7. CALCAREOUS NANNOFOSSILS FROM DEEP SEA DRILLING PROJECT SITES 442 THROUGH 446, PHILIPPINE SEA

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INTRODUCTION

During DSDP Leg 58 nine holes were drilled at five sites in the northern Philippine Sea (Figure 1). Lower-Miocene to Quaternary calcareous nannofossils were recovered from the three sites in the Shikoku Basin, whereas lower-Eocene to Quaternary assemblages were recovered at the two sites in the Daito Ridge and Basin province. Nannofossils are sporadic at all sites, except Site 445, where abundant nannofossils occur continuously in most cores.

The age and zone assignments of the cores (Table 1), based upon light microscope observation, essentially follow Bukry (1973, 1975). In the Pleistocene, the names and concepts of Bukry's zones are slightly modified to accommodate results of recent studies (Haq et al., 1977; Gartner, 1977). The *Emiliania overta* Subzone is replaced by the *Pseudoemiliania lacunosa* Subzone. The *Crenalithus doronicoides* Zone is not divided into subzones, and its top is marked by the beginning of the acme, instead of by the first occurrence of *Gephyrocapsa oceanica*. In the middle Miocene, the *Helicopontosphaera kamptneri* Subzone is replaced by the *Helicosphaera carteri* Subzone.

The following nannoplankton species are considered in this report:

Amaurolithus bizzarus (Bukry, 1973) Gartner and Bukry, 1975
A. delicatus Gartner and Bukry, 1975
A. primus (Bukry and Percival, 1971) Gartner and Bukry, 1975
A. tricorniculatus (Gartner, 1967) Gartner and Bukry, 1975
Braarudosphaera discula Bramlette and Riedel, 1954
B. bigelowii (Gran and Braarud, 1935) Deflandre, 1947
Bramletteius serraculoides Gartner, 1969
Calciosolenia murrayi Gran [*in* Murray and Hjort], 1912
Campylosphaera dela (Bramlette and Sullivan, 1961) Hay and Mohler, 1967
Catinaster calyculus Martini and Bramlette, 1963
C. coalitus Martini and Bramlette, 1963
Ceratolithus acutus Gartner and Bukry, 1974
C. armatus Müller, 1974
C. cristatus Kamptner, 1950
C. rugosus Bukry and Bramlette, 1968
C. telesmus Norris, 1965
Chiasmolithus altus Bukry and Percival, 1971
C. bidens (Bramlette and Sullivan, 1961) Hay and Mohler, 1967
C. consuetus (Bramlette and Sullivan, 1961) Hay and Mohler, 1967
C. expansus (Bramlette and Sullivan, 1961) Gartner, 1970
C. gigas (Bramlette and Sullivan, 1961) Radomski, 1968
C. grandis (Bramlette and Riedel, 1954) Radomski, 1968
C. solitus (Bramlette and Sullivan, 1961) Locker, 1968
C. titus Gartner, 1970
Coccolithus crassus Bramlette and Sullivan, 1961
C. cribellum (Bramlette and Sullivan, 1961) Stradner, 1962
C. eopelagicus (Bramlette and Riedel, 1954) Bramlette and Sullivan, 1961
C. magnicrassus Bukry, 1971
C. miopelagicus Bukry, 1971
C. pelagicus (Wallich, 1877) Schiller, 1930
C. subdistichus (Roth and Hay, 1967) Bukry [*in* Bukry et al.], 1971
Coronocyclus nitescens (Kamptner, 1963) Bramlette and Wilcoxon, 1967
Cruciplacolithus staurion (Bramlette and Sullivan, 1961) Gartner, 1971
C. tenuiforatus Clocchiatti and Jerkovic, 1970
Cyclicargolithus abisectus (Müller, 1970) Bukry, 1973
C. floridanus (Roth and Hay, 1967) Bukry, 1971
C. pseudogammation (Bouché, 1962) Bukry, 1973
Cyclococcolithus formosus Kamptner, 1963
C. gammation (Bramlette and Sullivan, 1961) Sullivan, 1964
C. kingii Roth, 1970
C. leptopora (Murray and Blackman, 1898) Kamptner, 1954
C. macintyrei Bukry and Bramlette, 1969
Cyclolithus bramlettei Hay and Towe, 1962
Dictyococcites bisectus (Hay, Mohler, and Wade, 1966) Bukry and Percival, 1971
D. hesslandii Haq, 1966 (= *D. scrippsae* Bukry and Percival, 1971)
Discoaster adamanteus Bramlette and Wilcoxon, 1967
D. asymmetricus Gartner, 1969
D. aulakos Gartner, 1967
D. barbadiensis Tan Sin Hok, 1927
D. bellus Bukry and Percival, 1971
D. berggrenii Bukry, 1971
D. bifax Bukry, 1971
D. binodosus Martini, 1958
D. bollii Martini and Bramlette 1963
D. braarudii Bukry, 1971
D. brouweri Tan Sin Hok, 1927
D. calcaris Gartner, 1967
D. challengeri Bramlette and Riedel, 1954
D. deflandrei Bramlette and Riedel, 1954
D. druggii Bramlette and Wilcoxon, 1967
D. exilis Martini and Bramlette, 1963
D. germanicus Martini, 1958
D. hamatus Martini and Bramlette, 1963
D. intercalaris Bukry, 1971
D. kugleri Martini and Bramlette, 1963
D. lodoensis Bramlette and Riedel, 1954
D. moorei Bukry, 1971
D. neohamatus Bukry and Bramlette, 1969
D. nonradiatus Klumpp, 1953
D. pentaradiatus Tan Sin Hok, 1927
D. prepentaradiatus Bukry and Percival, 1971
D. pseudovariabilis Martini and Worsley, 1971
D. quinqueramus Gartner, 1969
D. saipanensis Bramlette and Riedel, 1954
D. signus Bukry, 1971
D. strictus Stradner, 1961
D. sublodoensis Bramlette and Sullivan, 1961
D. surculus Martini and Bramlette, 1963
D. tamalis Kamptner, 1967
D. tani nodifer Bramlette and Riedel, 1954
D. tani tani Bramlette and Riedel, 1954
D. triradiatus Tan Sin Hok, 1927
D. variabilis Martini and Bramlette, 1963
D. wemmelensis Achuthan and Stradner, 1969
Discoasteroides kuepperi (Stradner, 1959) Bramlette and Sullivan, 1961

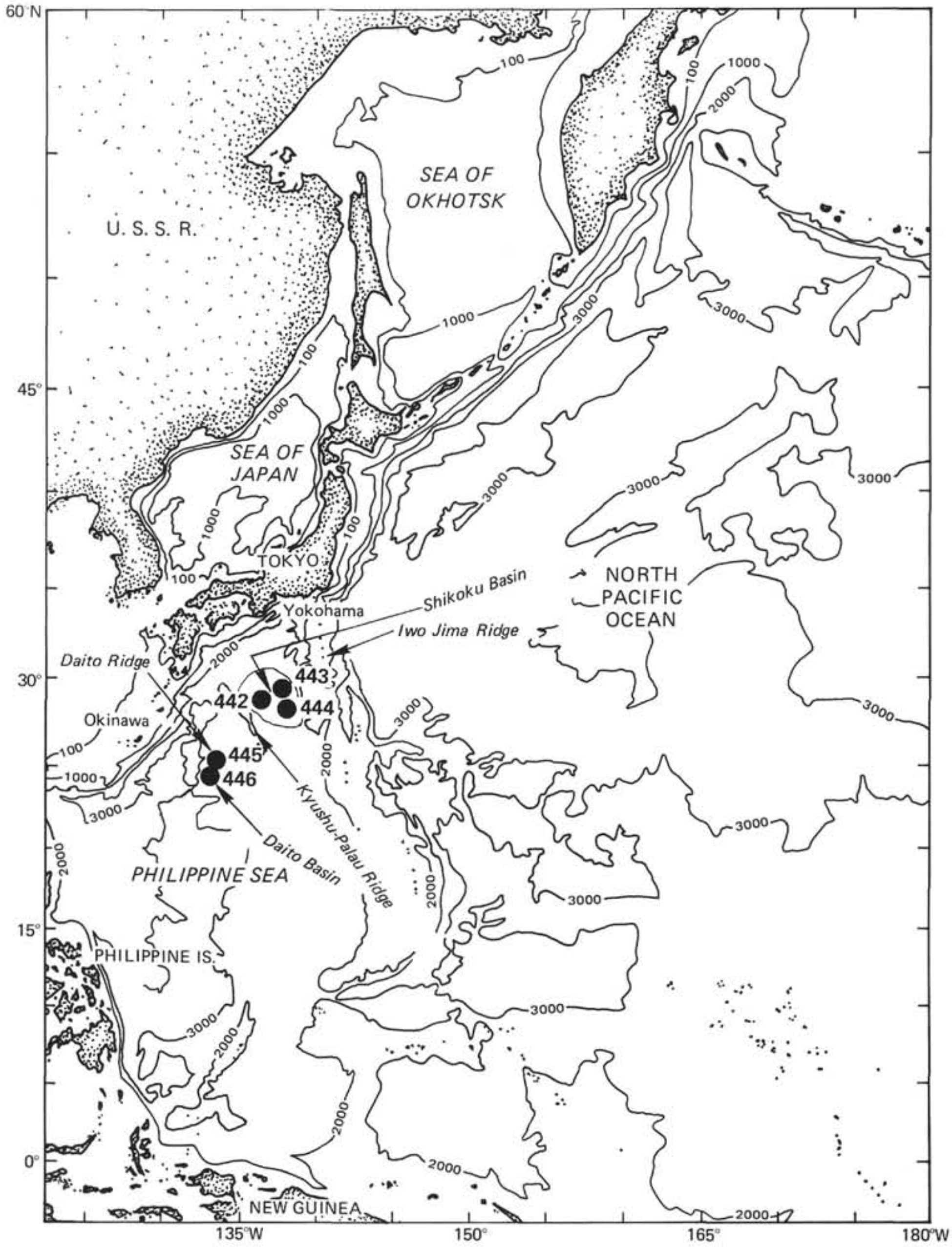

Figure 1. *Location of DSDP Leg 58 sites in the Philippine Sea.*

Discolithina bicaveata Perch-Nielsen, 1967
D. japonica Takayama, 1967
D. multipora (Kamptner [*in* Deflandre], 1959) Martini, 1965
D. plana (Bramlette and Sullivan, 1961) Levin, 1965
D. versa (Bramlette and Sullivan, 1961) Levin and Joerger, 1967
Emiliania huxleyi (Lohmann, 1902) Hay and Mohler [in Hay et al.], 1967
Ericsonia fenestrata (Deflandre and Fert) Stradner [in Haq], 1968
Florisphaera profunda Okada and Honjo, 1973
Gephyrocapsa caribbeanica Boudreaux and Hay, 1967
G. oceanica Kamptner, 1943
Helicosphaera ampliaperta Bramlette and Wilcoxon, 1967
H. carteri (Wallichi, 1877) Kamptner, 1954
H. compacta Bramlette and Wilcoxon, 1967
H. euphratis Haq, 1966
H. granulata (Bukry and Percival, 1971) Jafar and Martini, 1975
H. heezenii (Bukry, 1971) Jafar and Martini, 1975
H. intermedia Martini, 1965
H. lophota (Bramlette and Sullivan, 1961) Jafar and Martini, 1975
H. neogranulata (Gartner, 1977)
H. reticulata Bramlette and Wilcoxon, 1967
H. sellii (Bukry and Bramlette, 1969) Jafar and Martini, 1975
H. seminulum (Bramlette and Sullivan, 1961) Jafar and Martini, 1975
H. wallichii (Lohmann, 1902) Okada and McIntyre, 1977
Isthmolithus recurvus Deflandre [*in* Deflandre and Fert], 1954
Lophodolithus mochlophorus Deflandre [*in* Deflandre and Fert], 1954
L. nascens Bramlette and Sullivan, 1961
Micrantholithus flos Deflandre [*in* Deflandre and Fert], 1954
Nannotetrina fulgens (Stradner, 1960) Achuthan and Stradner, 1969
Neococcolithus dubius (Deflandre, 1954) Black, 1967
Orthorhabdus serratis Bramlette and Wilcoxon, 1967
Pedinocyclus larvalis (Bukry and Bramlette, 1969) Loeblich and Tappan, 1973
Pontosphaera syracusana Lohmann, 1902
Pseudoemiliania lacunosa (Kamptner, 1963) Gartner, 1969

TABLE 1
Zone and Geologic Age Assignments of Leg 58 Cores Based on Calcareous Nannofossils

Age	Zone	Subzone	Hole 442	Hole 442A	Hole 442B	Hole 443	Hole 444	Hole 444A	Hole 445	Hole 446	Hole 446A
Pleistocene	*Emiliania huxleyi*		1,CC	2A-1		1-1-2,CC	1,CC-2-1		1-1-1-5		
	Gephyrocapsa oceanica	*Ceratolithus cristatus*		2A-3-3A-2		3-3-4-3	2,CC-3,CC		1,CC		
		Pseudoemiliania lacunosa		3A-5-5A,CC		4,CC-8-4(?)	4-2-4-5		2-2-3-5		
	Crenalithus doronicoides			7A-1-13A,CC		9-1-13,CC	5-1-6,CC		4-1-6-3		
Pliocene L	*Discoaster brouweri*	*Cyclococcolithus macintyrei*							6-5-9,CC		
		Discoaster pentaradiatus									
		Discoaster surculus							10-4-12-4	2-1	
		Discoaster tamalis				17-4-17,CC	7-2-8-1				
Pliocene E	*Reticulofenestra pseudoumbilica*	*Discoaster asymmetricus*				18-3(?)			13-1-13,CC	2,CC	
		Sphenolithus neoabies							14-1-15,CC		
	Amaurolithus tricorniculatus	*Ceratolithus rugosus*				22-2-22,CC	10-2	1A-1-2A-3	16-2-16-4		
Miocene L		*Ceratolithus acutus*							16,CC-18-2		
		Triquetrorhabdulus rugosus							18-4		
	Discoaster quinqueramus	*Amaurolithus primus*				23-3-24,CC		3A-5-4A,CC	18,CC-22-2		
		Discoaster berggrenii				25-2-26,CC		5A,CC	22,CC-25-3		
	Discoaster neohamatus	*Discoaster neorectus*				30-2-35,CC		9A-4-14A,CC	25-5-27-5		
		Discoaster bellus									
	Discoaster hamatus	*Catinaster calyculus*							27,CC-28-4		
Miocene M		*Helicosphaera carteri*									
	Catinaster coalitus								28,CC-29-4		
	Discoaster exilis	*Discoaster kugleri*		26A-2-28A-1(?)		36-3-36-5		22A-1-22A-4	29,CC		
		Coccolithus miopelagicus				37-1-37,CC			30-2-31-1		
	Sphenolithus heteromorphus			31-1(?)	2B-1	39-2-43-2; 46-1-49-3		22A,CC-23A-1(?)	31-3-35,CC		
Miocene E	*Helicosphaera ampliaperta*										
	Sphenolithus belemnos				9B,CC				36-2-41-1		
	Triquetrorhabdulus carinatus	*Discoaster druggii*									
		Discoaster deflandrei							41-3-45-3		
Oligocene L		*Cyclicargolithus abisectus*									
	Sphenolithus ciperoensis	*Dictyococcites bisectus*							45,CC-47-3		
		Cyclicargolithus floridanus							47-6-52-1		
Oligocene M	*Sphenolithus distentus*								52-3-57,CC	14-5	
	Sphenolithus predistentus										
Oligocene E	*Helicosphaera reticulata*	*Reticulofenestra hillae*							58-2-59-3		
		Cyclococcolithus formosus									
		Coccolithus subdisticus									
Eocene L	*Discoaster barbadiensis*	*Isthmolithus recurvus*							59-4-60,CC		
		Chiasmolithus oamaruensis							61-2-63-1		
	Reticulofenestra umbilica	*Discoaster saipanensis*							63-3-65-1		
Eocene M		*Discoaster bifax*							66-1-71-4		
	Nannotetrina quadrata	*Coccolithus staurion*							72-1-87-2	20-1-23,CC	
		Chiasmolithus gigas									
		Discoaster strictus							88-2-89-6	25-1-29-1	
	Discoaster sublodoensis	*Rhabdosphaera inflata*								30-1-34-4	
		Discoasteroides kuepperi								38-4-39,CC	
	Discoaster lodoensis									40-2-43-2	1A-1-3A-3
Eocene E	*Tribrachiatus orthostylus*										9A-1-28A-1
	Discoaster diasstypus	*Discoaster binodosus*									
		Tribrachiatus contortus									

Reticulofenestra dictyoda (Deflandre and Fert, 1954) Stradner, 1968
R. gartneri Roth and Hay [*in* Hay et al.], 1967
R. hillae Bukry and Percival, 1971
R. pseudoumbilica (Gartner, 1967) Gartner, 1969
R. reticulata Perch-Nielsen, 1971
R. umbilica (Levin, 1966) Martini and Ritzkowski, 1968
Rhabdosphaera clavigera Murray and Blackman, 1898
R. inflata Bramlette and Sullivan, 1961
R. tenuis Bramlette and Sullivan, 1961
R. truncata Bramlette and Sullivan, 1961
Sphenolithus abies Deflandre [*in* Deflandre and Fert], 1954
S. ciperoensis Bramlette and Wilcoxon, 1967
S. conicus Bukry, 1971
S. dissimilis Bukry and Percival, 1971
S. distentus (Martini, 1965) Bramlette and Wilcoxon, 1967
S. furcatolithoides Locker, 1967
S. heteromorphus Deflandre, 1953
S. moriformis (Brönnimann and Stradner, 1960) Bramlette and Wilcoxon, 1967
S. neoabies Bukry and Bramlette, 1969
S. obtusus Bukry, 1971
S. predistentus Bramlette and Wilcoxon, 1967
S. pseudoradians Bramlette and Wilcoxon, 1967
S. radians Deflandré, 1952
Striatococcolithus pacificanus Bukry, 1971
Transversopontos fimbriatus (Bramlette and Sullivan, 1961) Locker, 1972
T. pulcheroides (Sullivan, 1964) Perch-Nielsen, 1971
T. pulchriporus (Reinhaldt, 1967) Sherwood, 1974
Tribrachiatus orthostylus Schamrai, 1963
Triquetrorhabdulus carinatus Martini, 1965
T. inversus Bukry and Bramlette, 1969
T. milowii Bukry, 1971
T. rugosus Bramlette and Wilcoxon, 1967
Umbellosphaera tenuis (Kamptner, 1937) Paasche [*in* Markali and Paasche], 1955
Umbilicosphaera sibogae (Weber-van Bosse, 1901) Gaarder, 1970
Zygrhablithus bijugatus (Deflandre, 1954) Deflandre, 1959

SITE 442 (HOLES 442, 442A, AND 442B) (TABLE 2)

Site 442 is in the west-central part of the Shikoku Basin. Hole 442 was cored only 0.5 meters to obtain necessary technical information for the re-entry operation scheduled at this site. Hole 442A was continuously cored until the first basalt layer was encountered in Core 31. Continuous coring at Hole 442B started about 20 meters above the basalt and recovered 20 cores, mostly basalt.

Quaternary and lower- to middle-Miocene nannofossils occur at this site. Preservation is moderately good to good in the Pleistocene and poor in the Miocene. Most fossils show various degrees of etching, without signs of overgrowth.

The Pleistocene assemblages of Sample 442-1, CC and Cores 2A to 13A are fairly diverse and contain numerous tropical species such as *Ceratolithus cristatus* and *Umbilicosphaera sibogae*. Although not abundant,

TABLE 2
Distribution of Calcareous Nannofossils, Site 442[a]

Age	Zone or Subzone	Hole	Sample (interval in cm)	Sub-bottom Depth (m)	Overall Abundance	Preservation[b]	Etching[c]	Overgrowth[c]	*Calciosolenia murrayi*	*Ceratolithus cristatus*	*C. Telesmus*	*Coccolithus eopelagicus*	*C. Miopelagicus*	*C. pelagicus*	*Cyclicargolithus abisectus*	*C. floridanus*	*Cyclococcolithus leptopora*	*C. macintyrei*	*Discoaster adamanteus*	*D. asymmetricus*
	Emiliania	442	1,CC	0.50	C	G	1	0		F	F			F			C			
	huxleyi	442A	2-1, 50–51	10.00	C	G	1	0		R				R		r	C			
	Ceratolithus		2-3, 52–53	13.02	F	M	2	0		R						r	C			
	cristatus		2,CC	19.00	F	M	2	0		F	R			R			C	r		
			3-2, 105–106	21.55	A	G	1	0	R	F				R			C	r		
	Pseudoemiliania		3-5, 75–76	25.75	F	M	2	0									C			r
	lacunosa		3,CC	28.50	A	M	2	0		R	R			R			F	r		
			4-3, 65–66	32.15	A	G	1	0		R				R			C			
			4,CC	38.00	C	G	0	0						R			F			
			5-3, 102–103	42.02	C	M	2	0		R							F			
			5,CC	47.50	R	M	2	0												
Pleistocene	*Crenalithus*		7-1, 80–81	57.80	A	M	2	0						R			C	R		
	doronicoides		7-4, 68–69	62.18	F	G	1	0									C	F		
			8-1, 80–81	67.30	C	M	2	0						R			C			
			9-2, 102–103	78.02	A	M	2	0		R	R			F			F			
			10-1, 42–43	85.92	F	G	1	0									F	R		
			12-5, 70–71	111.20	C	M	2	0		R				R			C	R		
			13,CC	123.50	C	M	2	0						R			C			
	Discoaster		26-2, 80–81	239.80	R	P	3	0											C	
M	*exilis (?)*		28-1, 95–96	257.45	R	P	3	0						F		F			F	
Miocene	*S. heteromorphus*		31-1, 4–6	285.04	R	P	3	0						C		A			C	
	H. ampliaperta	442B	2-1, 10–11	277.10	A	M	2	0					R	F		A			C	
E	*S. belemnos–D. druggii*		9,CC	353.00	A	P	3	0				F	R	A	F	A	F		C	

[a] In the distribution chart: A = abundant (more than 10% of assemblage); C = common (more than 1%, less than 10%); F = few (more than 0.1% less than 1%); R = rare (less than 0.1%). For overall abundance: A = abundant; C = common; F = few; R = rare. Reworked specimens: c = common; f = few; r = rare.
[b] G = good; M = moderate; P = poor.
[c] 1 = slight; 2 = moderate; 3 - strong.

reworked Pliocene and Miocene forms are frequently observed in this sequence.

Samples 442-1, CC and 442A-2-1, 50–51 cm yield common to abundant *Emiliania huxleyi,* indicating the uppermost Pleistocene to Holocene (*E. huxleyi* Zone). The interval between Samples 442A-2-3, 52–53 cm and 442A-3-2, 105–106 cm is assigned to the *C. cristatus* Subzone; rare *Pseudoemiliania lacunosa* in Sample 442A-3-2, 105–106 cm are considered reworked.

Gephyrocapsa oceanica becomes common above Sample 442A-5, CC, indicating the middle-Pleistocene *P. lacunosa* Subzone for the interval between Samples 442A-3-5, 75–76 cm and 442A-5, CC. Cores 442A-7 to 442A-13, with common *Gephyrocapsa caribbeanica* and few *G. oceanica,* belong to the lower-Pleistocene *Crenalithus doronicoides* Zone. Cores 442A-14 to 442A-25 are barren of nannofossils.

Samples 442A-26, 80–81 cm and 442A-28-1, 95–96 cm yield poorly preserved, rare nannofossils, including *Discoaster bollii, D. exilis,* and *Cyclocargolithus floridanus.* The absence of *Sphenolithus heteromorphus* seems to indicate the *D. exilis* Zone (lower middle Miocene).

Sample 442B-2-1, 10–11 cm contains abundant and moderately well preserved nannofossils of the *S. heteromorphus* Zone or *Helicosphaera ampliaperta* Zone. Sample 442A-31-1, 4–6 cm, collected about 60 cm above a thin limestone directly overlying the first layer of basalt, contains rare nannofossils. Although *S. heteromorphus* does not occur in this sample, common *Discoaster variabilis* indicates the same zones identified for Sample 442B-2-1, 10–11 cm.

After drilling seven cores into basalt, pieces of yellowish-brown and dark-chocolate-brown sediment were recovered in Core 442B-9, CC. Both sediment types contain abundant, but poorly preserved nannofossils of the early Miocene. The occurrence of *Discoaster druggii* indicates the *Sphenolithus belemnos* Zone or *D. druggii* Subzone for this sample. It is not clear whether the tropical species *S. belemnos* was distributed in the Shikoku Basin or not.

SITE 443 (TABLE 3)

Site 443 is in the north-central part of the Shikoku Basin. Lower-Miocene to Quaternary nannofossils occur in 43 of 49 sedimentary cores recovered at this site.

TABLE 2 – *Continued*

D. aulacos	*D. bollii*	*D. deflandrei*	*D. druggii*	*D. exilis*	*D. pentaradiatus*	*D. variabilis*	*Discolithina japonica*	*D. multipora*	*Emiliania huxleyi*	*Florisphaera profunda*	*Geophyrocapsa caribbeanica*	*G. oceanica*	(small *Gephyrocapsa*)	*Helicosphaera carteri*	*H. sellii*	*H. wallichii*	*Pontosphaera syracusana*	*Pseudoemiliania lacunosa*	*Reticulofenestra gartneri*	*R. pseudoumbilica*	*Rhabdosphaera clavigera*	*Sphenolithus abies*	*S. dissimilis*	*S. heteromorphus*	*S. moriformis*	*Thoracosphaera* spp.	*Triquetrorhabdulus carinatus*	*T. milowii*	*Umbellosphaera tenuis*	*Umbilicosphaera sibogae*
									A	A	C	A	F	F			R				R								R ~	F
									C	A	F	A		F		R					R								R ~	C
										A	F	A		F		R													R ~	F
							R	R		C	C	A	F	F		R	R									R			F ~	F
					r	r	R			A	A	A	F	C	r	R	R	R		r	F	r							R ~	F
							R			C	A	C	C	F				F												
										C	C	C	C	R		R		C				r								
										A	A	C	C	R				F		r										R
										C	C	C	A	R				C												R
										A	C	C	C	C				A												F
										C		C	C					A												
										C			F					A		r										R
							R			A	C	F	A					A			R									
							R			C	C	F	A	F				C												F
										A	C		A					C				r								R
										C	C	F	A	F				C												R
										C	C	F	F	F	R			A								R				F
							R			C	C	F	F		R			C												R
	F			C		C																								
	C	C		C		A																								
F		A				C																								
C		A				C													R					R						
		A	R																C				F		C		R	R		

Nannofossils are generally moderately well preserved in the lower and upper Pleistocene, but their preservation is poor elsewhere. Etching prevails, and recrystallization has not taken place except immediately above the sediment/basalt contact.

Nannofossil assemblages in the Quaternary cores (443-1 to 443-13) are similar to those observed at Site 442. However, reworked Pliocene and Miocene fossils are less abundant at this site.

The first *Emiliania huxleyi* in Sample 443-2,CC and the disappearance of *Pseudoemiliania lacunosa* in Sample 443-4-3, 65–66 cm mark the bases of the *E. huxleyi* Zone and the *Ceratolithus cristatus* Subzone, respectively. Although the beginning of the acme of *Gephyrocapsa oceanica* is less obvious here than at Site 442, Sample 443-8-4, 52–53 cm is the lowest which yielded common *G. oceanica.*

The lower-Pleistocene *Crenalithus doronicoides* Zone is identified in Cores 443-9 to 443-13. *Cyclococcolithus macintyrei* still occurs in the upper part of this sequence. This is probably because of reworking, rather than evolution.

The occurrence of *Discoaster tamalis* with other Pliocene discoasters indicates the *D. tamalis* Subzone (lower upper Pliocene) for the lower sections of Core 443-17. Sample 443-18-3, 66–67 cm contains abundant nannofossils, including common *Discoaster asymmetricus* and *D. tamalis,* and few *Reticulofenestra pseudoumbilica.* This sample is assigned to the *D. symmetricus* Subzone (upper lower Pliocene).

Core 443-22 belongs to the *Amaurolithus tricorniculatus* Zone (uppermost Miocene and lowermost Pliocene). Rare *Ceratolithus rugosus* in Sample 443-22-2, 120–121 cm indicate the upper part of this zone (*C. rugosus* Subzone). Rare *Discoaster quinqueramus* in Sample 443-22,CC are regarded as reworked.

Common *D. quinqueramus* together with *Amaurolithus primus* in Cores 443-23 and 443-24 indicates the *A. primuus* Subzone. Cores 443-25 and 443-26 represent the *Discoaster berggrenii* Subzone, and Cores 443-27 to 443-29 are practically barren of nannofossils.

Cores 443-30 to 443-35 belong to the *Discoaster neohamatus* Zone or *Discoaster hamatus* Zone. The absence of key species of the upper upper Miocene, such as *Discoaster hamatus, D. loeblichii, D. neorectus,* and *Catinaster calyculus* prevents detailed age assignment of these cores. The common to few *Cyclicargolithus floridanus* in this interval are considered reworked.

Discoaster kugleri is also absent at this site. Because of the absence of *Discoaster calcaris* and the sudden decrease of *C. floridanus,* Samples 443-36-3, 38–39 cm and 443-36-5, 38–39 cm are assigned to the *Catinaster*

TABLE 3
Distribution of Calcareous Nannofossils, Site 443[a]

Age	Zone or Subzone	Sample[b] (interval in cm)	Sub-bottom Depth (m)	Overall Abundance	Preservation	Etching	Overgrowth	*Amaurolithus delicatus*	*A. primus*	*A. tricorniculatus*	*Calciosolenia murrayi*	*Catinaster coalitus*	*Ceratolithus cristatus*	*C. rugosus*	*Coccolithus miopelagicus*	*Coccolithus pelagicus*	*Coronocyclus nitescens*	*Coronocyclus* sp.	*Cyclicargolithus floridanus*	*Cyclococcolithus macintyrei*	*C. leptopora*	*Discoaster adamanteus*	*D. asymmetricus*	*D. berggrenii*	*D. bollii*	*D. brouweri*	*D. calcaris*	*D. challengeri*
Pleistocene	*Emiliania huxleyi*	1-1, 49–50	0.49	A	M	2	0						F								C							
		1-3, 46–47	3.46	C	M	2	0						F			F					C					r		
		1,CC	7.00	C	M	2	0									F					C							
		2-3, 104–105	11.04	A	M	2	0				R		R			F					C							
		2,CC	16.50	A	M	2	0						F			F					C							
	Ceratolithus cristatus	3-3, 59–60	20.09	F	M	2	0									C					C							
		3,CC	26.00	A	M	2	0				R		F			F					C							
		4-3, 65–66	29.65	C	M	2	0														C							
	Pseudoemiliania lacunosa	4,CC	35.50	C	P	3	0						F								C							
		5-3, 105–106	39.55	C	P	3	0														C							
		5,CC	45.00	F	M	2	0														C							
		6-2, 101–102	47.51	A	P	3	0						R								F							
		6,CC	54.50	C	P	3	0														F							
		7-6, 77–78	62.78	A	P	3	0														A							
		8-4, 52–53	69.02	C	M	2	0									R					C							
	Crenalithus doronicoides	9-1, 66–67	74.16	A	M	2	0														F					r		
		9-5, 66–67	80.16	A	M	2	0						F							R	A							
		10-1, 76–77	83.76	A	M	2	0						F			R				R	C							
		10-5, 20–21	89.20	A	G	1	0						R			R				F	C					r		
		11-3, 98–99	96.48	A	M	2	0						R			F				C	C							
		12-1, 52–53	102.52	C	G	1	0						R			F				F	C							
		12,CC	111.50	F	M	2	0						R			R				C	C					f		
		13,CC	121.00	F	M	2	0						R			R				C	C					r		
Pliocene L	*Discoaster tamalis*	17-4, 20–21	155.20	C	P	3	0							R		F				C	C		F			C		
		17,CC	159.00	F	P	3	0													C	C		F			C		
Pliocene E	*D. asymmetricus*	18-3, 66–67	162.66	A	P	3	0							R		F				C	C		C			C		
	Amaurolithus tricorniculatus	22-2, 120–121	199.70	A	P	3	0	F		R				R		C				C	C		F			C		F
		22,CC	206.50	C	P	3	0	F	R							F				F	F	R		R		C		F
Miocene L	*Amaurolithus primus*	23-3, 21–22	209.71	A	P	3	0	R	R							F				F	C			C		F		C
		24-3, 68–69	219.68	C	P	3	0	R	R							C					C	R		C		F		C
		24,CC	225.50	C	P	3	0		R							C	F			R	C			C		C		C
	Discoaster berggrenii	25-2, 19–20	227.19	A	M	2	0									C				F	F	R		C		F		C
		26,CC	244.50	F	P	3	0															F		C		A		C
	Discoaster neohamatus	30-2, 71–72	275.21	F	P	3	0					A																F
		32,CC	301.50	A	P	3	0									C				R	F	F			F		F	F
		33-1, 132–133	302.82	C	P	3	0									F			F	F	F	F			C		R	F
		33,CC	311.00	C	P	3	0									F			C			F			C			F
Miocene M	*Discoaster hamatus*	34-3, 124–125	315.24	A	P	3	0					R				F			C	F	F	F			C	F	C	
		34,CC	320.50	C	P	3	0									F			F		F	F			F	R	C	
		35,CC	330.00	A	M	2	0								R	F			C	F	F	F			C		F	
	C. coalitus	36-3, 38–39	333.38	A	M	2	0								R	F			F	F	C				F			
	D. kugleri	36-5, 38–39	336.38	A	P	3	0								F	F			C	R	F	F			F			
	Coccolithus miopelagicus	37-1, 132–133	340.82	A	M	2	0								F	C			A	R	C	F			R			
		37,CC	349.00	A	M	2	0								R	C			A	R	F	F			R			
	Sphenolithus heteromorphus	39-2, 49–50	360.49	A	G	1	0								F	C		F	A	F	F	F						
		40-2, 140–141	370.90	A	P	3	0									F			A	R		R						
		41-1, 41–42	377.91	A	M	2	0								R	F		F	A	R	F	F						
Miocene E		43-2, 40–41	398.40	A	M	2	0								C	C		F	A	F	R	F						
	S. heteromorphus	46-1, 65–66	425.65	A	P	3	0											F	A	F								
		48-1, 101–102	445.01	A	M	2	0								R	A			A	F	F	C						
	H. ampliaperta	49-3, 40–41	456.90	C	P	3	0								F				A			C						

[a]See Table 2 for explanation of symbols.
[b]All from Hole 443.

coalitus Subzone or *Discoaster kugleri* Subzone. The nannofossil assemblage in Core 443-37, with abundant *C. floridanus* and no *Sphenolithus heteromorphus,* is indicative of the *Coccolithus miopelagicus* Subzone.

Samples 443-39-2, 49–50 cm to 443-43-2, 40–41 cm yielded assemblages of the *S. heteromorphus* Zone. Cores 443-46 to 443-49 belong either to the *S. heteromorphus* Zone or to the *Helicosphaera ampliaperta* Zone. *H. ampliaperta* was not observed at this site. Although abundant *D. deflandrei* seem to indicate the *H. ampliaperta* Zone for this oldest sedimentary sequence, the possibility of reworking makes definite age identification difficult.

SITE 444 (HOLES 444 and 444A) (TABLE 4)

Site 444, 45 nautical miles southwest of Site 443, was drilled to examine the age of basement which lies on the same magnetic anomaly as that at Site 443.

Hole 444 was continuously cored through the upper sedimentary sequence to a sub-bottom depth of 91.5 meters (10 cores). At Hole 444A, continuous coring was resumed at 82 meters, and 27 additional cores were recovered. Lower-Miocene to Quaternary nannofossils were observed, and the assemblages were found to be similar to those of Site 443, with the exception of a few zones or subzones missing at this site. Despite the great-

TABLE 3 – *Continued*

D. deflandrei	*D. exilis*	*D. intercalaris*	*D. moorei*	*D. neohamatus*	*D. pentaradiatus*	*D. pseudovariabilis*	*D. quinqueramus*	*D. signus*	*D. surculus*	*D. tamalis*	*D. triradiatus*	*D. variabilis*	*Discolithina japonica*	*D. multipora*	*Emiliania huxleyi*	*Florisphaera profunda*	*Gephyrocapsa caribbeanica*	*G. oceanica*	(small *Gephyrocapsa*)	*Helicosphaera carteri*	*H. sellii*	*H. wallichii*	*Orthorhabdus serratus*	*Pontosphaera syracusana*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*Rhabdosphaera clavigera*	*Sphenolithus abies*	*S. heteromorphus*	*S. moriformis*	*S. neoabies*	*Thoracosphaera* spp.	*Triquetrorhabdulus rugosus*	*Umbellosphaera tenuis*	*Umbilicosphaera sibogae*
													R		C	A		A	F	C		F		R											F
															C	A	C	A	C	F				R										R	F
															F	A	C	A	C	F														F	F
													R	R	F	A	C	A	A	C		F		R			R							F	F
													R		F	A	C	A	C	C														R	F
													F			C	C	A	A	C															
																A	A	C	C	C															R
													R	R		C	C	C	C							r									
																A	A	C	C						F										
																A	A	F	C	F	R				F	r						R			
																C	A	C	A						F										
																A	C	F	A	R					C										
																A	C	F	C	R					A										R
																A	F	C	F						C										F
													R			A	F	C	C	F					A										F
													R			C	F	F	F						A										R
																C	F	F	F	R					A										R
													R	R		C	C	F	C	F	R				A	r									R
													R	R		C	C	F	C	F	R				A										F
																C	F		C						C										F
				r												C	C	F	C	F					A										F
		r														C	F	R	C	R					C										
																C	C	F	C	F					A										F
		F			C				F	F	R					A																			
		C			C				C	F	R					C																			
		C			A				F	C		R				C										F									
		C			C				C		R	A				F										C									
		C			C		R		C			A				F										C									
		F			F		C		C			C														A									
		F			F		C		F			C														A									
		F			R		C		R		F	C														C									
		F			F		A		F		R	C														A									
		C					C		C		F	C																							
		C										C																							
F	F	F		R								C														A							R		
C	F	F				F						C														A									
C	F											C														C									
C	F	R										F														A									
C	F	F				F						F														C		R							
F	F					F						C														A									
F	F											C														C		R							
F	F											C														A							F		
R	F											C														F		R					R		
F	F											C														C		R							
F	F							F				C											R			C		R	F	F	F				
F	C							F				C											F										F		
F	F		R									C											R			R			F						
C	C		R									C											R						F	F					
A	F											C											R												
A	R											F																	F	F					
A	R																												R						

er water depth (about 500 m deeper than at Site 443), preservation of nannofossils is generally similar to that at Site 443, or better in some intervals.

Pleistocene assemblages are preserved in Cores 444-1 to 444-6. Although the Pleistocene thickness is less than half that encountered at Sites 442 and 443, all Pleistocene zones and subzones were observed at this site. Reworking is minor for discoasters, but is substantial for placoliths.

Samples 444-1,CC and 444-2-1, 98–99 cm, representing the *Emiliania huxleyi* Zone also contain reworked *Pseudoemiliania lacunosa*. The abrupt decrease of *P. lacunosa* in Sample 444-3,CC is interpreted as an indication of the base of the *Ceratolithus cristatus* Subzone. Core 444-4, representing the *P. lacunosa* Subzone, contains rare to few reworked *Cyclococcolithus macintyrei*.

Cores 444-5 and 444-6 yield nannofossils of the lower-Pleistocene *Crenalithus doronicoides* Zone. As at all the Shikoku Basin sites, the lowest Pleistocene assemblage (occurrence of *Gephyrocapsa caribbeanica* below the first *G. oceanica*) is not recognized.

A well-preserved and diverse assemblage of the *Discoaster tamalis* Subzone (lower upper Pliocene) is observed in Samples 444-7-2, 37–38 cm and 444-8-1, 53–54 cm. The three upper subzones of the *Discoaster brouweri* Zone are missing. Because there is only a maximum of 2 meters of sediment that represents these subzones, a hiatus or a condensed section is suspected. If the rare *D. tamalis* in this part of the section are reworked, then part or most of Cores 444-7 and 444-8 could belong to

TABLE 4
Distribution of Calcareous Nannofossils, Site 444[a]

Age	Zone or Subzone	Hole	Sample (interval in cm)	Sub-bottom Depth (m)	Overall Abundance	Preservation	Etching	Overgrowth	*Amaurolithus delicatus*	*A. primus*	*A. tricorniculatus*	*Catinaster calyculus*	*Ceratolithus cristatus*	*Coccolithus eopelagicus*	*C. miopelagicus*	*C. pelagicus*	*Coronocyclus* sp.	*Cyclicargolithus floridanus*	*Cyclococcolithus macintyrei*	*C. leptoporus*	*Discoaster adamanteus*	*D. asymmetricus*	*D. berggrenii*	*D. bollii*	*D. braarudii*	*D. brouweri*	*D. calcaris*	*D. challengeri*	*D. deflandrei*	*D. exilis*	*D. intercalaris*	*D. moorei*	*D. pentaradiatus*	*D. pseudovariabilis*	*D. quinqueramus*	*D. surculus*	*D. tamalis*	*D. variabilis*	*Discolithina japonica*	*D. multipora*	*Emiliania huxleyi*	*Florisphaera profunda*	*Gephyrocapsa caribbeanica*	*G. oceanica*	(small *Gephyrocapsa*)	*Helicosphaera carteri*	*H. granulata*	*H. sellii*	*H. wallichii*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*Rhabdosphaera clavigera*	*Sphenolithus abies*	*S. heteromorphus*	*S. moriformis*	*S. neoabies*	*Thoracosphaera* spp.	*Triquetrorhabdulus rugosus*	*Umbellosphaera tenuis*	*Umbilicosphaera sibogae*
Pleistocene	*Emiliania huxleyi*	444	1,CC	6.00	F	M	2	0					R							C																			R		C	A	F	A		F				r		R								C
			2-1, 98–99	6.98	F	P	3	0					R							C																					C	A	F	A	C	R			R	r	r								R	F
	Ceratolithus cristatus		2,CC	15.50	F	P	3	0					R						r	C																						A	C	A	C	F				r						r				F
			3,CC	25.00	A	P	3	0					R			R				C																						A	F	A	F					f										F
	Pseudoemiliania lacunosa		4-2, 1–2	26.51	A	G	1	0								F			r	C						r							r						R	R		A	C	C	C	C				A		R								C
			4-5, 20–21	31.20	C	M	2	0								R			f	C																						C	C	C	C					C										F
	Crenalithus doronicoides		5-1, 40–41	34.90	A	P	3	0								R			F	C																						C	F	F	A					A										R
			5-4, 75–76	39.75	F	M	2	0											F	C						r																C	C	F						C										F
			6-1, 41–42	44.41	C	M	2	0								F			F	C																						C	C	F		F				C										F
			6,CC	53.50	A	M	2	0								R			F	C																						C	F	R	F	F		R	R	A										F
Pliocene L	*Discoaster tamalis*		7-2, 37–38	55.37	A	M	2	0					R			F			C	C		R				F					R		F			F	R	F				C				F		R		C	C									
			8-1, 53–54	63.53	A	G	1	0								C	R		C	C		R				F					R		C			F	R	R				C				F			F	C	F		F			R				
E	*Amaurolithus tricorniculatus*		10-2, 115–116	84.65	A	G	1	0	R	R						F	R		F	C						C		F			R		C			F		F				C				F			R		A		F			F				
		444A	1-1, 142–143	83.42	A	G	1	0			R					F	F		F	C						F		R			F		A			C		R				F				F	F				A		C			F	F			
			1-5, 56–57	88.56	A	G	1	0	R							F	R		F	C						C		R					A			C		F				C				R	R				A		F			R				
Miocene			2-3, 133–134	95.83	A	G	1	0		R	R					C	F		C	C			R			C		C			F		C			C		C				F					R				A		F							
	Amaurolithus primus		3-5, 108–109	108.08	A	M	2	0		R		R				C	F		C	C	F		F			F		C			R		C		C	C		C				F				R	R				A		F							
			4,CC	120.00	A	M	2	0	R	R				R		C	R		F	C	R		F			C		C			F		F		C	C		F								F		R			A		R							
L	*D. berggrenii*		5,CC	129.50	F	P	3	1	R							C			C	C	F		F			C		C			F				C	C	R	C													C									
			9-4, 72–73	163.22	A	M	2	0						F		F			C	F	F			F		F		F	R									A													A									
	Discoaster neohamatus		10-1, 81–82	168.31	A	P	3	0						R		C			F	F	F			F		F		F	F			R						C													A									
			10,CC	177.00	A	G	1	0						F		A	R	F	C	F	F			C		F	F	R	C			R		F				C													A		F			F				
			11-3, 62–63	180.62	A	M	2	0						F		C	R	C	C	F	F			C		F	C		F			F		C				C													A		R			F		F		
			12-1, 100–101	187.50	A	M	2	0						F		F		C	F	F	R			F	R		C		F					C				C													A					R				
			12-3, 5–6	189.55	A	G	1	0						R		C	F	C	F	C	F			R			F		C					F				C										F				A		R			F		R		
	Discoaster hamatus		13-2, 75–76	198.25	C	P	3	0										A			C			F			R		F	F				F				C																						
			14-3, 61–62	209.11	F	P	3	0										R			F			F			F		C	C								C																						
M			14,CC	215.00	F	P	3	0										C			C			C			F		C	C								C																						
	D. exilis (?)		22-1, 16–17	262.66	C	P	3	0							F			C			C			C					A	F								C																						
			22-4, 70–71	267.70	C	P	3	0							F			A			C			F					C	F								C																						
	S. heteromorphus		22,CC	272.00	A	M	2	1							R			A	F	F	C								A									C															R	C	F	F				
E	*H. ampliaperta*		23-1, 60–61	272.60	A	M	2	1							C			A		C	C								C									C															R	C	F	F				

[a]See Table 2 for explanation of symbols.

the upper upper Pliocene. Nannofossils are sporadic in the Pliocene, and definite conclusions are difficult to draw.

Core 444-10 and Samples 444A-1-1, 142–143 cm to 444A-2-3, 133–134 cm contain a well-preserved assemblage of the *Amaurolithus tricorniculatus* Zone. Samples 444A-3-5, 108–109 cm and 444A-4,CC yield an assemblage of the *Amaurolithus primus* Subzone (upper upper Miocene), whereas the absence of *A. primus* in Sample 444A-5,CC indicates the older *Discoaster berggrenii* Subzone. Cores 444A-6 to 444A-8 are barren of nannofossils.

Discoaster calcaris first occurs in Sample 444A-14,CC, indicating the *Discoaster neohamatus* Zone or *D. hamatus* Zone for Cores 444A-9 through 444A-14. As at Site 443, the absence of key species prevents detailed age assignment of these cores.

Cores 444A-15 to 444A-18 are barren of nannofossils, and the first basalt layer was encountered in Core 444A-19. Below this igneous layer, Cores 444A-21 to 444A-23 recovered more sediment. Although Core 444A-21 is barren, many intervals in Core 444A-22 and Section 444A-23-1 contain abundant nannofossils.

In the upper four sections of Core 444A-22, a poorly preserved nannoflora is observed. The assemblage consists of only two placolith and five discoaster species, and the absence of *D. calcaris* and *Sphenolithus heteromorphus* seems to indicate the *Discoaster exilis* Zone (lower middle Miocene).

Nannofossils are overgrown in Sections 444A-22,CC and 444A-23-1 immediately above the second layer of basalt. Within this short interval, the degree of etching is reduced, but the severity of recrystallization greatly increases toward the sediment/basalt contact. The assemblage in Samples 444A-22,CC and 444A-23-1, 60–61 cm indicates the *S. heteromorphus* Zone or *Helicosphaera ampliaperta* Zone; thus, the oldest sediment recovered at this site is the same age as that found at Site 443.

SITE 445 (TABLES 5 and 6)

Site 445, in a small basin in the Daito Ridge, was continuously cored to 892 meters, and 94 cores of sediment were recovered. No basalt was reached at this site, and middle-Eocene to Quaternary nannofossils were observed. Because of heavy and continuous reworking, the age assignment of cores is limited. All reworked specimens observed at this site represent a few zones prior to the time of redeposition.

Nannofossils are well preserved in the upper sequence (upper upper Miocene and above); only slight etching and negligible recrystallization were recognized. Slight etching and moderate to heavy overgrowth were observed in the lower cores. Recrystallization of nannofossils is strongest in the Oligocene and becomes less severe in the middle-Eocene turbidites.

Core 445-1 contains a late-Quaternary assemblage of the *Emiliania huxleyi* Zone and *Ceratolithus cristatus* Subzone. In addition to the lower-Pleistocene and Pliocene species, some reworked older forms, such as *Cyclicargolithus floridanus* and *Sphenolithus moriformis,* were also observed. Although the *C. cristatus* Subzone is recognized only in Sample 445-1,CC, part or all of Core 445-2 could belong to this zone if the common specimens of *Pseudoemiliania lacunosa* in Core 2 are reworked. The bases of the lower-Pleistocene *P. lacunosa* Subzone and the *Crenalithus doronicoides* Zone are recognized within Samples 445-3-5, 28–29 cm and 445-6-3, 52–53 cm, respectively.

Samples 445-6-5, 52–53 cm through 445-12-4, 44–45 cm contain an upper-Pliocene assemblage of the *Discoaster brouweri* Zone. *Florisphaera profunda* first becomes abundant in the lower part of this zone. The base of the *Discoaster pentaradiatus* Subzone is identified in Sample 445-9,CC, but other subzone boundaries are obscured by reworking.

Cores 445-13 to 445-15 contain an assemblage of the lower-Pliocene *Reticulofenestra pseudoumbilica* Zone, and the base of Core 445-13 represents the boundary of subzones within this zone. Samples 445-16-2, 54–55 cm to 445-18-4, 15–16 cm represent the *Amaurolithus tricorniculatus* Zone, and all three subzones were identified.

Nannofossils indicative of the upper-Miocene *Discoaster quinqueramus* Zone occur in Samples 445-18,CC through 445-25-3, 65–66 cm, and the first *Amaurolithus primus* in Sample 445-22-2, 23–24 cm indicates the base of the *A. primus* Subzone. The first occurrence of *Florisphaera profunda* was observed in the upper part of this subzone.

Samples 445-25-5, 65–66 cm to 445-27-5, 11–12 cm belong to the *Discoaster neohamatus* Zone. The absence of key species prevents identification of the subzones. The *Catinaster calyculus* Subzone (lower upper Miocene) is identified in Samples 445-27,CC to 445-28-4, 81–82 cm. *C. calyculus* and *C. coalitus* are abundant in some samples, and *Discoaster hamatus* is also common in this interval.

D. hamatus and *C. coalitus* do not occur below Sample 445-28-2, 81–82 cm, making age assignment very difficult for the upper middle Miocene. The rare occurrence of *Discoaster kugleri* only in Sample 445-29,CC indicates that Samples 445-28,CC to 445-29-4, 49–50 cm belong to the *Helicosphaera carteri* Subzone or to the *C. coalitus* Zone.

Core 445-30 and Sample 445-31-1, 80–82 cm are assigned to the *Coccolithus miopelagicus* Subzone, and the few specimens of *Sphenolithus heteromorphus* in these samples are considered reworked.

The assemblage in Samples 445-31-3, 80–82 cm to 445-35,CC represents the *S. heteromorphus* Zone or the *Helicosphaera ampliaperta* Zone (lower middle to upper lower Miocene). Reworking and the very limited occurrence of *H. ampliaperta* prevent separation of these zones. Samples 445-36-2, 30–31 cm to 445-41-1, 42–43 cm represent the *Sphenolithus belemnos* Zone or the *Discoaster druggii* Subzone. The absence of *S. belemnos* prevents separation of these two zones at this site.

Samples 445-41-3, 42–43 cm to 445-45-3, 120–121 cm belong to the lowermost-Miocene *Discoaster deflandrei* Subzone or the upper-Oligocene *Cyclicargolithus abisectus* Subzone. Because of strong reworking, the Oligo-

TABLE 5
Distribution of Neogene Calcareous Nannofossils, Site 445[a]

Age	Zone or Subzone	Sample (interval in cm)[b]	Sub-bottom Depth (m)	Overall Abundance	Preservation	Etching	Overgrowth	*Amaurolithus bizzarus*	*A. delicatus*	*A. primus*	*A. tricorniculatus*	*Calciosolenia murrayi*	*Catinaster calyculus*	*C. coalitus*	*Ceratolithus armatus*	*C. cristatus*	*C. rugosus*	*C. telesmus*	*Coccolithus miopelagicus*	*C. pelagicus*	*Coronocyclus nitescens*	*Coronocyclus* sp.	*Cyclicargolithus abisectus*	*C. floridanus*	*Cyclococcolithus macintyrei*	*C. leptopora*	*Dictyococcites bisectus*	*Discoaster adamanteus*	*D. asymmetricus*	*D. bellus*	*D. berggrenii*	*D. bollii*	*D. braarudii*	*D. brouweri*
Pleistocene	*Emiliania huxleyi*	1-1, 6-7	0.06	A	G	0	0					R				F		R		R				r	r	F								
		1-3, 103-104	4.03	A	G	1	0									F				C				f	f	C		f	f					f
		1-5, 9-10	6.09	A	G	1	0									F				R					r	C								r
	C. cristatus	1,CC	8.50	A	G	1	0					R				R				R				r	f	C								
	Pseudoemiliania lacunosa	2-2, 42-43	10.42	A	G	1	0					R				R				R				r		F								
		2-4, 31-32	13.31	A	G	0	0									R				R						F								
		3-1, 128-129	19.23	A	G	1	0									R				R						F								
		3-3, 73-74	21.73	A	G	1	0									F				R						C								
		3-5, 28-29	24.28	A	G	1	0					R				F		R		R						C								
	Crenalithus doronicoides	4-1, 48-49	27.98	A	G	1	0									F				R					R	C								f
		4-3, 48-49	30.98	A	G	1	0									R				R					R	F								r
		4,CC	37.00	A	G	0	0									F				F					F	C								f
		5-3, 29-30	40.29	A	G	0	0									F				F					F	C								
		6-1, 52-53	47.02	A	G	0	0									R				R					C	C								
		6-3, 52-53	50.02	A	G	0	0									F				R					C	C								
Pliocene L	*Cyclococcolithus macintyrei*	6-5, 52-53	53.02	A	G	1	0									R				F					C	F								C
		7-2, 42-43	57.92	A	G	1	0									R				F					C	C		R						C
		7-5, 42-43	62.42	A	G	1	0									R				F					C	F								C
	Discoaster pentaradiatus	8-2, 16-17	67.16	A	G	0	0									R				C	R				F	C								C
		8-5, 16-17	71.66	A	G	0	0									F		R		R					C	F								C
		9,CC	84.50	A	G	0	0									F	R			F					C	F								C
	Discoaster surculus	10-4, 44-45	89.44	A	G	0	0									R	R			F					F	C			R					C
		11-2, 53-54	96.03	A	G	0	0									R	F			C					C	C			R					C
		11-4, 53-54	99.03	A	G	1	0									R	F			F					F	C			R					F
	Discoaster tamalis	12-1, 44-45	103.94	A	G	0	0									R	R			F		R			C	C			F					C
		12-4, 44-45	108.44	A	G	0	0			r						R	R			F		F			C	C		R	R					C
E	*Discoaster asymmetricus*	13-1, 89-90	113.89	A	G	0	0				r					R	F			R		F			F	C		F	C					C
		13-3, 89-90	116.89	A	G	0	0									R	F			F		F			C	C		F	C					C
		13,CC	122.50	A	G	0	0		r		r				R	F	F			F		F			C	F		F	F					C
	Sphenolithus neoabies	14-1, 56-57	123.06	A	G	0	0									R	R			F		F			C	C		R	R					C
		14,CC	132.00	A	G	0	0		r								F			R		F			F	C		R						F
		15-2, 54-55	134.04	A	G	1	0										F					F			C	C		F						F
		15,CC	141.50	A	G	0	0										F					F			F	C		R						C
	Ceratolithus rugosus	16-2, 54-55	143.54	A	G	0	0			R	R						R			F		F			F	C		R						F
		16-4, 54-55	146.54	A	G	0	1	R	R	R	R						R			C		F			C	C		R						C
Miocene L	*C. acutus*	16,CC	151.00	A	G	0	1		R	R										C		C			F	C		R						C
		17,CC	160.50	A	G	0	0		F		R									F		R			F	C		R						C
		18-2, 15-16	162.15	A	G	0	0			R										C		F			F	C		F	R					C
	T. rugosus	18-4, 15-16	165.15	A	G	1	0		R	R										C		F			F	C			R					C
	Amaurolithus primus	18,CC	170.00	A	G	0	1			R										C	R	F			F	C			R		R			F
		19-2, 74-75	172.24	A	G	1	1			R										A		F			C	C		R			C			A
		19,CC	179.50	A	G	1	0		R	F										C	R	C			F	C		F			F			C
		20-2, 75-76	181.75	A	G	1	1													A		C			F	F		R			C			A
		21-1, 99-100	189.99	A	G	1	1			R										A		F		r	F	C		F			A			A
		21,CC	198.50	A	G	1	1		R	R										A	R	C		r	F	A		F			C			C
		22-2, 23-24	200.23	A	G	1	1			R										C	R	C		r	F	F		R			F			C
	Discoaster berggrenii	22,CC	208.00	A	G	1	1													C	R	R		r	C	F		F						C
		23-2, 117-118	210.67	A	G	1	1													C	F	F			F	F		F			F			F
		24-1, 78-79	218.28	A	M	2	1													A	R	R			C	F		R			F			C
		24-5, 78-79	224.28	A	M	2	1						r							A		F			F	C		R			F			C
		25-3, 65-66	230.65	A	M	2	0													C		F			F	C		R		R	R			A
	Discoaster neohamatus	25-5, 65-66	233.65	A	M	2	0													C		F			F	F		F		F				A
		26-1, 78-79	237.28	A	P	3	0													C					C	F		F		R			C	C
		26-4, 78-79	241.78	A	M	2	0													F		F			F	F		R	R	F			C	C
		27-2, 11-12	247.66	A	M	2	0													C	R	R			F	F		R		R			A	C
		27-5, 11-12	252.11	A	M	2	0						C	F						C		R			C	F		F		F		R	C	F
	Catinaster calyculus	27,CC	255.50	A	M	2	0						A	F						C					F	F		F		F		F	F	R
		28-2, 81-82	257.81	A	M	1	2						C	A						C				f	C	F		C		F			F	
		28-4, 81-82	260.81	A	M	2	1						R							C				f	C	F		C				F	F	
	H. carteri	28,CC	265.00	A	M	2	1													A					C	C		R						
		29-2, 112-113	267.62	A	M	2	1												R	A		R		f	C	F		F				C	R	
	C. coalitus	29-4, 49-50	269.99	A	M	2	1												R	A					C	F		F				F	F	
	D. kugleri	29,CC	274.50	A	P	3	1													F					C	C		F				F	R	
M	*Coccolithus miopelagicus*	30-2, 48-59	276.48	A	M	1	2												F	A					C	F		F					F	
		30-4, 48-49	279.48	A	M	1	2												F	C	R	R		C	C	F		R						
		31-1, 80-82	284.80	A	M	1	2												R	C	F	F		A	F	F								
	Sphenolithus heteromorphus	31-3, 80-82	287.80	A	M	1	2												F	C	F	F		A	F	C		F						
		31-6, 80-82	292.30	A	P	2	2												F	C	R	F		A	F	C		F						
		32-3, 28-29	296.78	A	P	2	2												R	F	R	F		A	F	F								
		33-2, 29-30	304.79	A	M	1	2												F	C				A	F	R								
	Helicosphaera ampliaperta	33,CC	312.50	A	M	1	2													F	R		R	A	F									
		34-4, 51-52	317.51	A	M	1	2												F	C	F		F	A	F		r							
		35-2, 85-86	324.35	A	M	1	2												F	F	F		F	A	F	R	r	C						
		35,CC	331.50	A	M	1	2												R	F	R		R	A	R	R	r	F						
E	*Sphenolithus belemnos*	36-2, 30-31	333.30	A	M	1	2												F	C	F		C	A	F			F						
		36,CC	341.00	A	P	2	2												R	C	F		C	A	F									
		37-3, 82-83	344.82	A	M	1	2												F	C	R		F	A	R	R		R						
		38-1, 37-39	350.87	A	M	1	2												F	C	R		C	A	R		f	R						
		38-5, 39-41	356.89	A	M	1	2												F	C			C	A	R		r							
	Discoaster druggii	39-2, 70-71	360.70	A	P	2	3												R	F			F	A	R		r	R						
		39,CC	369.50	A	M	1	2												C	C	R		C	A				R						
		40-3, 77-78	373.27	A	M	1	2												F	R	R		C	A			f							
		41-1, 42-43	379.42	A	M	1	2												C	C	R		C	A										

[a]See Table 2 for explanation of symbols. All from Hole 445.

TABLE 5 – *Continued*

D. calcaris	*D. challengeri*	*D. deflandrei*	*D. druggii*	*D. exilis*	*D. intercalaris*	*D. kugleri*	*D. hamatus*	*D. moorei*	*D. neohamatus*	*D. pentaradiatus*	*D. prepentaradiatus*	*D. quinqueramus*	*D. signus*	*D. surculus*	*D. tamalis*	*D. variabilis*	*Discolithina japonica*	*D. multipora*	*Emiliania huxleyi*	*Florisphaera profunda*	*Gephyrocapsa caribbeanica*	*G. oceanica*	(small *Gephyrocapsa*)	*Helicosphaera ampliaperta*	*H. carteri*	*H. granulata*	*H. intermedia*	*H. neogranulata*	*H. sellii*	*H. wallichii*	*Pseudoemiliania lacunosa*	*Ceratolithus acutus*	*Reticulofenestra pseudoumbilica*	*Rhabdosphaera clavigera*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. conicus*	*S. dissimilis*	*S. heteromorphus*	*S. moriformis*	*S. neoabies*	*Thoracosphaera* spp.	*Triquetrorhabdulus carinatus*	*T. milowii*	*T. rugosus*	*Umbellosphaera tenuis*	*Umbilicosphaera sibogae*
										r									A	A		A	F		C				r	R	r			C						r		R				R	C
										c				f				R	C	A	C	C	C		C					R	c		r	F		r				r		R					F
														r					C	A	F	A	F		F					R	f			F													F
																				A		A	R		C					R				C								R				F	C
					r												R	R		A	C	C	C		C				r		C			C		r						R					F
																				A	F	R	C		F						C			F								R					R
																	R	F		A		C	C		C				r		A		r	C								F					F
																		R		A		C	A		C				F	R	C			C								F					C
																	R	F		A		C	C		C					R	A			C								R					F
										r				r						A	F	F	F		F			R	R		A		r	C													F
										r				r				R		A	C	F	A		F				R	R	A		r	C								R					C
		r								f					r	r		R		A	C	F	C		C			R	R		A		f	C	R	r						F					F
										r				r				R		A	C	F	C		C					F	A			C								R					F
										r										A			C		C			R	R		A			C								F					R
																				A	R		C		C				R		A			C								F					
										R				r						A			F		R			R		R	A			F								R					
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										F								R		A					F				F	R	A			F		r											
					R					C								R		A					F				F	F	A			C	R							R					
										R										A					C					F	C			C								F					
																				A					C				R	F	A			C								R					
					F					A				F	F			R		C					F				F	F	C		c	C								R					
					R					A				F	F			R		A					F					F	C			F								R					
					F					A				C	F	R				C					F					R	C			F	R	r						R					
		r			R					A				C	F					C					C					F	F		f	F	R							R					
					F					C				C	C			R		C					F					R	F			F		R											
	F				F					C				C		C		R		C					C						R		A	R	R												
	R				R					C				C	R	R				F					C					R			C	R	R	F					R	R					
	R				C					A				C	R	F		R		F					F								C	R		F					R						
	F				F					C				C	R	F				F					F								C		R	F					R	R					
	F				F					C				C		F		F		F					F								A	R	R	C											
	R				F					A				C		R		R		R										R			C	R		R											
					C					A				C		R				F					F								A			F					R						
	F				C					C				C		C				F					F								C		F	C											
	C				C					C				C		C				F					F								C		R	F											
	F				F					C				C		C				R					F				R				C		R	F					R						
	R				F					C				C				F		F					F								C			F											
	F				C					C				C		C				F					F							R	C		R	F											
r	C				F					C				F		C																	A			R									R		
	F	r			F					C		F		F		C				R					F								A		R	F				R	R	R			R		
	F				F					F		C		F		C									R	R				R			F			F				R	R	R			R		
	F	r			F					C		C		F		C										F							A		R	F									R		
	F	r			F					F		A				C		R								F							F			C				F	R				R		
	F				R					F	R	C		R		F									F	F							F			F				R					F		
	C	f			F					F	R	C		R		C										R							A		R	F									F		
	R	r			R					F	R	C		F		F									R	F			R				C			F				F					F		
	C	f								R	R					C									R	R							A			F				R					F		
	F				F					F		A		F		F										F							A		R	R									R		
	F				F					F		A		C		C										R			R				A			F									R		
	C				R					F		C		F		C									F	R							F			C									R		
	F				R				R	R		A		R		C																				F									F		
	F								R	F		C				C									R	R							C			R				F					F		
	F								F	F						A																	C														
	R								F	F	F					A																	A			F									F		
									C	F	F					C																	A			R									F		
	R								F	F	F					C										F							A			R									R		
R	F						C									A																	A			F				R					F		
	F						F				R					A																	A												R		
R	R															A																	A							R					F		
R		R									R					A																	C												R		
F		F						R								C																	A			R			r						F		
F		F														C																	A			R									F		
		F		F		R		R								C																	C						r	R					F		
		C		C				R								C																	A								F		r		R		
		C		C				F					R			C																	C						f		C		f		R		
		F		F				R					R			C																	F						f		C						
		C		C				F								C										R							R						C	R	F			R			
		C		C				F								F																							C	R	R						
		A		F				F								F										R											R		A	C	R		r				
		A						F								F																							A	F	F						
		A																																					A	C	F						
		A						R																R															C	F	C		f	R			
		A	R																																				C	F	C		f	R			
		A	R																																				F	F				R			
		A	R					R																																C			F	F			
		A	F																																			R		C			F	R			
		A	R													R																					R	F		C	F		F	R			
		A	R																								R											F		C	F		R	R			
		A	R																																			C		C			F	F			
		A	R																																			F		C				F			
		A	C																																			C		F			F	F			
		A																																			F	C		C			F				
		A	F																																			C		C			F	R			

TABLE 6
Distribution of Paleogene Calcareous Nannofossils at Site 445[a]

Age	Zone or Subzone	Sample[b] (interval in cm)	Sub-bottom Depth (m)	Overall Abundance	Preservation	Etching	Overgrowth	*Braarudosphaera bigelowi*	*Bramletteius serraculoides*	*Campylosphaera dela*	*Chiasmolithus altus*	*C. consuetus*	*C. expansus*	*C. gigas*	*C. grandis*	*C. solitus*	*Coccolithus cribellum*	*C. eopelagicus*	*C. miopelagicus*	*C. pelagicus* s.l.	*C. subdistichus*	*Coronocyclus nitescens*	*Cruciplacolithus staurion*	*Cyclicargolithus abisectus*	*C. floridanus*	*C. pseudogammation*	*Cyclococcolithus formosus*	*C. gammation*	*C. kingi*	*Cyclolithus bramlettei*	*Dictyococcites bisectus*	*D. hesslandii*	*Discoaster adamanteus*	*D. barbadiensis*
Oligocene L	*Discoaster deflandrei*	41-3, 42–43	382.42	A	M	1	2												F	F		F		F	A							R	F	
		41-6, 42–43	386.92	A	M	2	2												R	C				C	A						R	F	R	
		42-3, 19–20	391.69	A	M	2	2												F	C				C	A						R	R	F	
		42,CC	398.00	A	M	2	2											R	R	C				F	A							F	R	
		43-3, 90–91	401.90	A	M	1	2										R	R	F	C				C	A						R	F	F	
	Cyclicargolithus abisectus	43,CC	407.50	A	M	1	2		R								R			C	R			C	A						F	F	R	
		44-3, 120–121	411.70	A	M	1	2										F	F	R	C	R	R		C	A						F	F	F	
		44,CC	417.50	A	M	1	2										F	F		A		R		C	A						F	F	F	
		45-3, 120–121	421.20	A	M	1	2										F	R	R	A	R			C	A						C	F	F	
	Dictyococcites bisectus	45,CC	426.50	A	M	1	2										F	R	R	C	R			C	A						C	C	R	
		46-3, 94–95	430.44	A	M	1	2											F	R	C	R	R		F	A						C	C		
		46,CC	436.00	A	M	1	2										R	R		A		R		C	A						F	F	R	
		47-3, 48–49	439.48	A	M	1	2										R	F		C	R	R		C	A						F	F	R	
Oligocene M	*Cyclicargolithus floridanus*	47-6, 48–49	443.98	A	M	1	2										R	R		C	R	R		C	A						F	F		
		48-3, 94–95	449.44	A	M	1	2		R		R						R	R		C	F	R		C	A						F	F		
		48,CC	455.00	A	M	1	2				R						R	F		C	R			C	A						F	F		
		49-3, 85–86	458.85	A	M	1	2		R		R							R		C	F	R		C	A						F	F		
		50-2, 51–52	466.51	A	M	1	2										R	F		C	R	R		C	A						F	F	R	
		51-3, 10–11	477.10	A	M	1	2										R	R		F	F			F	A						C	F	R	
		52-1, 13–14	483.63	A	M	1	2										R	R		C	R	R		F	A						C	C	R	
	Sphenolithus distentus	52-3, 13–14	486.63	A	M	1	2										R	R		C	R	R		F	A						C	F		
		53-3, 51–52	496.51	A	M	1	2										R	F		C	R	R		F	A						F	C	R	
		54-3, 51–52	506.01	A	M	1	3										R	F		C	R	R		F	A						F	F		
		55-3, 55–56	515.55	A	M	1	3										R	R		A	F			F	A						F	C		
		56-3, 46–47	524.96	A	M	1	3		R								R	F		C	R				A						C	F		
		56-5, 46–47	527.96	A	M	1	3		R		R						R	F		A	R				A		r				F	C		
		57-2, 85–86	533.35	A	M	1	3		F								R	F		C	F				A		r				F	F		
		57-4, 85–86	536.35	A	M	1	2		C								F	F		A	F				A		c				C	F	R	
		57,CC	540.50	A	G	0	1		F									R		A	F				A		f		R		C	C		
	S. predistentus	58-2, 48–49	542.48	A	M	1	2		C								F	F		A	F				A		F		R		C	C		f
Oligocene E		58-4, 48–49	545.48	A	M	1	2		F								F	F		C	F				A		F				C	C	R	
	H. reticulata	59-1, 23–24	551.73	A	P	2	3		F									R		C	F				C		F		R		C	A		
		59-3, 23–24	553.23	A	P	2	3		F									R		C	F				C		F				C	A	R	
Eocene L	*Isthmolithus recurvus*	59-4, 23–24	554.73	A	P	2	3		F								R	R		A	F				C		C		R		C	A		R
		59-6, 23–24	557.73	A	P	2	3		F									F		C	F				A		C		R		C	A		C
		60-2, 63–64	561.63	A	M	1	2		R									R		A	F				C		C		F		F	C		A
		60-4, 63–64	564.63	A	M	1	2		R								R	R		C	R				C		C		R	R	C	C		A
		60,CC	569.00	A	M	1	2											R		C	R				F		C		R		C	A		A
	Chiasmolithus oamaruensis	61-2, 95–96	571.45	A	P	2	3		R									F		C					C		C				A	A		C
		61-4, 95–96	574.45	A	P	2	3		R									R							C		R				C	A		A
		61,CC	578.50	A	P	3	3											R							C						C	A		A
		62-2, 58–59	580.58	A	P	2	3											F		F					C		F				C	A		A
		62-5, 58–59	585.08	A	M	1	2		R									F		C					F		F		R		C	A		C
		63-1, 90–91	588.90	A	P	2	3		R									C		R					C		F			R	R	C		C
	Discoaster saipanensis	63-3, 90–91	591.90	A	M	2	2								R			F		F					A		F		R	R	F	A		C
		63,CC	597.50	A	M	2	2								R			F		F					A		F			R	F	A		C
		64-2, 133–134	600.33	A	P	3	2		R	R					R			R		R					C		F		R		C	A		F
		64-4, 133–134	603.33	A	P	3	2		R						R			F		F					C		R				F	A		C
		64-6, 133–134	606.33	A	M	2	2		R						R			R		F					A		F				C	A		C
		65-1, 41–42	607.42	C	M	2	2			R								R							C		R				F	A		A
Eocene M	*Discoaster bifax*	66-1, 43–45	616.93	A	M	1	2		R	R					F	R		F		C			R		A		F	R	F					C
		67-1, 77–78	626.77	A	M	1	1		R	R				r	F	F		C		A					C		C	R	F					A
		70-1, 62–63	655.12	A	M	1	1		R	R				r	R	F		R		C					A	R	F		R	R				C
		71-4, 43–44	668.93	A	M	1	2	R	R	R			R	r	R	F	R	R		C			R		A	F	F			R				F
	Coccolithus staurion	72-1, 24–25	673.74	A	M	1	2			R				R	R	F		R		A			R		F	F	F			R				C
		73-1, 101–102	684.01	A	M	1	2			F			R	F	F	C				C			R		C	C	F	R		R				C
		74-2, 63–64	694.63	C	G	1	0			R				R	R	C	R	R		C					A	C	F			R				C
		75-1, 100–101	703.00	A	M	1	2			R			R	R	F	F		R		F					A	C	F							C
		76-2, 73–74	713.73	A	M	1	2			R			R	F	R	C	R	R		F			R		A	C	F							C
		77-2, 27–28	723.77	A	M	1	2	R		R			R	F	R	C				F			R		A	C	F							C
	Chiasmolithus gigas	78-2, 22–23	732.22	A	M	1	2			R		R	R	R	R	F				F					A	A	F			F				C
		79-2, 43–44	741.93	A	M	1	2			R				R	F	F		R		F					A	A	F			R				F
		80-2, 56–57	752.06	A	M	1	2	R		R		R	R	R	F	F		R		F			R		A	F	F		R	R				F
		81-2, 40–41	760.90	C	M	1	2			F		R		R	F	F		R		F			R		A	C	F							F
		82-3, 79–80	772.29	C	M	1	2			F		R		R	R	F				F			R		A	C	F			R				R
		83-2, 91–92	780.41	C	M	1	1			R		R			R	C	R	R		F			R		C	F	F			R				C
		84-2, 107–108	790.07	C	P	2	3			R				R	R	F		R		R			R		C	F	R							C
		85-2, 87–88	799.37	F	M	1	1			R		R			R	C				R			R		C	R	R			R				C
		86-2, 24–25	808.24	F	M	1	2							R	R	C				F			R		C	R	F							A
		87-2, 50–51	818.00	C	M	1	1			R				R	R	F		R		R			R		F	F	C		R					F
	Discoaster strictus	88-2, 82–84	827.82	C	M	1	1	R		R					R	F		R		R			R		F	F	F			R				C
		89-2, 52–53	837.02	F	M	1	2					R	R		R	C		R		F			R		F	F	C							C
		89-6, 59–60	843.09	F	M	1	2						R		R	F				F			F		F	F	F			R				C

[a]See Table 2 for explanation of symbols.
[b]All from Hole 445.

TABLE 6 – *Continued*

D. bifax	D. binodosus	D. deflandrei	D. tanii nodifer	D. saipanensis	D. strictus	D. tanii	D. wemmerensis	Discolithina plana	D. versa	Discolithina sp.	Ericsonia fenestrata	Hayella situliformis	Helicosphaera compacta	H. euphratis	H. heezenii	H. reticulata	H. rophota	H. seminulum	Isthmolithus recurvus	Lophodolithus mochlophorus	L. nascens	Nannotetrina fulgens	Pedinocyclus larvalis	Reticulofenestra dictyoda	R. hillae	R. reticulata	R. umbilica	Rhabdosphaera tenuis	R. truncata	Sphenolithus ciperoensis	S. conicus	S. dissimilis	S. distentus	S. furcatolithoides	S. moriformis	S. obtusus	S. predistentus	S. pseudoradians	S. radians	Striatococcolithus pacificus	Thoracosphaera spp.	Transversopontis fimbriatus	Triquetrorhabdulus carinatus	T. inversus	T. milowii	Zygrhablithus bijugatus
		A																													F	C			C									F		R	
		A																													F	C			C									C		F	
		A										R																			R	F			C									F		F	
		A										R																			F	C			C									F		F	
		A										R																		r	R	F			C									C			
		A											r																	r		C	r		C		r						F		R	R
		A																												r		F			A									F		R	F
		A										R																		r		R	r		A		r						F		R	F
		A										R																		r					C								R		R	F
		A																												F		R	r		A		r						C		R	
		C																												C					C								R		R	
		A										R																		F					A		r						R		F	
		A										R																		F					A						R		R		F	
		C										R																		F			F		A						R					R
		C																												F			F		A		F									
		C																												R			F		C		F				R		R			F
		C										F												R							R			F		A		C				R					
		C										F																		R			C		A		F				R					
		C										R		R																R			F		A		C									R
		C										R		R																R			F		C		C						R			
		C												R																			F		C		C									
		C				F						F		R																			R		A		A									R
		C		r		R						R		R																			R		C		C	R			R					R
		C				F						R		R														r						R		C		C	R								
		C				F								F															r					R		C		A				R					
		C				R								F											R									R		C		A				R					R
		F				R								F			R																	F		C		C									R
		C				F							R	F	R		R										r		r						F		C		C	R			R					F
		R				R							F	R	R		F								R		r		r						R		C		F	R			F					F
		C		r		R							R	F	R					R							R	C								C		C	R			R					F
		F	R			R								F	R					R							R		F								C	R	C									F
		R				R														F									F								F		F									
			R	r		R														R									A										R									
			R	C	R	R								R						R							R		C								C											
				C	R	F								R						R							F	C	C								C							R				
				A	F	C								R	R		R			R								A	F								F		F		R		R					
				A	R	F	R													R								C	F											R			R					
			R	C	R	F								R						R								C	F								F		F				R					R
				C	R	R																						F	F								F											
				C	R	R																						A	R								C											
				C	R																							C	R																			
				A																								C	R								F		R				R					
			R	C	R	R										R												C	F								C		F				R					
	R		R	C	R								R			R												A	F						R	F			R									
			R	F	R																							C	F								C			R									
	R		R	F	R																						R	F	R								C											
			R	R	R																								R								F											
	R			F																					R			F									F			R			R					
			R	F	R																					R			R									R		R						R		R
				A	R																					F			F																			
	R		R	R	R											R		R							C		R	A							F	C			R	R		F			R		R
R	R		R	F	R		R								R		R							C		R	C							C	C			R	R		R			R		R
R				R	R	R	R								R		R							A			F							F	F				F		F			R		
	R		R	F	R		R	R	R						R		R	R						C			R							F	C			R	F		R	R		R		
				R	R												R	R		R	R			A					R					F	C				R	R	R			F		
	R		R	R	R		R	R									R							A										F	F				F	R	R			R		
	R		R	R	R												R	R						C										F	C			F	C		R	R		R		
	F			F	R		R								R		R							C			r							C	F				R	R	R			F		
	R			F			R										R					R		C										F	C			R	F		R			F		
	R			F			R	R	R						R		R	R				R		F											C			R	R	R	R			R		
	R			R				R		R							F				R			R				R							F				R	R				R		
										R					R		R	R						F											C			R	R	R	R			R		
				R				R	R	R					R		R	R				R		F					R						C				F		R			R		
				F													R					R		F											F				F	R				F		
	R		R	R	R					R							R							F											C				F	R				F		
				F	R					F							R	R						A											C				R	R		R		R		
				F						R							R	R		R				A											F				R					R		
				C						F							F	R						A											C				R	R		R		R		
				C					R	F							F	R						A											C				F					F		
				F	R					F							F	R				R		A											A				F			R		F		
				F						F							R	R				R		A											A				R					R		
				C					R	R							R							A										R	A				F					R		
				C					R	R							R					R		A										R	C				R	R				R		

cene/Miocene boundary, marked by the end of the acme of *C. abisectus,* was not identified. The rare *Sphenolithus ciperoensis* in the lower samples are considered reworked.

The assemblage in Samples 445-45,CC to 445-47-3, 48–49 cm are indicative of the *Dictyococcites bisectus* Subzone (lower upper Oligocene), and *Discoaster deflandrei* becomes abundant here. The coexistence of *S. ciperoensis* and *S. distentus* permits assignment to the *Cyclicargolithus floridanus* Subzone for Samples 445-47-6, 48–49 cm through 445-52-1, 13–14 cm.

Samples 445-52-3, 13–14 cm to 445-57,CC represent the *S. distentus* Zone (middle middle Oligocene). Reworked lower-Oligocene forms, such as *Cyclococcolithus formosus, Reticulofenestra hillae,* and *R. umbilica,* were frequently observed in the lower samples.

Core 445-58 and the upper three sections of Core 445-59 yielded a mixed assemblage of the *Sphenolithus predistentus* Zone (lower middle Oligocene) and the *Helicosphaera reticulata* Zone (lower Oligocene). Strong reworking of the index species prevents more-detailed age assignment of this sequence. Although rare, *Isthmolithus recurvus* occurs consistently. Sporadic reworked Eocene discoasters, such as *Discoaster barbadiensis* or *D. saipanensis,* were also noticed. A hiatus is likely within this sequence.

The lower sections of Cores 445-59 and 445-60 yielded common to abundant *D. barbadiensis* and *D. saipanensis,* together with rare *I. recurvus,* indicating the *I. recurvus* Subzone (upper upper Eocene). Although *Chiasmolithus oamaruensis* does not occur at this site, the last occurrence of *Chiasmolithus grandis,* in Sample 445-63-3, 90–91 cm, indicates the *C. oamaruensis* Subzone for Samples 445-61-2, 95–96 cm to 445-63-1, 90–91 cm.

Samples 445-63-3, 90–91 cm to 445-65-1, 41–42 cm represent the *D. saipanensis* Subzone (lower upper Eocene). The first occurrences of *Dictyococcites bisectus* and *D. hesslandii* are recognized at the base of this Subzone. Preservation of nannofossils is particularly poor in the upper Eocene, and nannofossils become sporadic in the middle Eocene.

Cores 445-66 to 445-71 belong to the *Discoaster bifax* Subzone (upper middle Eocene). The index species is observed only in the middle part of this sequence, and the base of the subzone is identified by the first occurrence of *Reticulofenestra umbilica*. Reworked *Chiasmolithus gigas* occurs in these cores.

The first *C. gigas* is observed in Sample 445-87-2, 50–51 cm, and Cores 445-72 to 445-87 are assigned to the *Coccolithus staurion* Subzone and *C. gigas* Subzone. Nannofossils are still abundant in the upper cores, but only common to rare in the lower cores of this sequence.

Sporadic samples with common to few nannofossils were observed in Cores 445-88 to 445-89. Rare *Nannotetrina fulgens* with other middle-Eocene forms indicates the *Discoaster strictus* Subzone (middle middle Eocene) for these two cores. The lowest four cores (445-90 to 445-94) recovered at this site are barren of nannofossils, with the exception of a few intervals in which rare specimens with no age significance occur.

SITE 446 (HOLES 446, 446A) (TABLE 7)

Site 446 is in the Daito Basin, south of the Daito Ridge. In Hole 446, 46 cores were recovered, and the first basalt was encountered in Core 41. Coring at Hole 446A was resumed at a level slightly above the uppermost basalt layer, and 28 cores of sediment intruded by many basalt sills were recovered.

The occurrence of nannofossils was minimal at this site. Very sporadic occurrences representing the middle Pliocene and middle Oligocene were observed in only two of 19 upper cores. In the lower sequence, where Eocene turbidites were encountered, occurrences of nannofossils are more frequent. Preservation is moderate to poor through the nannofossil-rich samples. Dissolution is slight to moderate, whereas recrystallization is heavy, except in the Pliocene.

Core 446-1 is barren of nannofossils, but Core 446-2 contains a few moderately well-preserved fossils of the middle Pliocene. Sample 446-2-1, 53 cm contains *Pseudoemiliania* sp. aff. *P. lacunosa, Reticulofenestra pseudoumbilica, Sphenolithus neoabies, Discoaster brouweri, D. challengeri, D. intercalaris, D. pentaradiatus, D. surculus,* and *D. variabilis,* with other long-range placolith species. This sample is assigned to the *Discoaster asymmetricus* Subzone and the lower portion of the *D. brouweri* Zone. Reworked forms, such as *Catinaster coalitus, Cyclicargolithus floridanus, Discoaster berggrenii, D. quinqueramus*, and *Sphenolithus heteromorphus*, were also observed.

A similar assemblage (less *P.* sp. aff. *P. lacunosa* and with the addition of *D. asymmetricus* and *D. tamalis*) occurs in Sample 446-2,CC. This sample is also tentatively assigned to the *D. asymmetricus* Subzone. In addition to the reworked species already mentioned, *Ceratolithus acutus, Discoaster deflandrei, D. hamatus,* and *D. moorei* were also observed in this sample.

Cores 446-3 to 446-19 are barren of nannofossils, except the 10-cm-thick calcareous ooze recovered in Section 446-14-5. Sample 446-14-5, 35–36 cm contains abundant and heavily overgrown nannofossils of the middle-Oligocene *Sphenolithus distentus* Zone. The assemblage consists of abundant *C. floridanus* and *D. deflandrei*, with common to rare *Cyclicargolithus abisectus, Coronocyclus nitscens, Dictyococcites bisectus, Discoaster tani, Sphenolithus distentus, S. predistentus*, and *Triquetrorhabdulus carinatus*.

Cores 446-20 to 446-23 yielded common to few nannofossils. The rarity of *Chiasmolithus gigus* and the absence of *Reticulofenestra umbilica* and *Discoaster bifax* seem to indicate the *C. gigas* Subzone (middle middle Eocene). Because reworking is common in these cores, the overlying *Coccolithus staurion* Subzone is included in this part of the section. Reworked forms include *Discoaster lodoensis, D. sublodoensis,* and *Rhabdosphaera inflata*. The lowest occurrence of *Nannotetrina fulgens* is in Sample 446-29-1, 44–45 cm. Samples 446-25-1, 17–18 cm to 446-29-1, 44–45 cm therefore represent the *Discoaster strictus* Subzone (middle middle Eocene). Reworking is minimal in this interval.

Nannofossils occur sporadically in Cores 446-30 through 446-39, and only four samples contain a sufficient concentration of fossils to be studied. Samples 446-30-1, 35–36 cm and 446-34-4, 25–26 cm contain common to few *Discoaster sublodoensis* and rare *Rhabdosphaera inflata*, indicating the *R. inflata* Subzone. Although preservation is poor, the flora is well diversified in these samples. Samples 446-38-4, 54–56 cm and 446-39,CC contain abundant *Discoaster lodoensis* and *Discoasteroides kuepperi*, with rare *D. sublodoensis*. The absence of *R. inflata* indicates the *D. kuepperi* Subzone for these samples.

Cores 446-40 to 446-43 and 446A-1 to 446A-3 contain an assemblage of the *D. lodoensis* Zone. Common to few *Coccolithus crassus* consistently occur, and *Tribrachiatus orthostylus* appears commonly in the lower samples.

About 10 cm of light-bluish-green sediment overlying about 3 cm of dark-green sediment was recovered as one solid piece of rock in 446-40,CC. The light-colored material contains abundant Cretaceous nannofossils, with few Eocene fossils. The dark-colored material, on the other hand, yields almost equal numbers of the Cretaceous and Eocene fossils. The Eocene assemblage in both sediments is identical to that found immediately above and below this sample, which belongs to the *D. lodoensis* Zone. The Cretaceous assemblage indicates late Albian or Cenomanian. The observed species are *Cretarhabdus conicus, Cruciellipsis chiastia, Eiffellithus turriseiffeli, Parhabdolithus angustus, P. asper, P. embergeri, Podorhabdus albianus, Prediscosphaera cretacea, Toranolithus orionatus, Watznaueria barnsae, W. communis,* and *Zygodiscus diplogramus*.

Thin layers of sediments between basalt layers in Cores 446A-4 to 446A-8 are barren of nannofossils. Common to few nannofossils occur sporadically in Cores 446A-9 to 446A-28, which consist of many alternating basalt and sedimentary rock layers. The absence of *C. crassus* and the commonness of *D. lodoensis, D. kuepperi,* and *T. orthostylus* indicate the *T. orthostylus* Zone (upper lower Eocene) for the oldest sediment recovered at this site.

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TABLE 7
Distribution of Eocene Calcareous Nannofossils, Site 446[a]

Age	Zone or Subzone	Hole	Sample (interval in cm)	Sub-bottom Depth (m)	Overall Abundance	Preservation	Etching	Overgrowth	*Braarudosphaera discula*	*Campylosphaera dela*	*Chiasmolithus bidens*	*C. consuetus*	*C. expansus*	*C. gigas*	*C. grandis*	*C. solitus*	*C. titus*	*Coccolithus crassus*	*C. cribellum*	*C. eopelagicus*	*C. magnicrassus*	*C. pelagicus* s. ampl.	*Cruciplacolithus staurion*	*C. tenuiforatus*	*Cyclicargolithus pseudogammation*	*Cyclococcolithus formosus*
Eocene M	*C. staurion*	446	20-1, 45–46	172.95	C	M	1	2		R		F		R	R	R	R					F	R	R	R	F
			20,CC	182.00	C	M	1	2	R	R		R			R	R	R					F	R	R	F	C
	C. gigas		21,CC	191.50	F	M	1	1	R	R		R			R	R	R					F	R	R	R	C
			23,CC	210.50	C	M	1	3		F		R		R	R	R	R					C	R	R	F	C
	Discoaster strictus		25-1, 17–18	220.17	A	M	1	3		F		R			R	R	F		R	R		C	R	F	F	C
			26-1, 106–107	230.50	F	P	2	3									F			F		C	F		F	A
			27,CC	248.50	F	M	1	3				R	R		R	R	F			R		C	F	R	C	A
			29-1, 44–45	258.44	C	M	1	2		R		R				R	R			F		C	R		C	C
	Rhabdosphaera inflata		30-1, 35–36	267.85	F	P	2	3		F		R					F			R		F	F		C	C
			34-4, 25–26	310.25	C	P	2	3		R		R			R	R	F			F		F	R	R	C	C
	Discoasteroides kuepperi		38-4, 54–56	348.54	C	P	2	3		F		R				R		R		R		F				A
			39,CC	362.50	F	M	2	2		C		F				F	F	R	R	R		F		R	F	A
	Discoaster lodoensis		40-2, 28–30	364.28	C	G	1	0		C		R			R	F	F	F	F	R		F				C
			40,CC	372.00	C	M	2	2		F		F				F	R	F	F	R	R	F				C
E			41-2, 149–150	374.99	C	M	1	2		C	R	R					F	F	F		R	C				C
			43-2, 103–104	393.53	F	M	2	2		C		R						C	F			C				F
	Tribrachiatus orthostylus	446A	9-1, 8–9	438.58	F	P	2	3														C				F
			13,CC	486.00	F	M	1	2														C				F
			18-1, 138–140	525.38	F	P	2	3		F												C				F
			25,CC	600.00	C	P	1	3		F		R				R						C				C
			28-1, 11–12	619.11	C	M	2	2														C				

[a]See Table 2 for explanation of symbols.

TABLE 7 – *Continued*

C. gammation	*C. kingi*	*Cyclolithus bramlettei*	*Discoaster barbadiensis*	*D. binodosus*	*D. germanicus*	*D. lodoensis*	*D. tanii nodifer*	*D. nonaradiatus*	*D. saipanensis*	*D. sublodoensis*	*Discoasteroides kuepperi*	*Discolithina bicaveata*	*D. multipora*	*D. plana*	*D. versa*	*Discolithina* sp.	*Helicosphaera lophota*	*H. seminulum*	*Lophodolithus mochlophorus*	*L. nascens*	*Micrantholithus flos*	*Nannotetrina fulgens*	*Neococcolithus dubius*	*Reticulofenestra dictyoda*	*Rhabdosphaera inflata*	*R. tenuis*	*R. truncata*	*Sphenolithus furcatolithoides*	*S. moriformis*	*S. radians*	*S. spiniger*	*Striatococcolithus pacificanus*	*Thoracosphaera* spp.	*Transversopontis fimbriatus*	*T. pulcheroides*	*T. pulchriporus*	*Tribrachiatus orthostylus*	*Triquetrorhabdulus inversus*	*Zygrhablithus bijugatus*
	R	R	C	R			R	R	F				R		F		F	R	R			R		A	r	R	R	F	C	C		F	R	R		R		R	
	R		C	R		r	R		F	r		R		R	R		F		R	R				A			R	F	C	C				R					
	R	F	C		R	r		R	F			R	R	F	R		F	R	R			R		A			R	F	C	C	R	F		R		R			R
		F	C						F					R	R	R	F		R			R		A		R	R	F	C	C		F		R	R	R		C	
	R	F	C						F								F		R			R		A				F	C	C	R	R						C	R
		F	C														F	F						A					C	C								C	
	R		A						F			R					C	R					R	A			R		C	C				R				F	
		R	C		R				F	R		F	R	R	R	R	F	R	R			R		A	R	R			C	C			R	R				F	
		R	F			R				C								R	R		R			C	R				C	F								R	
R	R	F	C			R	R		R	F								R					F	C	R	R			C	C			R					C	
R		R	A	R		A		R		R	C						F												C	F							R		
R			C	F		C				R	A						F	F					F	F					A	C									
F		R	C	F		A		R			C			R			R	F					F	F					C	C			F		R	R			
F			C	R		A					A						R	F					F	F					C	C			F						
F		F	C	R	R	A		R			C			F		R	R	C					R	F					F	A			R	R			C		
		R	F	F		A					A							F											F	F			F				F		
			C			A					A																		C	C			F				F		
			C	F		C					A																		C	C			F				C		
F			C	F		C					A																		C	C							C		
R			C	F		C					A																		C	C			F				C		
			C	F		C					A		F																C	C			F				C		