	4		32	
		66X-4, 104-105	631.8	150	34				21	10	<1	33	
		66X-5, 22-23	632.5	300	24	9			27	10	7	23	C1
		66X-5, 104-105	633.3	150	11	15			11	15	5	43	
		66X-6, 22-23	634.0	50	16	8			18	16		42	
		66X-6, 104-105	634.8	300	23	25		<1	6	3	2	41	
		66X-7, 22-23	635.5	300	12	33			21	3	1	28	
late Oligocene	*Naviculopsis biapiculata* (*Distephanus speculum haliomma*)	67X-1, 19-20	636.2	100	22			1	65	8	3	1	B
		67X-1, 104-105	637.0	300	23			1	49	15	12	<1	
		67X-2, 19-20	637.7	200	19	1		1	48	27	8	1	
		67X-2, 104-105	638.5	250	14			1	57	20	6	2	
		67X-3, 19-20	639.2	300	18				48	27	6		
		67X-3, 104-105	640.0	200	16			1	63	17	5	3	
		67X-4, 19-20	640.7	300	16			2	60	17	3	1	
		67X-4, 104-105	641.5	300	8		7	7	39	28	2	9	A
		67X-5, 19-20	642.2	300	7		3	3	45	24	1	18	
		67X-5, 104-105	643.0	300	5			27	31	15	3	20	
		67X-6, 19-20	643.7	300	6			37	19	26	2	9	
		67X-7, 19-20	645.2	300	3		<1	49	20	13	1	13	
		68X-2, 22-23	646.8	300	1		11	30	25	8	1	22	
		68X-3, 22-23	648.3	250	4		6	6	46	25	2	11	
		68X-3, 104-105	649.1	300	7		5	8	52	13	1	14	
		68X-4, 22-23	649.8	300	6		1	15	41	19	4	15	

Notes: Main changes are in Section 67X-4 and between Cores 66X and 67X. The species shifts in Sections 66X-4 and 66X-5 (see Table 1) are not reflected in generic data. Abundance Floras A to C2 are shown.

D. speculum diommata (Ehrenberg, 1845) Bukry, 1979
D. speculum haliomma (Ehrenberg, 1844) Bukry, 1978
D. speculum minutus (Bachmann in Ichikawa et al., 1967) Bukry, 1976, emend. Bukry, 1981
D. speculum speculum (Ehrenberg, 1839) Glezer, 1966
D. speculum triommata (Ehrenberg, 1845) Bukry, 1981
D. staurodon (Ehrenberg, 1844) Bukry, 1978
Naviculopsis biapiculata (Lemmermann, 1901) Frenguelli, 1940
N. constricta (Schulz, 1928) Frenguelli, 1940, emend. Bukry in Barron, Bukry, and Poore, 1984
N. eobiapiculata Bukry, 1978
N. lata (Deflandre, 1932) Frenguelli, 1940
N. lata var. *obliqua* Bukry, 1982
N. sp. aff. *N. navicula* (Ehrenberg, 1840) Deflandre, 1950
N. ponticula ponticula (Ehrenberg, 1844) Bukry, 1976
N. trispinosa (Schulz, 1928) Glezer, 1966

Coccoliths

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Helicosphaera carteri (Wallich, 1877) Kamptner, 1954
H. recta Haq, 1966
Sphenolithus capricornutus Bukry and Percival, 1971
S. ciperoensis Bramlette and Wilcoxon, 1967
S. delphix Bukry, 1973
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Zygrhablithus bijugatus (Deflandre in Deflandre and Fert, 1954) Deflandre, 1959

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