8. CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE MIDDLE AMERICA TRENCH AND SLOPE, DEEP SEA DRILLING PROJECT LEG 84[1]

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ABSTRACT

DSDP Leg 84 recovered Tertiary and Upper Cretaceous calcareous nannofossils along the landward slope of the Middle America Trench at five sites offshore of Guatemala and one site offshore of Costa Rica. At four sites, drilling reached tectonized, ophiolitic basement that underlies Pleistocene (Hole 566), upper Miocene (Hole 566C), lower Eocene (Sites 569 and 570), and possibly lower Maestrichtian/upper Campanian (Site 567—Upper Cretaceous limestone above basement may be displaced) slope sediment. Three significant hiatuses occur within the area of drilling and encompass most of the middle to lower upper Miocene, lower Oligocene, and middle Eocene intervals. Short, localized hiatuses occur in Pleistocene and Pliocene sediment. Reworking of calcareous nannofossils caused by downslope displacement of older sediment occurs at all the sites, and is especially significant within lower Miocene (*Helicosphaera ampliaperta* Zone) sediment penetrated at Site 567, 3 km upslope from the trench floor. One new Miocene *Discoaster* species (*Discoaster tuberi* Filewicz, n. sp.) is described in this chapter.

INTRODUCTION

During Leg 84, ten holes were cored at five sites along the landward slope of the Middle America Trench (MAT) offshore of Guatemala, and one hole was cored at another site along the same slope margin offshore of Costa Rica (Figs. 1–3). Tertiary sediment containing age-diagnostic nannofossils was recovered at all six sites (along with a 1.5-m-thick Upper Cretaceous limestone in Hole 567A). Additional drilling of the trench floor, landward slope, and shelf was achieved on the first MAT transect, north of the Tehuantepec Ridge off Acapulco (DSDP Leg 66), and on the second MAT transect offshore of Guatemala (DSDP Leg 67). The primary objective of the third MAT transect drilled on Leg 84 was to determine the age, structure, and stratigraphy of the slope sediments present landward of the trench offshore of Guatemala. A similar objective was met during Legs 66 and 67 for their respective geographic positions along the MAT axis, but drilling was terminated without the desired slope penetration when gas hydrates (clathrates) with a seismically undefined base were penetrated. Leg 84 is the first cruise approved by the JOIDES advisory panels to specifically drill into gas hydrates above their seismically defined base, and to study clathrate origin and occurrence in the marine environment.

A total of 700 samples from 200 cores (1043 m of section) recovered on Leg 84 was examined for nannofossils under the light microscope. Calcareous nannofossils are relatively continuous in occurrence, and provide detailed biostratigraphic correlation when present. A list of zonal and age assignments for these cores is presented in Figure 4. Assemblage preservation varies from moderate to poor, with extensive overgrowth of species morphotypes in lower Eocene (Sites 569 and 570) and lower Maestrichtian/upper Campanian (Site 567) limestones penetrated above basement. Assemblage numbers range from rare to abundant, with occasional dilution of the species content because of high sedimentation rates within the Holocene to Pleistocene mudstones. Thin intervals of Pliocene and upper to middle Miocene sediment are dominated by siliceous microfossils, and are barren of calcareous nannofossils.

Tertiary and Late Cretaceous nannofossil species considered in this report are listed alphabetically according to generic epithet in the Appendix.

BIOSTRATIGRAPHY

The Pleistocene to Holocene zonation utilized in this study is after Gartner (1977). Zonal boundaries are sometimes tentative, especially at the *Emiliania huxleyi* Zone/*Gephyrocapsa oceanica* Zone boundary (first occurrence of *E. huxleyi*) and *Gephyrocapsa oceanica* Zone/*Pseudoemiliania lacunosa* Zone boundary (last occurrence of *P. lacunosa*), owing to (1) high sedimentation rates and clastic input, which have diluted the nannofossil, assemblage, and (2) a high abundance of siliceous microfossils, which may be due to the close proximity of these trench-slope sites to shore, where upwelling can inject surface waters with high nutrient levels favorable to diatom productivity.

Intermittent downslope sediment displacement, as documented by sedimentary structures and benthic foraminifers (Baltuck et al., this volume), has sporadically reworked specimens of *Helicosphaera sellii* and *Calcidiscus macintyrei*, which are zonal guide species, thus causing further difficulty in zonal assignments for the lower Pleistocene. Stradner and Allram (1982) and Musylov (1982) experienced similar problems in their attempt to zone Pleistocene MAT-slope mudstones.

The Pliocene through Eocene zonation utilized is after Bukry (1973, 1975) and Okada and Bukry (1980). The *Calcidiscus macintyrei* Subzone (CN12d) is relabeled *Discoaster triradiatus* to avoid confusion with the Pleisto-

[1] von Huene, R., Aubouin, J., et al., *Init. Repts. DSDP*, 84: Washington (U.S. Govt. Printing Office).
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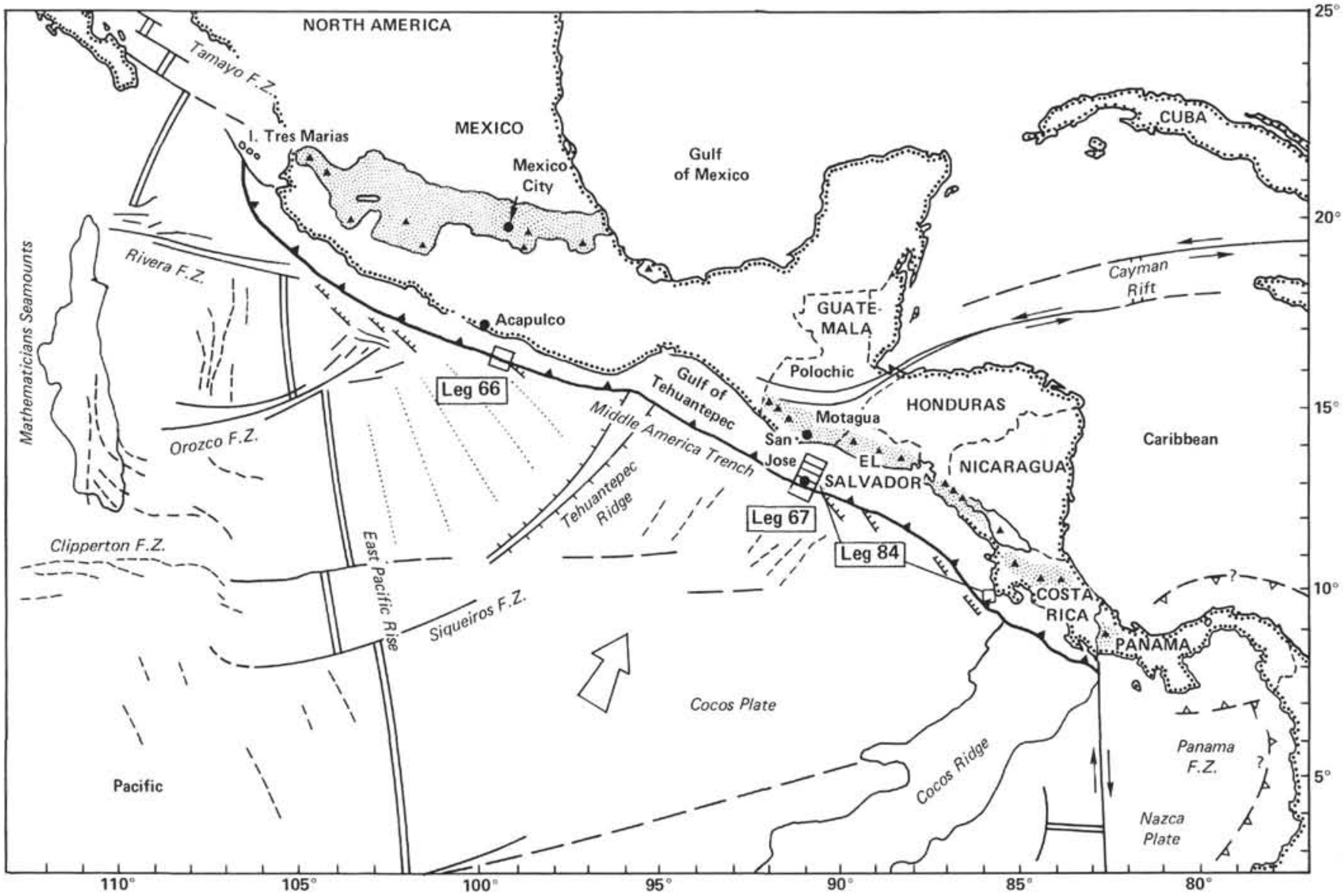

Figure 1. Locations of Legs 84, 67, and 66 in relation to regional tectonic structures offshore of Central America.

cene *C. macintyrei* Subzone of Gartner (1977). The lower/middle Miocene boundary is tentatively placed at the *Sphenolithus heteromorphus* Zone/*Helicosphaera ampliaperta* Zone boundary (first occurrence of *C. macintyrei* or last occurrence of *H. ampliaperta*). The Oligocene/Miocene boundary is placed at the *Discoaster deflandrei* Subzone/*Cyclicargolithus abisectus* Subzone boundary (last continuous occurrence of *C. abisectus*) after Okada and Bukry (1980), and the lower/middle Eocene boundary is placed at the *Discoaster sublodoensis* Zone/*Discoaster lodoensis* Zone boundary (first occurrence of *D. sublodoensis*) after Hardenbol and Berggren (1978).

Upper Cretaceous nannofossils within a 1.5-m-thick limestone penetrated in Hole 567A are assigned to Standard European stage nomenclature after Theirstein (1976).

SITE SUMMARIES

Site 565 (09°43.69′N, 86°05.44′W; water depth 3099 m)

Coring in Hole 565 recovered 328 m (34 cores) of Pleistocene and upper Neogene (upper Miocene and lower Pliocene undifferentiated) homogeneous trench-slope mudstone. This site is off the Nicoya Peninsula of Costa Rica on the landward slope of the MAT (Fig. 3), and was selected primarily to identify the age and lithologic characteristics of sediments within and below the slope cover; it is the only Leg 84 site that was not drilled off the Guatemalan MAT landward slope.

Calcareous nannofossils occur consistently throughout this section in rare to frequent abundances; preservation ranges from poor to moderate, owing to dissolution. Heavy terrigenous mixing throughout the interval and close proximity to the nannofossil CCD (especially in Samples 565-7,CC through 565-28,CC, as documented by benthic foraminifers [McDougall, this volume]) are the significant factors contributing to the low nannofossil abundances and etched preservation. Species which indicate cold surface-water temperatures, such as *Coccolithus pelagicus*, are extremely rare, suggesting that paleotemperatures did not prohibit assemblage abundance or diversity. The ranges of selected nannofossil taxa, along with qualitative information describing assemblage abundance and preservation, are presented in Figure 5.

Nannofossil zonal markers, though rare, are present throughout the section, and allow delineation of four Holocene/Pleistocene zones and two zones within the Pliocene. Low diversity of the *Discoaster* assemblage until terrigenous admixture became less (Sample 565-29,CC at 276.5 m) does not allow a precise subdivision of the upper Pliocene *Discoaster brouweri* Zone, but both the top and bottom of the *D. brouweri* zonal interval are well defined by last-occurrence datums of *D. brouweri* and *Sphenolithus neoabies*.

Reworking of Cretaceous nannofossils is rare to nonexistent from the Pleistocene to upper Pliocene interval through 29,CC. Upper Cretaceous reworking is more prev-

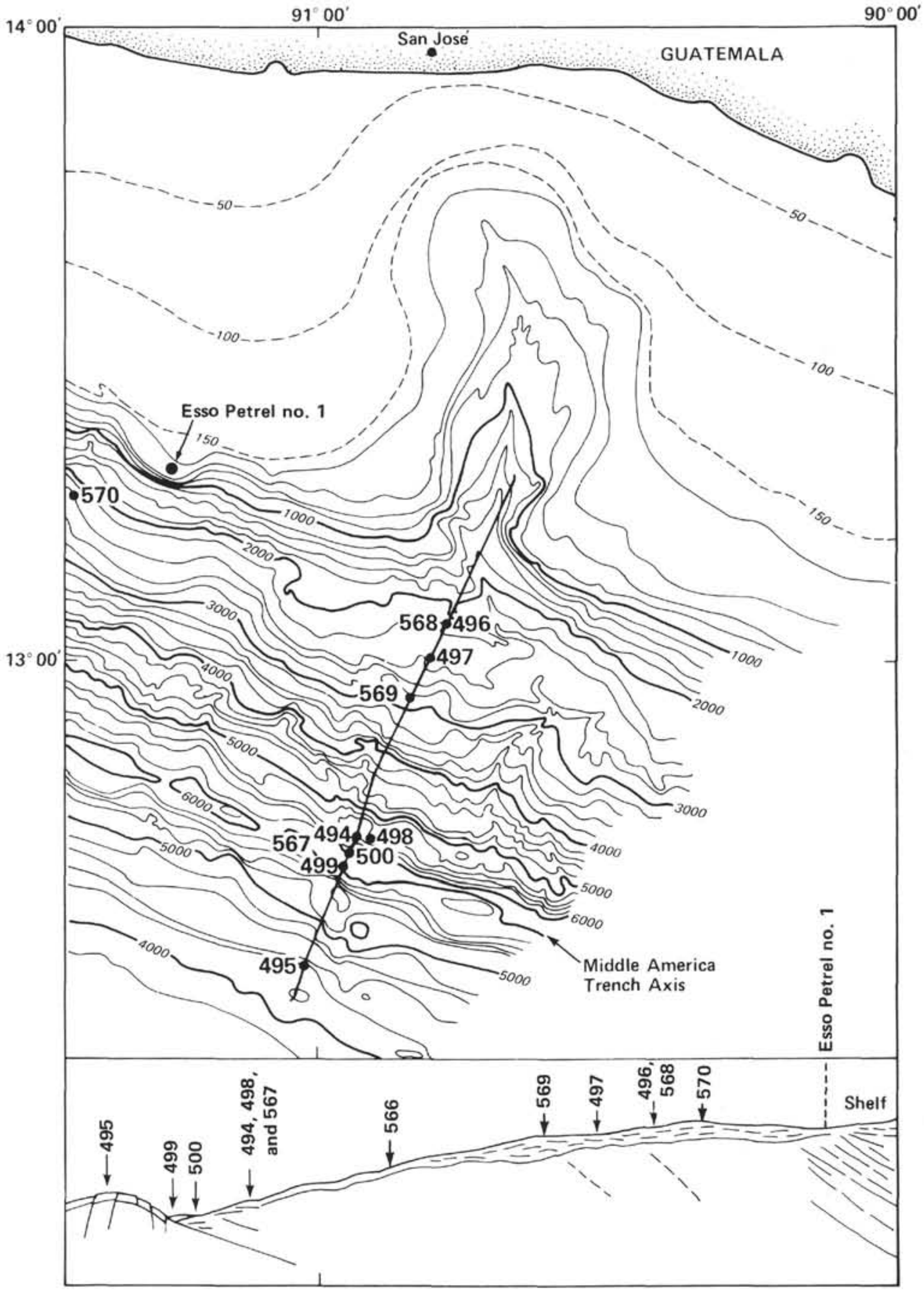

Figure 2. Locations of Leg 84 and Leg 67 sites offshore of Guatemala. Esso Petrel no. 1 well is also shown.

alent within the upper Miocene and lower Pliocene from 565-30,CC through 565-34,CC. Very rare species reworked from the Oligocene and Pliocene are also in the Pleistocene (565-5,CC), but never form a significant assemblage constituent.

Core 565-1 is tentatively assigned to the *Emiliania huxleyi* Zone, and contains frequent *Emiliania* sp. cf. *E. huxleyi*.

The interval from Section 565-2-3 through Sample 565-8-2, 109 cm is assigned to the upper Pleistocene *Gephyrocapsa oceanica* Zone, and is dominated by *Calcidiscus leptoporus* and small *Gephyrocapsa* spp. (sensu Gartner, 1977). Core 565-7, which has a common abundance of nannofossils with moderate preservation, contains the first rare but consistent occurrence of reworked Cretaceous species *Watznaueria barnesae*. Soft, light gray angular calcareous blebs in Section 565-2-3, which are lithified in Section 565-4-4, contain overgrown Neogene species and are therefore not reworked from significantly older sediments.

The interval from Sample 565-9-4, 106 cm, through 565-9,CC is barren of nannofossils, but Sample 565-10,CC contains the highest occurrence of *Helicosphaera sellii*, along with *Pseudoemiliania lacunosa*. The combined

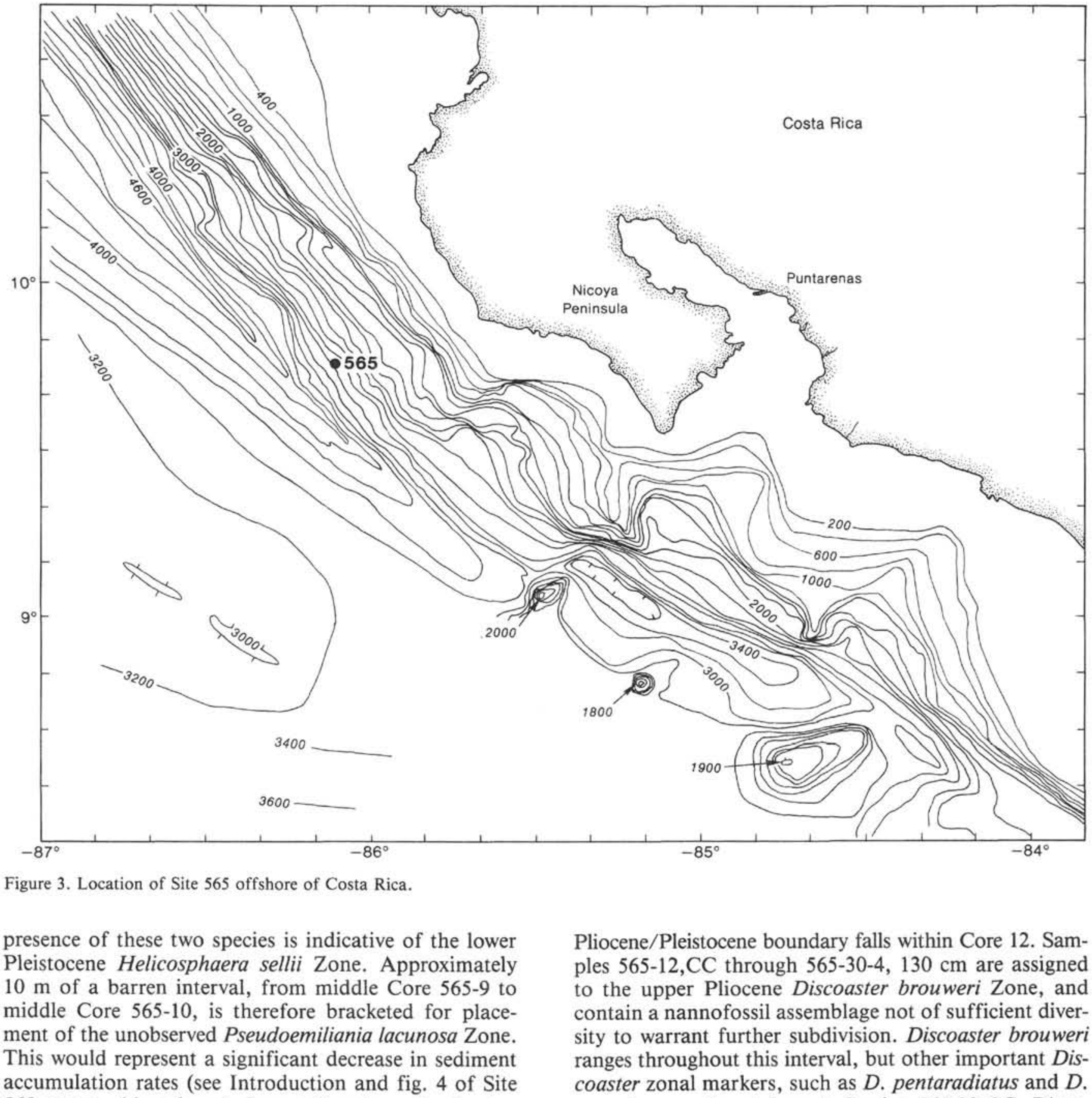

Figure 3. Location of Site 565 offshore of Costa Rica.

presence of these two species is indicative of the lower Pleistocene *Helicosphaera sellii* Zone. Approximately 10 m of a barren interval, from middle Core 565-9 to middle Core 565-10, is therefore bracketed for placement of the unobserved *Pseudoemiliania lacunosa* Zone. This would represent a significant decrease in sediment accumulation rates (see Introduction and fig. 4 of Site 565 report, this volume), from 165 m/m.y. for the top 80 m of the section to about 13 m/m.y. between approximately 80 and 90 m. If sediment accumulation rates are assumed to have been relatively constant for the entire cored interval, then there is the possibility of a minor unconformity (no greater than 0.9 m.y.) within this interval. Sediment accumulation rates below Core 9 were approximately 125 m/m.y. down to the total depth of Site 565.

The interval from Sample 565-11,CC through Sample 565-12-4, 74 cm contains the highest rare occurrence of *Calcidiscus macintyrei*, which would place this interval within the lower Pleistocene *C. macintyrei* Zone.

Sample 565-12,CC contains the highest consistent occurrence of *Discoaster brouweri*, which indicates that the Pliocene/Pleistocene boundary falls within Core 12. Samples 565-12,CC through 565-30-4, 130 cm are assigned to the upper Pliocene *Discoaster brouweri* Zone, and contain a nannofossil assemblage not of sufficient diversity to warrant further subdivision. *Discoaster brouweri* ranges throughout this interval, but other important *Discoaster* zonal markers, such as *D. pentaradiatus* and *D. surculus*, are absent down to Section 565-29,CC. *Discoaster tamalis* and other significant lower Pliocene–upper Miocene *Discoaster* species were not observed.

Sample 565-30,CC contains the highest occurrence of *Sphenolithus neoabies*, and is assigned to the lower Pliocene *Recticulofenestra pseudoumbilica* Zone. Reworked upper Cretaceous species, including the upper Maestrichtian species *Micula murus*, consistently occur within this core and continue to occur with regularity to 565-34,CC. This suggests erosion of Upper Cretaceous marine sediments from upslope.

Samples 565-31,CC through 565-34,CC contain the same low-diversity nannofossil assemblage present in 565-30,CC, along with the rare occurrence of Miocene species *Catinaster* sp. aff. *C. mexicanus* and very rare *Dis-*

			Landward MAT slope offshore Guatemala						Landward MAT slope offshore Costa Rica
			Lower		Middle			Upper	
Age	Zone	Subzone	567, 567A	566, 566A, 566C	569	569A	568	570	565
Holo.	*Emiliania huxleyi*			566	1-2/4,CC		1-2, 80/6-2, 43		1,CC
Pleistocene	*Gephyrocapsa oceanica*			1-2/5-2, 83				1-2/6-6, 37	2-3/8-2, 109
	Pseudoemiliania lacunosa						6-4, 43/11-1, 89		
	small *Gephyrocapsa*						11,CC/13-2,61	6,CC/8,CC	9-4, 106/9,CC
	Helicosphaera sellii				5,CC/6,CC		13-4, 45/21-CC	9,CC/23-4, 47	10,CC
	Calcidiscus macintyrei		567 1,CC/2,CC						11,CC/12-4, 74
Pliocene l.	CN12 *Discoaster brouweri*	CN12d *Discoaster triradiatus*			7-2, 10/7-6, 11				
		CN12c *Discoaster pentradiatus*		566A	7,CC/8-2,2				
		CN12b *Discoaster surculus*						23-6, 36/25-4, 36	12,CC/30-4,130
		CN12a *Discoaster tamalis*		1,CC					
e.	CN 11 *Reticulofenestra pseudoumbilica*	CN11b *Discoaster asymmetricus*	567A						
		CN11a *Sphenolithus neoabies*						25,CC/26,CC	30,CC
	CN10 *Amaurolithus triconiculatus*	CN10c *Ceratolithus rugosus*	1-4, 50/3-6, 33						
		CN10b *Ceratolithus acutus*						26-4, 23/27-1, 50	
Miocene l.		CN10a *Triquetrorhabdulus rugosus*							31-4,129/34,CC
	CN9 *Discoaster quinqueramus*	CN9b *Amaurolithus primus*		566C	8,CC/9,CC		23,CC/25-2, 148		
		CN9a *Discoaster berggrenii*		1,CC/H2,CC				28-1, 43/35-1, 30	
	CN8 *Discoaster neohamatus*								
m.	CN7 *Discoaster hamatus*								
	CN6 *Catinaster coalitus*								
	CN5 *Discoaster exilis*						25-4,23/28-2,11	35-4, 5/35-4, 40	
e.	CN4 *Sphenolithus heteromorphus*				10-2, 20/10,CC		28-6, 10/38-2, 147		
	CN3 *Helicosphaera ampliaperta*		3,CC/13,CC		11-2, 71/12,CC		38-4, 138/42-3, 126		
	CN2 *Sphenolithus belemnos*		18-1/18,CC						
	CN1 *Triquetrorhabdulus carinatus*	CN1c *Discoaster druggii*			13-4, 3/26-4, 44		42-7, 40/44-4, 70	35-5, 45/35,CC	
		CN1b *Discoaster deflandrei*				1-1, 99			
		CN1a *Cyclicargolithus abisectus*							
Oligocene l.	CP19 *Sphenolithus ciperoensis*	CP19b *Dictyococcites bisectus*			27-1, 19/27,CC	2-1, 147/6-1, 43			
		CP19a *Cyclicargolithus floridanus*							
	CP18 *Sphenolithus distentus*					7-1, 143			
	CP17 *Sphenolithus predistentus*					7,CC			
e.	CP16 *Helicosphaera reticulata*								
Eocene l.	CP15 *Discoaster barbadiensis*	CP15b *Isthmolithus recurvus*				8-1, 74/8,CC			
		CP15a *Chiasmolithus oamaruensis*							
	CP14 *Reticulofenestra umbilica*	CP14b *Discoaster saipanensis*				9-1, 18/9,CC			
		CP14a *Discoaster bifax*							
m.	CP13 *Nannotetrina quadrata*								
	CP12 *Discoaster sublodoensis*								
e.	CP11 *Discoaster lodoensis*					10-1, 1		36-2, 10/36,CC	
	CP10 *Tribrachiatus orthostylus*							37-1, 28	
	CP9 *Discoaster diastypus*							37-1, 42/38-1, 55	
late Campanian—early Maestrichtian			19-1, 60/19,CC						

Figure 4. Age and zonal assignments for Leg 84 holes based on calcareous nannofossils. Sample numbers representing upper and lower limits of a given zone or age are separated by a slash; sample intervals in cm. MAT = Middle America Trench.

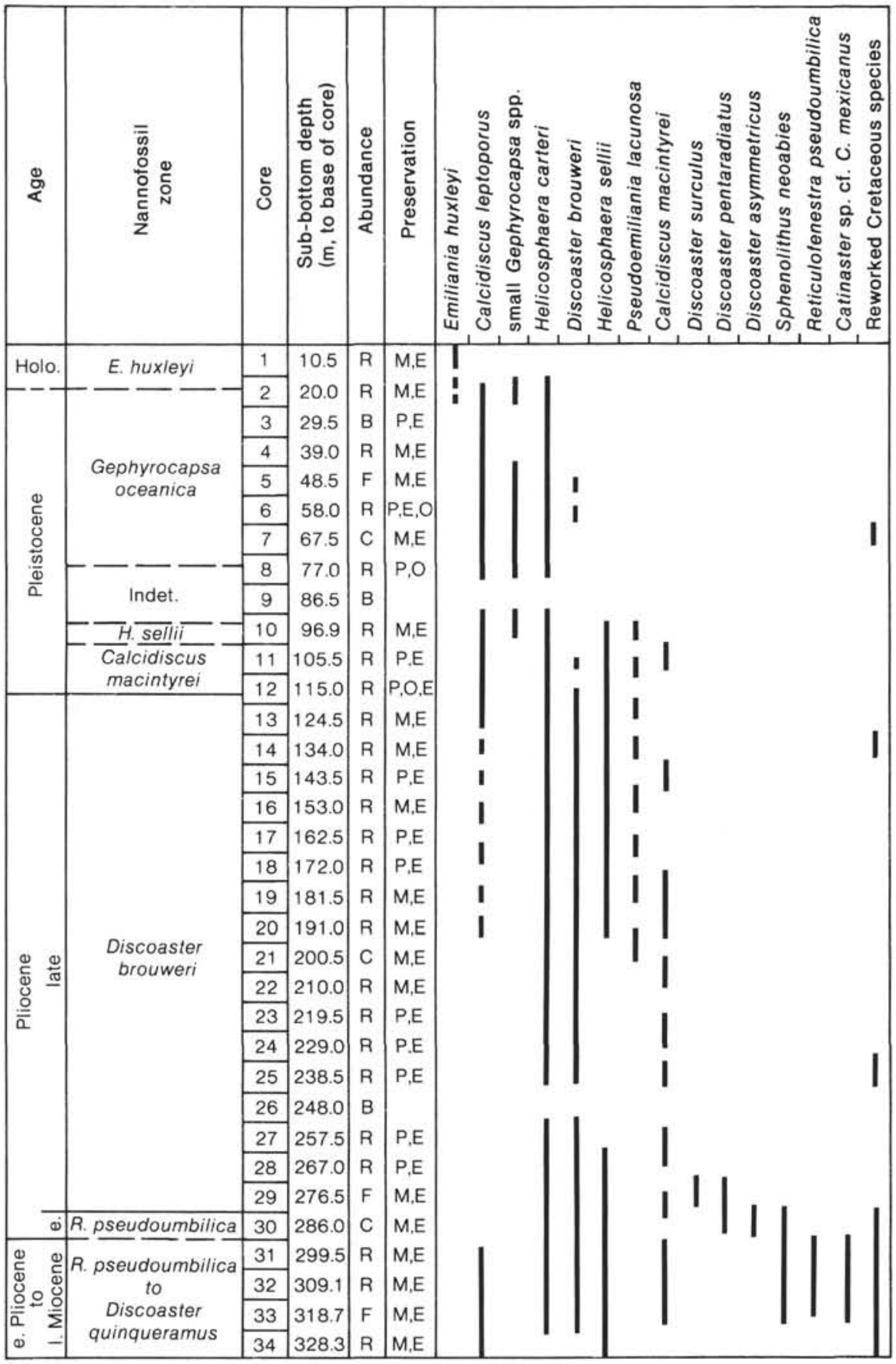

Figure 5. Range of stratigraphically significant calcareous nannofossils at DSDP Site 565. (See note to Table 1 for explanation of abbreviations.) Solid line indicates consistent occurrence of species through cored section. Dashed line indicates sporadic species occurrence.

coaster berggrenii. A specific zonal assignment for this interval is not possible, and only a general age of late Miocene or early Pliocene is applicable.

Site 566

Three shallow holes (no sediment was recovered from Hole 566B, which is not considered here) were drilled at Site 566 along the east flank of an erosional canyon on the trench slope, 22 km upslope from the axis of the Guatemalan MAT. Upper Miocene to Pleistocene sediment was recovered on shallow ultramafic basement in all three holes. Drilling took place in an actively eroding canyon, however, and older slope sediments may have been previously removed. Nannofossil occurrence, abundance, and preservation are summarized in Table 1.

Upper Pleistocene nannofossils are abundant and well preserved. Slight dissolution of placoliths resulted in the destruction of the central bar in some specimens of *Gephyrocapsa*. Pliocene nannofossils occur in lesser numbers with similar, slightly etched preservation; poorly pre-

Table 1. Distribution of calcareous nannofossils at Site 566.

Age	Zone or subzone	Sample (interval in cm)	Sub-bottom depth (m)	Abundance	Preservation	*Emiliania huxleyi*	*Gephyrocapsa oceanica*	*Gephyrocapsa omega*	*Gephyrocapsa* spp. sensu Gartner, 1977—small	*Calcidiscus macintyrei*	*Crenalithus doronicoides*	*Helicosphaera carteri*	*Helicosphaera wallichii*	*Rhabdosphaera stylifer*	*Pseudoemiliania lacunosa*	*Coccolithus miopelagicus*	*Syracosphaera histrica*	*Nannoconus* sp.	*Coccolithus pelagicus*	*Coccolithus carteri*	*Helicosphaera sellii*	*Discoaster brouweri*	*Discoaster pentaradiatus*	*Sphenolithus neoabies*	*Reticulofenestra pseudoumbilica*	*Discoaster intercalaris*	*Discoaster berggrenii*	*Discoaster quinqueramus*	*Dictyococcites bisectus*	*Dictyococcites antarcticus*	*Micula mura*	*Watznaueria barnesae*	*Discoaster surculus*
		Hole 566																															
Holocene-late Pleisto-cene	*Emiliania huxleyi*–*Pseudoemiliania lacunosa*	1-2, 29–30	1.80	C	M, E	C	C	R	C	R	F	F																					
		1,CC	4.00	C	M, E		R	R	C	R	F	F	R	R	R																		
		2-2, 32–33	5.83	B																													
		2-4, 32–33	8.82	F	P, O				F	F		R				V																	
		2,CC	10.00	C	M, E		F	R	C	R	F	F					V																
		3,CC	12.30	C	M, E		R		C		F	R						R															
		4-2, 56–57	14.37	F	P, OE		F	R	F	R		R			V																		
		4,CC	21.90	C	M, E			R	C	R	F	F																					
		5-2, 83–84	24.24	R	P, O				R		R																						
?		5,CC	31.40	B																													
		6-1, 69–70	32.10	B																													
		8,CC	52.80	B																													
		9,CC	55.80	B																													
late Plioc.	*Discoaster brouweri*	**Hole 566A**																															
		1,CC	7.00	F	M, E					R	F	R							R	R	R	F	V	R									
		Hole 566C																															
late Miocene	*Discoaster quinqueramus*	1,CC	59.30	R	P, O, E					R	R	R										R	R	R	R	R	R	R					
		2-1, 45–46	59.76	R	P, O																			R				R					
		2,CC	68.80	F	P, O						R	R												F			R	R	V	R	V		
		3,CC	78.50	R	P, O						R												R	F		R	R	F				V	
		H2,CC	109.10	R	P, O							R											R	R			R	R					V
?		5,CC	117.20	B																													

Note: Checklist Abundance: A = abundant (more than 10 specimens per field of view at ×800); C = common (1–10 specimens per field of view at ×800); F = few (1 specimen per 2–10 fields of view at ×800); R = rare (1 specimen per 11–100 fields of view at ×800), V = very rare (1 specimen per 101–1000 fields of view at ×800). Assemblage Abundance: A = abundant; C = common; F = few; R = rare. Preservation: G = good, M = moderate, P = poor, E = etching, O = overgrown.

served upper Miocene nannofossil assemblages occur in very low numbers, with overgrowth of *Discoaster* species, fragmentation of *Ceratolith* species, and etching of placolith species indicating significant diagenesis and possible downslope transport.

Reworking of nannofossils is sparse and restricted primarily to Cretaceous species in Holes 566 and 566C. *Sphenolithus neoabies* (middle Miocene to lower Pliocene) occurs in Sample 556A-1,CC in an unusually low abundance, indicating that its presence is also a result of reworking into an upper Pliocene sample.

Hole 566 (12°48.34′N, 90°41.79′W; water depth 3745 m)

A total of 56 m (9 cores) of Holocene through Pleistocene mudstone, resting upon serpentinite basement, was drilled. The interval from Section 566-1-2 through Sample 566-5-2, 83 cm is assigned to the upper Pleistocene/Holocene *Emiliania huxleyi* Zone and *Pseudoemiliania lacunosa* Zone. Abundant, minute placoliths with affinities to *E. huxleyi* were observed in Sample 566-1-2, 29–30 cm, together with small *Gephyrocapsa* spp., *Crenalithus* spp., *Helicosphaera carteri*, and *Gephyrocapsa oceanica*. Cores 566-2 through 566-4 are also dominated by this assemblage without the presence of *E.* sp. cf. *E. huxleyi*. Specimens of *Pseudoemiliania lacunosa* occur sporadically in Cores 566-1 and 566-4, which makes exact assignment of the *P. lacunosa*/*G. oceanica* Zone boundary tenuous. Sample 566-3,CC contains very rare *Nannoconus* sp. reworked from the Cretaceous.

Samples 566-5,CC through 566-9,CC contain serpentinite, and are, of course, barren of nannofossils. Mudstone fragments mixed with serpentinites in 566-9,CC contain the same Pleistocene nannofossil assemblage as seen in the section above, and are derived from downhole caving.

Hole 566A (12°47.91′N, 90°41.99′W; water depth 3826 m)

Hole 566A was drilled 1000 m downslope from Hole 566, along the axis of the same submarine canyon. Only one core (7 m) was recovered; it contained mudstone mixed with serpentinite in Sample 566A-1,CC. The marine mudstone in this sample is probably upper Pliocene; it contains a flora dominated by *Crenalithus spp., H. carteri, Discoaster brouweri, Calcidiscus macintyrei*, and very rare *Discoaster pentaradiatus*. The co-occurrence of these species indicates the *Discoaster brouweri* Zone. Very rare specimens of *Sphenolithus neoabies*, which is ubiquitous throughout lower Pliocene and upper Miocene sediment, are thought to be reworked, since they make up less than 0.1% of the assemblage and no other lower Pliocene species are present.

Hole 566C (12°48.84′N, 90°41.53′W; water depth 3661 m)

Hole 566C is approximately 1000 m upslope from Hole 566, again near the axis of the submarine canyon. Hole 566C is the deepest hole (136.6 m) drilled at this site, and contains 66 m (7 cores) of upper Miocene mudstones on serpentinite basement. Core 566C-H1, a wash core recovered from a depth of approximately 50 m, contains a mixed Pliocene/Pleistocene assemblage composed of small *Gephyrocapsa* spp., *H. carteri*, and very rare *Discoaster pentaradiatus*.

Samples 566C-1,CC through 566C-3,CC contain *Discoaster berggrenii, Discoaster quinqueramus*, and *Sphenolithus neoabies*, and are assigned to the upper Miocene *Discoaster quinqueramus* Zone. Very rare reworked Cretaceous species are present in 566C-2,CC; 566C-3,CC contains very rare reworked *Micula murus*, a species restricted to the late Maestrichtian.

No sediment was recovered from Core 566C-4, and a wash core (566C-H2) taken at approximately 109 m contains the same upper Miocene nannofossils as previously encountered uphole. Cores 566C-5 through 566C-7 once again contained serpentinite.

Site 567

Holes 567 and 567A were drilled on the landward toe of the Guatemalan MAT, approximately 110 m from DSDP Site 494 and 3 km from the trench floor. Drilling objectives were (1) to penetrate basement lithology and possibly drill through to the subducted oceanic slab, and (2) to elucidate the stratigraphic sequence of Tertiary through Upper Cretaceous trench-slope deposits recorded by marginal recovery in cores from Site 494. Biostratigraphic results from Site 494 cores (Aubouin, von Huene, et al., 1982) were consistently compared with sediments recovered throughout the drilling of Site 567, as a reference for lithology and age control.

Approximately 176 m of Pleistocene sediments were washed until continuous coring (31 cores, 283 m) began close to the Pleistocene/Pliocene boundary. A short sequence of lower Pleistocene through Pliocene mudstone was recovered to 220 m above lower Miocene sediment. Disturbed sediment containing lower Miocene, Oligocene, middle Eocene, and Cretaceous angular lithic clasts in a mud matrix (usually lower Miocene) was also cored between 260 and 368 m. I shall discuss further the evidence that this sequence represents a sedimentary breccia rather than a drilling breccia. Igneous basement was drilled from 385 to 501 m (total depth).

Poorly preserved calcareous nannofossils occur in rare abundance within the Pleistocene/Pliocene sediments of both Hole 567 and Hole 567A (Table 2). Assemblage preservation and diversity is better, and abundance is greater, in the lower Miocene sediment. Nannofossil preservation and abundance fluctuate from overgrown or etched rare specimens to moderately preserved common specimens within the Oligocene, middle Eocene, and Upper Cretaceous angular lithic fragments.

Hole 567 (12°42.96′N, 90°55.99′W; water depth 5500 m)

Core 567-H1 (wash core) is Pleistocene, as indicated by the occurrence of small *Gephyrocapsa* spp. and *G. oceanica* in Sample 567-H1,CC. A mixture of middle to upper Miocene species such as *Catinaster coalitus* and *Sphenolithus heteromorphus* also occurs, indicating that reworking of Miocene sediments occurred in Pleistocene time.

Sample 567-1,CC contains rare *Discoaster brouweri* and *Calcidiscus macintyrei*; 567-2,CC contains only small *Gephyrocapsa* spp. Both cores are assigned to the lower Pleistocene (probably *Calcidiscus macintyrei* Zone), and they are probably very close to the Pleistocene/Pliocene boundary.

Hole 567A (12°42.99′N, 90°55.92′W; water depth 5500 m)

Samples 567A-1-4, 50 cm through 567A-3-6, 29 cm contain sparse lower Pliocene nannofossil assemblages which include *Reticulofenestra pseudoumbilica, Sphenolithus neoabies, Calcidiscus macintyrei, Discoaster pentaradiatus*, and *Discoaster asymmetricus*, mixed with rare reworked middle and upper Miocene species such as *Discoaster* sp. cf. *D. bollii* and *Catinaster coalitus*. This interval is assigned to the lower Pliocene, and Sample 567A-3-6, 32–33 cm contains long-ranging species which could be Miocene to lower Pliocene.

The interval from Section 567A-3,CC through Core 567A-10 (65 m) is assigned to the lower Miocene Helicosphaera ampliaperta Zone, and contains such age-diagnostic species as *H. ampliaperta, H. mediterranea, H. scissura*, and *Sphenolithus heteromorphus* and *Discoaster deflandrei*. The unconformity between lower Pliocene and lower Miocene sediment therefore occurs between Samples 567A-3-4, 28–29 cm and 567A-3,CC, at approximately 220 m, this is in general agreement with age correlations with Site 494 (basal Pliocene unconformity at 225 m). Below this horizon, Site 567 lithologic and biostratigraphic sequences and interpretations differ significantly from those for Site 494 (see Introduction and table 6 of Site 567 report, this volume).

Lower Miocene sediment (*H. ampliaperta* Zone) was also encountered in Hole 498A (3 km west along strike of the lower trench slope), and 40 to 50 km north in the middle slope are penetrated at DSDP Sites 496, 568, and 569, and approximately 80 km north on the shelf edge, as documented at the Esso Petrel well (Seely, 1979). But only 110 m to the north, at Site 494, lower Miocene nannofossil species are absent.

Cores 567A-11 to 567A-13 consist of a mixture of angular clasts of variable lithology, which contains moderately preserved Oligocene, middle Eocene and Upper Cretaceous nannofossil assemblages in association with lower Miocene mud matrix. This can be explained by disturbance and brecciation of multiple aged sediments by either rotary drilling or downslope mass transport. The Leg 67 staff's preliminary interpretation of the broken, angular lithic fragments recovered from Site 494 (245–285 m) is that they constitute a drilling breccia, and that the oldest lithology recovered thus represents the *in situ* formation. Accordingly, a stratigraphic sequence of lower Miocene, middle Eocene, and Upper Cretaceous sediments overlying possible basement was reported. Sediments cored at Site 567 yielded better recovery, and in many cases interformational conglomerates of angular lithic clasts in a coherent matrix can be observed. This would suggest that the angular clasts were emplaced by slumping or other types of downslope movement and are genetically part of a sedimentary breccia. The youngest age obtained from the clasts or matrix would, of course, then represent the true age of deposition.

Discrete angular lithic clasts and matrix (often obscured) were selectively sampled to determine the upper and lower limits of age spread. Results are tabulated in Table 3, and indicate that reworking of a middle Eocene to Oligocene clast occurred as high as Section 567A-7-2, whereas the first reworked Upper Cretaceous occurs in Section 567A-8-4. Both matrix and clasts are lower Miocene from lower Section 567A-8-4, to 567A-10,CC. Clasts from Cores 567A-11 and 567A-12 are Oligocene and Upper Cretaceous (probably Campanian), and clasts from Core 567A-13 are primarily middle Eocene or Upper Cretaceous. Matrix mudstone from Sample 567A-13-2, 20–21 cm contained Cretaceous to Oligocene nannofossils, whereas soft mud (possible matrix) from 567A-11,CC, 567A-12,CC, and 567A-13,CC consistently yielded a youngest nannofossil age of early Miocene (*Helicosphaera ampliaperta* Zone). Deposition would then have taken place in the early Miocene, with erosion, mass transport, and redeposition of subaerially exposed Oligocene through Upper Cretaceous sediments as coherent lithic clasts.

Core 567A-14 through Section 567A-17,CC recovered weathered blue serpentinite mud, which may or may not be age equivalent to that of the blue mud sequence recovered at Site 494 (225–245 m). Both blue mud sequences are barren of nannofossils.

Sample 567A-18-1, 49 cm contains *H. ampliaperta*, *H. carteri*, and *Triquetrorhabdulus milowii*, along with scattered Cretaceous and Eocene species, and is assigned to the lower Miocene *Sphenolithus belemnos* Zone or *Helicosphaera ampliaperta* Zone.

Sample 567A-18,CC contains the base of a blue serpentinite mud overlying 6 cm of soft gray mudstone which contains traceable bedded layers truncated by an apparent erosional contact. Lithic clasts within the serpentinite mud were selectively examined for nannofossils, which indicate either middle Eocene or upper Cretaceous sediment. The soft gray mudstone below the serpentinite mud contains a middle Eocene flora, along with very rare lower Miocene specimens of *H. ampliaperta*, which is again indicative of lower Miocene sediment dominated by reworked material.

Core 567A-19 recovered 1.5 m of marly limestone containing moderately recrystallized species of upper Cretaceous nannofossils. The presence of *Broinsonia parca*, *Micula staurophora*, *Ceratolithoides aculeus*, and *Uniplanarius gothicus* indicates that this sediment, as sampled throughout Sections 567A-19-1 and 567A-19,CC, is upper Campanian/lower Maestrichtian. This limestone is the lowermost recovered marine sediment overlying igneous basement, but the possibility of downslope displacement cannot be ignored, since it represents an age and lithology which has consistently been found reworked throughout Tertiary sediments from Core 567A-8 and below.

Cores 567A-20 through 567A-29 recovered gabbro conglomerates, serpentinites, and metabasalts, which are, of course, barren of *in situ* nannofossils. Blue serpentinite mud was examined throughout this interval to determine the extent and stratigraphic level of downhole contamination. Very rare Tertiary species were observed in Sections 567A-20-1 and 567A-24,CC, indicating that downhole sluff is minimal and does not originate from any particular horizon.

Age Comparison of Pre-Pliocene Sediments from Sites 494 and 567

Post-cruise sampling of lithologies from the Site 494 Pre-Pliocene section (Sample 494-20-4, 56–57 cm through Sample 494-30-1, 100–101 cm) revealed nannofossil assemblages similar in age to those reported by Musylov (1982). Middle Miocene nannofossils were observed in Sample 494-21-1, 55 cm, and middle Eocene nannofossils indicative of the *Reticulofenestra umbilica* Zone (one zone younger than Musylov's age determination) range from Sample 494-22-4, 15 cm through Sample 494-27-3, 55 cm. Lower Miocene nannofossils are not present within angular mudstone chips or matrix sampled from this interval; this indicates that approximately 50 m of middle Eocene mudstone is present at Site 494, just 110 m north of Site 567.

Upper Cretaceous, probably upper Campanian or lower Maestrichtian, marly limestone is present from Sample 494-28-1, 10–12 cm through Sample 494-28-1, 50–52 cm. It is underlain by more middle Eocene mudstone from Sample 494-29-1, 86 cm to Sample 494-29-2, 37 cm, above another occurrence of Upper Cretaceous limestone sampled at 494-30-1, 100–101 cm. The Cretaceous limestone in Core 494-29 can therefore be interpreted as a displaced lithology within the middle Eocene. The Upper Cretaceous limestone within Core 494-30 is the lowermost marine sediment encountered at Site 494 above the igneous pebbles at total depth, and may or may not be displaced. Since the sediments are structurally complex and highly irregular below the unconformable surface of the Neogene slope cover (Site 567 report, this volume), the 100 m of lower Miocene sedimentary melange encountered at Site 567, 110 m closer to the trench axis on the down side of a normal fault, may be a result of the tectonic activity typical near an active subduction zone.

Site 568 (13°0.433′N, 90°48.00′W; water depth 2010 m)

Hole 568 was drilled on the upper middle slope of the Guatemalan MAT, approximately 1 km north of DSDP Site 496 and 48 km landward from the trench axis. A total of 417.7 m (44 cores) of Holocene/Pleistocene through

Table 2. Distribution of calcareous nannofossils at Site 567.

Age	Zone or subzone	Sample (interval in cm)	Sub-bottom depth (m)	Abundance	Preservation	Reworking	*Helicosphaera Sellii*	*Gephyrocapsa* spp. sensu Gartner, 1977—small	*Calcidiscus leptoporus*	*Crenalithus doronicoides*	*Discoaster brouweri*	*Calcidiscus macintyrei*	*Helicosphaera carteri*	*Sphenolithus neoabies*	*Discoaster pentaradiatus*	*Reticulofenestra pseudoumbilica*	*Coccolithus pelagicus*	*Catinaster mexicanus*	*Discoaster variabilis*	*Dictyococcites antarcticus*	*Discoaster deflandrei*	*Discoaster intercalaris*	*Discolithina plana*	*Helicosphaera scissura*	*Discoaster saundersi*	*Sphenolithus heteromorphus*	*Reticulofenestra gartneri*	*Cyclicargolithus floridanus*	*Helicosphaera ampliaperta*	*Helicosphaera californica*	*Helicosphaera intermedia*	*Orthorhabdus* sp.	*Triquetrorhabdulus milowii*	*Discolithina multipora*	*Sphenolithus conicus*	*Helicosphaera recta*	*Discoaster druggii*	*Triquetrorhabdulus carinatus*	*Helicosphaera minuta*	*Discolithina anisotrema*	*Sphenolithus belemnos*	*Helicosphaera rhomba*
		Hole 567																																								
early Pleist.	*Calcidiscus macintyrei*	1,CC	185.80	R	P,E		R	R	R	R	R	R	R																													
		2,CC	195.50	R	P,EO				R	R			R																													
		Hole 567A																																								
early Pliocene	*Reticulofenestra pseudoumbilica–Amaurolithus tricorniculatus*	1-4, 50-52	200.51	R	M,E									R																												
		1-6, 70-72	203.71	R	P,O						V	R																														
		1,CC	205.20	R	P,E					R	V		R		V	V	R																									
		2-1, 36-37	205.57	R	P,O						R																															
		2-4, 54-55	210.25	B																																						
		2-6, 57-58	213.28	B																																						
		2,CC	214.90	R	P,E	R			R	R	R		R	R		R		R	R																							
		3-2, 49-50	216.90	R	M,E	R								R	R	R	R			R	R																					
		3-2, 115-116	217.56	B																																						
		3-4, 28-29	219.69	R	M,E	R						R		R	R	R		R				R																				
		3-4, 115-116	220.56	B																																						
		3-6, 32-33	222.73	R	M,E								R			R			R																							
early Miocene	*Helicosphaera ampliaperta*	3-6, 115-116	223.56	F	P,O								F				R				R		R	R	R	R	F	F	R													
		3,CC	224.60	F	M,E								R						R		R				R	R	R	F	F	R	R	R	R	R								
		4-2, 60-61	226.71	B																																						
		4,CC	234.10	F	M,E	R													R		R						F	F							R	R	R	R	R			
		5-2, 148-149	237.09	B																																						
		5-4, 136-137	239.97	R	P,O																						R	R							R							
		5,CC	243.60	F	M,O								R								F			R	R		F	F				R			R		R	R		R	R	R
		6-2, 37-38	245.47	F	M,E								R				R			R	F				R		F	F	R			R			R						R	
		6-4, 100-101	249.10	F	M								R				R				R						F	F			R							R				
		6-5, 39-40	249.99	B																																						
		6,CC	253.10	R	P,OE											R	R				R																					
		7-1, 107-108	254.18	B																																						
		7-2, 8-9	254.68	R	P,O	R																						R														
		7-2, 11-12	254.71	R	M,O	R															R						R										R					
		8-2, 99-100	265.20	F	R,O											R					R					R		F	R										R			
		8-4, 46-47	267.67	R	M	R							R				R				R					R	R	R	R													
		8-4, 53-54	267.74	R	P,E																R							R														
		8-4, 78-79	267.99	F	M	R							F				R				R					R	F	F	F		R											
		8,CC	271.90	F	M,E								F				R		F		F					R	F	F	I					R							R	
		9-2, 108-109	274.49	F	P,OE	R							F				R		R		F			R		R		F	F				R									
		9-4, 108-110	277.49	R	P,O	R							R								R					R		R	R													
		9,CC	280.70	F	M,E	R											R		F		F					R	R		F			R	R									
		10-2, 18-19	282.39	F	P,O	R							F				F				R			R		R	R									R						
		10-4, 43-44	285.64	R	P,O	R							R								R					R			R					R				R				
		10,CC	289.50	R	M,E	F							F				F		F		R					R	F	F	F					R					V		R	
		11-1, 72-73	290.22	F	M,E	R										F	R										F	F	R													
		11-2, 14-15	291.14	F	M,O	C											R				F						R									R						
		11,CC	298.40	C	M,O	C							R								F						R		R								R	R				
		12-2, 78-79	300.69	C	M,O	C											C											F										R				
		12-4, 9-11	303.00	F	M,EO	C															V						R		V													
		12-4, 78-79	303.69	R	P,O	R							R				R				R					R	R		R					R								
		12-5, 44-45	304.85	F	M,EO	C																																				
		12,CC	307.30	F	M,EO	F							R			R	R				F				R	R	F	R	R				R	R								
		13-1, 70-71	308.01	C	M,O	C											F																									
		13-1, 109-110	308.39	C	M,E	C											F																	R								
		13-1, 147-148	308.77	R	P,O	C																																				
		13-2, 20-21	309.01	R	P,E	C											R																									
		13,CC	316.20	F	M,E	F							R			R	R				R					R		R	R													R
?		14-2, 2-3	317.73	B																																						
		14-2, 38-39	318.09	B																																						
		14-2, 54-55	318.25	B																																						
		14,CC	325.10	B																																						
		16,CC	342.80	B																																						
		17-1, 80-81	343.61	B																																						
		17,CC	351.70	B																																						
		18-1, 15-16	351.86	R	P,O	R											R																									
early Miocene	*Helicosphaera ampliaperta* or *Sphenolithus belemnos*	18-1, 48-49	352.19	F	M,E	F							R				R										F		R				R	R					R			
		18,CC	352.82	C	M,O	C											F											C														
		18,CC	352.82	F	P,O	C																																				
		18,CC	352.82	C	M	C											F											C														
		18,CC	352.82	F	M	F							R				F												V													
early Maestrichtian–late Campanian		19-1, 60-61	359.31	R	P,O																																					
		19-1, 74-75	359.45	C	P,O																																					
		19,CC	360.20	F	P,O																																					

Note: See note to Table 1 for explanation of abbreviations.

lower Miocene mudstone was recovered. The primary objective at this site was to monitor and study the occurrence of gas hydrate, which had been previously encountered at Site 496, causing termination of drilling.

Abundant nannofossil assemblages are well preserved throughout the Pleistocene (Core 568-1 through Section 568-21,CC), but lack consistent occurrences of the index species *Pseudoemiliania lacunosa* and *Helicosphaera sellii* (Table 4). Specimens of *Calcidiscus macintyrei* are reworked in Cores 568-1 through 568-11.

Middle Miocene to lower Pliocene nannofossils are rare to absent, but moderately preserved when present in Cores

Table 2. (Continued).

Discolithina vigintiforata	*Sphenolithus abies*	*Helicosphaera euphratis*	*Dictyococcites bisectus*	*Eiffellithus turriseiffeli*	*Micula staurophora*	*Neochiastozygus concinnus*	*Discoaster exilis*	*Coronocyclus nitescens*	*Syracosphaera pulchra*	*Watznaueria barnesae*	*Toweius* sp.	*Discoaster lodoensis*	*Chiasmolithus titus*	*Fasciculithus tympaniformis*	*Sphenolithus moriformis*	*Cribrosphaerella ehrenbergii*	*Discoaster mohleri*	*Thoracosphaera* sp.	*Zygodiscus elegans*	*Uniplanarius trifidus*	*Discoaster barbadiensis*	*Prediscosphaera cretacea*	*Helicosphaera obliqua*	*Dictyococcites scrippsae*	*Helicosphaera bramlettei*	*Discoaster tanii ornatus*	*Sphenolithus predistentus*	*Sphenolithus radians*	*Reticulofenestra samodurovii*	*Reticulofenestra umbilica*	*Helicosphaera compacta*	*Cretarhabdus crenulatus*	*Manivitella pemmatoidea*	*Broinsonia enormis*	*Microrhabdulus decoratus*	*Ceratolithoides aculeus*	*Uniplanarius gothicus*	*Broinsonia parca*	*Discoaster bifax*	*Rhabdosphaera tenuis*	*Neochiastozygus dubius*	*Chiasmolithus solitus*	*Coccolithus eopelagicus*	*Helicosphaera seminulum*	*Coccolithus formosus*	*Helicosphaera lophota*	*Discoaster saipanensis*	*Sphenolithus spiniger*	*Transversopontis pulcher*	*Zygrhablithus bijugatus*	*Discoaster multiradiatus*	*Discoaster germanicus*	*Chiasmolithus grandis*	*Chiasmolithus consuetus*	*Eiffellithus eximius*	*Lucianorhabdus cayeuxii*	*Tranolithus orionatus*
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	F	F						R	R								V	R																																					
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				R	F					C																						F				R		R																	R	R	
					F					F						R						R										R				R	R	R																			R

568-23 through 568-25 (Table 5). Middle and lower Miocene nannofossils encountered in Cores 568-27 through 568-41 contain rare to common and only moderately preserved nannofossils. Upper Oligocene or lower Miocene nannofossils in Cores 568-42 and 568-43 are rare and are poorly to moderately preserved. Sample 568-44,CC (417.7 m total depth) is barren of age-diagnostic nannofossils.

Reworking of nannofossils other than *C. macintyrei* is minimal; several lower Pleistocene to middle Miocene species are present in Cores 568-1 through 568-5. Samples 568-1-2, 80 cm through 568-6-2, 43 cm are assigned to the Holocene or upper Pleistocene *Emiliania huxleyi* Zone or *Gephyrocapsa oceanica* Zone on the basis of occurrence of *Gephyrocapsa oceanica*, *Helicosphaera carteri*, small *Gephyrocapsa* spp., and possibly *E. huxleyi*.

Table 3. Nannofossil age determinations of selected, apparently *in situ* lithologies from Hole 567A, cores 6–18. Age spread suggests reworking of Oligocene, middle Eocene, and Late Cretaceous clasts into an early Miocene sedimentary breccia. See Table 2 for distribution of taxa.

Sample (interval in cm)	Lithology	Description	Age
6-4, 100–101	Gray mudstone	Angular clast (1 cm)	Miocene
6-4, 100–101	Gray mudstone	Matrix	Miocene (prob. early)
7-2, 11–12	Hard blue-green mudstone	Angular clast (1 cm)	Oligocene–mid. Eocene
8-4, 46–47	Gray mudstone	Small clast (5 mm) with matrix	Mixed: clast—Late Cret. matrix—early Miocene
8-4, 78–79	Gray mudstone	Matrix	early Miocene
8-4, 81–82	Gray mudstone	Brecciated bedded layer (~1 cm thick)	early Miocene
10-2, 18–19	Light gray mudstone	Brecciated bedded layer (1–2 cm thick)	early Miocene
11-1, 72–73	Gray mudstone, mottled	Matrix with small (1 mm) clasts	Oligocene
12-4, 9–11	Soft blue mudstone	Clast	Late Campanian–Maest.
12-5, 44–45	Soft white limestone	Clast	Late Campanian–Maest.
13-1, 70–71	Firm, dark brown mudstone	Angular clast (1 cm)	middle Eocene
13-1, 104–110	Gray-brown mudstone	Angular clast (1 cm)	middle Eocene
13-1, 147–148	Gray limestone	Angular clast (~5 cm)	Cretaceous
13-2, 20–21	Soft gray mud	Matrix	Mixed: Oligocene–Cret.
13,CC	Soft gray mud	Matrix	Mixed: early Miocene–Late Cretaceous
18,CC	Soft green mudstone	Clast	middle Eocene
18,CC	Soft white mudstone	Clast	Late Cretaceous
18,CC	Soft gray mudstone	Possible matrix underlying serpentinite mud	Mixed: middle Eocene with rare early Miocene

Samples 568-6-4, 43 cm through 568-11-1, 89 cm, are assigned to the upper Pleistocene *Pseudoemiliania lacunosa* Zone on the basis of the same assemblage as that just mentioned, with the addition of *P. lacunosa* and the absence of *E. huxleyi*. Cores 1 through 11 (Section 1) of Hole 568 are approximately age-equivalent to Cores 1 through 11 of Hole 496.

The interval from Sample 568-11,CC through Sample 568-13-2, 61 cm is tentatively assigned to the small *Gephyrocapsa* Zone on the basis of the dominant abundance of small *Gephyrocapsa* spp. and the lack of *G. oceanica*. This interval is approximately equivalent to the interval from Sample 496-11-3, 60 cm through Sample 496-12-2, 62 cm, where Musylov (1982) also lists abundant small *Gephyrocapsa* spp.

The interval from Sample 568-13-4, 45 cm through Sample 568-21,CC is assigned to the lower Pleistocene, and is equivalent to Sections 14-1 through 24-5 of Hole 496. There is little change from the assemblage encountered upsection, and the sporadic, rare occurrences of *P. lacunosa* and *Helicosphaera sellii* make zonal assignment difficult. Lack of *Calcidiscus macintyrei* in this section (though apparently reworked above Core 568-12) suggests that the lowermost Pleistocene may be absent.

Samples 568-22-2, 146 cm through 568-23-2, 90 cm are dominated by siliceous microfossils and are barren of calcareous nannofossils. Samples 568-23,CC through 568-25-2, 148 cm are middle Miocene to lower Pliocene, judging by the occurrence of *H. carteri, C. leptopora, Discoaster brouweri, Sphenolithus abies*, and *Reticulofenestra pseudoumbilica*. Sample 568-24,CC is barren of calcareous nannofossils. This section is probably equivalent to a condensed upper Miocene through lower Pliocene section (496-26-3, 67 cm through 496-28-5, 28 cm) at Site 496.

The presence of a short upper Pliocene section, which was established for Site 496 (Sections 496-25-2 through 496-26-3), was not observed for Site 568 on the basis of the microfossil disciplines; this suggests the development of an unconformity between sites. The absence at both sites, of sediments definitely belonging to the *Catinaster coalitus* through *Discoaster neohamatus* zones suggests the presence of a second, more extensive upper middle to lower upper Miocene unconformity or condensed section in this region.

Samples 568-25-4, 23 cm through 568-28-2, 11 cm are middle Miocene and assigned to the *Discoaster exilis* Zone. Rare *Discoaster exilis, D. challengeri*, and *Discoaster* sp. cf. *D. bollii* are present in Sample 568-25-4, 23 cm, and Sample 568-27,CC contains *Coccolithus miopelagicus* and *Discoaster adamanteus* with *D. exilis.*

Samples 568-28-6, 10 cm through 568-38-2, 147 cm are assigned to the middle Miocene *Sphenolithus heteromorphus* Zone. They contain a well-developed assemblage with *S. heteromorphus, D. exilis* s. ampl., *Discoaster signus, C. miopelagicus, H. carteri,* and *Discoaster varia-*

Table 4. Distribution of Holocene and Pleistocene calcareous nannofossils at Site 568.

Age	Zone or subzone	Sample (interval in cm)	Sub-bottom depth (m)	Abundance	Preservation	*Gephyrocapsa omega*	*Gephyrocapsa oceanica*	*Crenalithus doronicoides*	*Gephyrocapsa* spp. sensu Gartner, 1977—small	*Calcidiscus leptoporus*	*Calcidiscus macintyrei*	*Helicosphaera carteri*	*Cricolithus jonesii*	*Helicosphaera wallichii*	*Umbilicosphaera sibogae*	*Pseudoemiliania lacunosa*	*Ceratolithus cristatus*	*Thoracosphaera saxae*	*Sphenolithus neoabies*	*Dictyococcites antarcticus*	*Syracosphaera pulchra*	*Reticulofenestra pseudoumbilica*	*Sphenolithus heteromorphus*	*Discoaster brouweri*	*Helicosphaera sellii*	*Orthorhabdus serratus*	*Discolithina japonica*	*Discoaster bergrenii*	*Watznaueria barnesae*	*Discolithina plana*	*Discoaster barbadiensis*
Holocene-late Pleistocene	*Emiliania huxleyi*-*Gephyrocapsa oceanica*	1-2, 80-81	2.31	F	P	R	F	C	C	R	F	F																			
		1,CC	3.40	C	M, E	R	C	C	C	F	R	F	F	R																	
		2-2, 144-145	6.35	F	P, E		R	F	C																						
		2-4, 138-139	9.29	F	P		F	F	C			F																			
		2-6, 146-147	12.37	F	P, E		F	C	C			F		R																	
		2,CC	13.00	C	M, E	R	F	C	C	F	R	F			R																
		3-2, 135-136	15.86	R	P, E			F	F		R	R																			
		3-4, 135-136	18.86	R	M, E			F	F			R																			
		3-6, 135-136	21.86	F	M, E	R	F	C	C	R		F			R																
		3,CC	22.70	C	M, E	F	C	C	C	F	R	F				V															
		4-2, 118-119	25.39	F	P, EO		F	C	C	F		F																			
		4-4, 118-119	28.39	F	P, E		F	C	C			R					V														
		4,CC	32.30	F	M, E	R	F	C	C	P	R	F				V		R													
		5-2, 144-145	35.25	C	M, E	R	R	C	C	F	F	F																			
		5-4, 144-145	38.24	C	M, E	R	F	C	C	R		F																			
		5-6, 144-145	41.25	F	M, E	R	F	C	C	R		R			R																
		5,CC	42.00	C	M, E	F	F	C	C	F	R	F	R	R	R			R													
		6-2, 43-44	43.94	C	P, EO	R	F	C	C	F		F			R																
late	*Pseudoemiliania lacunosa*	6-4, 43-44	46.94	F	M, E		F	C	C	R	R	R		R		R			R												
		6,CC	51.40	C	M, E		F	C	C	F		F				R															
		7-2, 48-49	53.39	F	M, E	R	F	C	C	R		R				R				R	R	R									
		7-4, 48-49	56.39	F	M, E		R	C	C	F		R				R				R			R								
		7,CC	61.10	F	M, E		R	C	C	R		R																			
		8-4, 36-37	65.97	F	P, E		R	C	C			R				R															
		8-6, 36-37	68.97	C	P, O		R	C	F	F		F																			
		8,CC	70.40	C	M, E		F	F	A	R		F	R		R	R								R							
		9-2, 149-150	73.40	C	M, E	R	F	C	C			R													R						
		9-4, 149-150	76.40	C	P, O		F	C	C	R		F								F											
		9,CC	80.10	C	M, E		C	C	C	F	R	C	R							R											
		10-2, 149-150	83.10	C	P, O			C	C	R		F								F											
		10-4, 146-147	86.06	C	P, O		F	C	C	R		R																			
		10,CC	89.40	C	M, E		F	C	C	F		F	R													R					
		11-1, 88-89	90.29	C	P, O		F	C	C	F	R	R								F											
	small *Gephyrocapsa*	11,CC	98.80	A	M, E			C	A	F		F									R				R						
		12-2, 144-145	101.75	C	P, O			C	A			F																			
		12,CC	108.30	A	M, E		R	C	A	F		F														V	V				
		13-2, 60-61	110.41	A	M, O			C	A	F		F													R						
Pleistocene early	small *Gephyrocapsa*-*Calcidiscus macintyrei*	13-4, 45-46	113.26	A	M, O			C	A	F		C								R											
		13,CC	117.80	A	M, E			C	A	F		C																	R	R	
		14-4, 105-106	123.36	A	M, E		R	C	A	F		C																			
		14-6, 61-62	125.92	A	M, O			C	A	R		C																			
		14,CC	127.40	A	M, E			C	A	C		C						R							R						
		15-2, 97-98	129.88	C	P, O			C	C			F								R											
		15-6, 60-61	135.51	F	P, OE	R	R	F	C	F		F																			
		15,CC	137.20	F	P, E		F	C	C	F		F				F	R														
		16-2, 15-16	138.86	F	M, E		R	C	C			R				R															
		16-6, 15-16	144.86	F	P, O		F	C	C	F		R																			
		16,CC	146.90	F	P, E	F	F	C	C	F		F	A		R	R					R										
		17-4, 85-86	152.26	F	P, O			C	C	F		F								R											
		17-6, 85-86	155.26	F	P, E		R	C	C	F		R	R			F											R				
		17,CC	156.50	F	P, E		F	C	C	F		R												R							
		18-2, 24-25	158.25	C	M, E	F	C	C	C	F		F																			
		18-4, 24-25	161.25	C	P, E	F	F	C	C	R		R																			
		18,CC	166.20	C	M, E	R	F	C	A	R		F	R	R											R						
		19-2, 89-90	168.60	C	P, E		R	C	C	R		R	R																		
		19-4, 45-46	171.16	C	M, E		F	C	C	F		F																			
		19,CC	176.00	C	M, E		R	C	A	C		C	R			R															
		20-2, 94-95	178.45	B																											
		20-4, 94-95	181.45	C	P, O			C	C	R																					
		20,CC	185.70	C	M, E		R	C	R	C		C		R	R						R				R	R	R			R	
		21-1, 137-138	187.08	F	M, E			F	F	F	R	F																			
		21,CC	187.30	F	M, E			C	F	R		F				R									R						R

Note: See note to Table 1 for explanation of abbreviations.

Table 5. Distribution of Pre-Pleistocene calcareous nannofossils at Site 568.

Age	Zone or subzone	Sample (interval in cm)	Sub-bottom depth (m)	Abundance	Preservation	*Reticulofenestra pseudoumbilica*	*Calcidiscus leptoporus*	*Sphenolithus neoabies*	*Discoaster calcaris*	*Discoaster brouweri*	*Coccolithus pelagicus*	*Helicosphaera carteri*	*Discoaster asymmetricus*	*Discoaster challengeri*	*Triquetrorhabdulus milowii*	*Discolithina vigintiforata*	*Sphenolithus abies*	*Discolithina plana*	*Discoaster variabilis*	*Coronocyclus nitescens*	*Cyclicargolithus floridanus*	*Discoaster adamanteus*	*Discoaster exilis*	*Coccolithus miopelagicus*	*Calcidiscus macintyrei*	*Discolithina anisotrema*	*Sphenolithus heteromorphus*	*Discoaster elegans*	*Discoaster bollii*	*Helicosphaera minuta*	*Discolithina multipora*	*Discoaster tuberi*	*Discoaster signus*	*Discoaster sanmiguelensis*	*Discoaster deflandrei*	*Sphenolithus conicus*	*Helicosphaera euphratis*	*Discoaster icarus*	*Sphenolithus belemnos*	*Helicosphaera ampliaperta*	*Dictyococcites scrippsae*	*Chiasmolithus consuetus*	*Reticulofenestra gartneri*	*Helicosphaera intermedia*	*Watznaueria barnesae*	*Discoaster saundersi*	*Discoaster calculosus*	*Helicosphaera recta*	*Triquetrorhabdulus carinatus*	*Orthorhabdus serratus*
?		22-2, 146–147	198.37	B																																														
		22-4, 98–99	200.89	B																																														
		22-6, 146–147	204.37	B																																														
		23-2, 149–150	208.10	B																																														
Pliocene–mid. Miocene	*D. brouweri–D. exilis*	23,CC	214.80	R	M, E	R	R	R	R	R	R	R																																						
		24-2, 84–85	217.14	B																																														
		24-3, 100–101	218.81	R	P, E					R	R	R																																						
		24-4, 84–85	220.14	B																																														
		24-6, 84–85	223.14	B																																														
		25-2, 148–149	227.49	B																																														
middle Miocene	*Discoaster exilis*	25-4, 23–24	229.24	F	M, O			R				F	R	R	R	F	F																																	
		25,CC	234.20	R	M, E				A	A	A																																							
		27-2, 67–68	246.08	F	P, O						F	R						R	R	R	F																													
		27-4, 67–68	249.08	B																																														
		27,CC	253.40	F	P, OE						F	R					R	R	R	R	F	R	R	R																										
		28-2, 10–11	255.01	F	P, O						F	R							R		F			R	R	R																								
	Sphenolithus heteromorphus	28-6, 10–11	261.01	F	P, O						F	R							R		F	R		R			R																							
		28,CC	263.10	C	M, E						C	F				R				R	C		F	F			F	R	F	R	R																			
		29-4, 51–52	268.11	F	P, O							F									R		F	R			F																							
		29-6, 51–52	271.11	F	P, O						R	R				R					F		F	R			F																							
		29,CC	272.60	C	M, E						F	F				R			R		F		C	F			F				R	F	R																	
		30-2, 28–29	274.39	F	P, O						R	R									R		F	R			F					F																		
		30-4, 33–34	277.43	B																																														
		30,CC	282.30	F	M, E						R	F					R			R	F		F	R			F					F	R	R																
		31-1, 110–111	283.41	F	M, E							F		R							F		F	R			F					F		R	R															
		31,CC	292.00	C	M, EO						R	F		R		R	R		R		C		F	R			F				R	C		R		R	R													
		32-2, 58–59	294.09	F	M, EO							F								R	F		F				R					F		R																
		32-6, 59–60	300.10	F	P, O						F	R									F		F				R					R		R				R												
		33-2, 30–31	303.40	F	P, O						R	R											F				R				R	R		R																
		33-4, 30–31	306.40	C	M, O						F	F									F		C	R			F					F		R																
		35-4, 130–131	327.01	C	M						F	F			R						F		C	R	R		F					F				F														
		36-6, 130–131	339.81	C	M, O						F	F							R				F	R	R		F					F				F			F											
		37-2, 46–47	342.67	C	M, OE							F		R		R					F		C	R	F		F					F			F		R													
		37-4, 45–46	345.66	B																																														
		37,CC	350.20	B																																														
		38-2, 146–147	353.17	F	P, O						R	F											F				F					F	R		R															
early Miocene	*Helicosphaera ampliaperta*	38-4, 138–139	356.09	R	P, O						R																F								F					R										
		38-6, 146–147	359.17	F	P, O						F	F			R	R	R			R	R			R											F		R			F	R	R	R	R						
		40-2, 147–148	372.58	F	M						R	F			R		F			F						R	R				R				F		F	R		R			R		R	R	F			
		41-4, 42–43	384.23	F	P, O						R	F					R			F	F						R				R				F		F			R			R			R	R			
		42-3, 125–126	393.26	R	M						R	R					R				F														F												R	R		
	S. belemnos–D. deflandrei	42-7, 40–42	398.42	F	M							R				R	R				F			R											R		F							F				R	R	
		43,CC	408.40	R	M, E																R														R		R		R					R					R	R
		44-2, 69–70	410.60	R	P, O												R				R														R														F	
		44-4, 69–70	413.60	R	P, O												R				R																												F	
		44,CC	417.70	B																																														

Note: See note to Table 1 for explanation of abbreviations.

bilis. Only 3 m of section (Core 496-30, Sections 7 and 8) are assigned to the *S. heteromorphus* Zone at Site 496. The 78-m thickness of this same zone penetrated at Site 568 may be a result of greater sedimentation rates in this upslope area during part of the middle Miocene.

Samples 568-38-4, 138 cm through 568-42-3, 126 cm are assigned to the lower and middle Miocene *Helicosphaera ampliaperta* Zone. They contain *H. ampliaperta, S. heteromorphus, H. intermedia, H. euphratis*, and *Discoaster deflandrei*, and are equivalent to Cores 31 through 40 of Hole 496 (drilling there ceased with Core 40). Deposition of sediment breccia at Site 567 also occurred during the time corresponding to this lower Miocene zone.

Samples 568-42-7, 40 cm through 568-44-4, 70 cm (firm mudstone lithologies) are considered lower Miocene, and contain consistent occurrences of *Helicosphaera euphratis, D. deflandrei, Triquetrorhabdulus carinatus*, and *Sphenolithus moriformis*. No specimens of *Cyclicargolithus abisectus* or *Dictyococcites bisectus* are present, indicating that Oligocene sediments were not penetrated. High bedding-angle dips, a poorly preserved mixture of upper Eocene to Miocene diatoms, and the occurrence of pyritized radiolarians suggest that the Eocene to lower Miocene unconformable surface encountered upslope in the Esso Petrel well (Seely, 1979) may have affected sedimentation in Cores 42–44 of Hole 568. If so, one of several hypotheses (see Site 568 report, this volume) is that the subcropping Eocene lithologies may have afforded a rough surface topography, which would allow local reworking, together with high-angle draping of the overlying lower Miocene to upper Oligocene sediments along a highly irregular erosional surface.

Sample 568-44,CC is barren of any age-diagnostic nannofossils.

Site 569

Two holes were drilled at Site 569 above a seismically defined basement high on the mid-slope of the Guatemalan MAT, 32 km upslope from the trench axis. Sampling of slope sediments (charged with gas hydrates, as documented at Site 497) and basement complex were the primary objectives at this site.

Recovery in Hole 569 included 250.7 m of Pleistocene to upper Oligocene mudstone. Hole 569A, offset about 900 m west and directly over the high, was washed to 246 m to recover upper Oligocene and probably lower Eocene sediment above several meters of metabasalt basement at 361 m (total depth).

Calcareous nannofossils are frequent to common and moderately preserved within most of the Pleistocene through upper Eocene intervals (Table 6), except for the lower Miocene interval from 125 to 231 m in Hole 569, where assemblage diversity and abundances drop. Lower Eocene nannofossils are also rare and heavily recrystallized within Sample 569A-10-1, 1–2 cm.

Reworking is minimal and largely restricted to the Pleistocene, where several rare Cretaceous species were observed.

Hole 569 (12°56.31′N, 90°50.35′W; water depth 2744 m)

Samples 569-1-1, 108 cm through 569-4,CC are assigned to the Holocene/upper Pleistocene *Emiliania huxleyi* Zone or *Gephyrocapsa oceanica* Zone, and contain common abundances of *G. oceanica, Helicosphaera carteri*, small *Gephyrocapsa* spp., and minute placoliths with affinities to *Emiliania huxleyi*. Samples 569-5,CC and 569-6,CC (40.0–49.7 m) are also Pleistocene, but species diversity and abundances are unfavorably low for detailed zonation. *P. lacunosa* is present, indicating an age older than the *G. oceanica* Zone. Very rare specimens of the Cretaceous species *W. barnesae* are present in Sample 569-6,CC. Samples 569-7-2, 10 cm through 569-7-6, 10 cm are barren of nannofossils.

Sample 569-7,CC (58.9 m) is assigned to the upper Pliocene *Discoaster pentaradiatus* Subzone. It contains frequent *Discoaster pentaradiatus* and rare *D. brouweri* and *D. decorus*. A change in lithologic color, which may represent the Pliocene/Pleistocene boundary, is present near 569-7-6, 49 cm, but samples bracketing the contact are barren of nannofossils. Sample 569-8-2, 2 cm also contains rare *D. brouweri* and *D. pentaradiatus*, but the low assemblage diversity and abundance preclude definite zonal assignment. Samples 569-8,CC through 569-9,CC are barren of nannofossils. Lower Pliocene through upper middle Miocene sediments are absent or represented stratigraphically by the barren/nondiagnostic (all microfossil disciplines) section present from 569-8-2, 2 cm through 569-9,CC.

Samples 569-10-2, 20 cm through 569-10,CC are middle Miocene and assigned to the *Sphenolithus heteromorphus* Zone. Diagnostic species include *S. heteromorphus, Discoaster exilis* s. ampl., *Coccolithus miopelagicus*, and *Discoaster signus*. The 8-m core interval is age-equivalent to the 92-m-thick section penetrated in Sections 28-6 through 38-2 from Hole 568.

Samples 569-11-2, 71 cm through 569-12,CC are assigned to the lower and middle Miocene *Helicosphaera ampliaperta* Zone, and contain *H. ampliaperta*, S. heteromorphus, and *Discoaster deflandrei*. This 17-m section is age-equivalent to Sections 38-4 through 42-3 (37 m thick) of Hole 568.

Samples 569-13-4, 3 cm through 569-22,CC (111.2–202.6 m) are lower Miocene on the basis of rare to frequent occurrences of moderately to poorly preserved specimens of *D. deflandrei, Cyclicargolithus floridanus, Sphenolithus moriformis, S. conicus, Sphenolithus* sp. cf. *S. belemnos*, and *Discoaster saundersi*. Sample 569-17,CC also contains rare *Triquetrorhabdulus milowii*, which is restricted to lower Miocene or younger sediment. The absence of *Discoaster druggii* indicates that this entire interval may be within the *Sphenolithus belemnos* Zone, but low assemblage abundances and diversity prohibit definite zonal assignment. Core 569-23 is dominated by siliceous microfossils and barren of nannofossils.

Samples 569-26-3, 62 cm and 569-26-4, 44 cm were selected from a light gray calcareous mudstone within

Table 6. Distribution of calcareous nannofossils at Site 569.

Age	Zone or subzone	Sample (interval in cm)	Sub-bottom depth (m)	Abundance	Preservation	*Gephyrocapsa* spp. sensu Gartner, 1977—small	*Crenalithus doronicoides*	*Helicosphaera carteri*	*Emiliania huxleyi*	*Gephyrocapsa oceanica*	*Calcidiscus leptoporus*	*Discoaster brouweri*	*Umbilicosphaera mirabilis*	*Pseudoemiliania lacunosa*	*Watznaueria barnesae*	*Calcidiscus macintyrei*	*Helicosphaera sellii*	*Discolithina japonica*	*Discoaster intercalaris*	*Discoaster decorus*	*Discoaster pentaradiatus*	*Sphenolithus heteromorphus*	*Discoaster variabilis*	*Coccolithus pelagicus*	*Triquetrorhabdulus rugosus*	*Discoaster signus*	*Discoaster tuberi*	*Triquetrorhabdulus auritus*	*Coccolithus miopelagicus*	*Coronocyclus nitescens*	*Sphenolithus abies*	*Cyclicargolithus floridanus*
		Hole 569																														
Holocene–late Pleistocene	*Emiliania huxleyi–Gephyrocapsa oceanica*	1-1, 107–108	1.08	F	P,E	F	F	R																								
		1,CC	1.20	A	M,E	A	C	C	?	F	F	V																				
		2-2, 148–149	4.19	F	P,OE	C	F	R			R																					
		2,CC	11.10	F	M,E	F	F	R		R	R																					
		3-2, 17–18	12.78	R	P,OE	R	R	R			R																					
		3,CC	20.60	F	M	F	C	R		R	F																					
		4-2, 70–71	22.80	C	P,OE	F	C	F		R	F		R																			
		4,CC	30.30	C	M	C	C	F		F	F																					
Pleist.	*P. lacunosa–C. macintyrei*	5-2, 16–17	31.97	F	P,OE	F	F	R						R																		
		6-4, 29–30	44.80	B																												
		6,CC	49.70	F	M		F	R		R	R		R	F	R	R																
?		7-2, 10–11	51.31	B																												
		7-6, 10–11	57.31	B																												
l. Plioc.	*D. pentaradiatus*	7,CC	58.90	C	M,E		C	F			R	R	R	R		F	R	R	R	F	F											
?		8-2, 2–4	60.43	R	M,E			R				R									R											
		9-2, 20–22	70.21	B																												
middle Mioc.	*Sphenolithus heteromorphus*	10-2, 20–21	79.61	R	P,OE																	R	R	R								
		10,CC	87.40	R	P,OE			F				F				R						F	F	F	R	R	F	R	R	R	R	F
early Miocene	*Helicosphaera ampliaperta*	11-2, 71–72	89.62	F	M			F														F	R	F			R	R	F			F
		12-2, 69–70	99.30	B																												
		12,CC	106.70	C	M			F														C	F	F				R	F		R	F
	Sphenolithus belemnos–Discoaster deflandrei	13-4, 3–4	111.24	R	M			F															R	F						R	R	R
		14-2, 149–150	119.00	F	M			R																R								F
		15-2, 103–104	128.14	F	P,OE			R																F							R	F
		16-1, 66–67	135.77	B																												
		17-6, 148–149	153.79	R	P,O			R																R								
		18-2, 138–139	157.27	B																												
		19-1, 30–31	164.41	F	P,OE			R																								F
		20-1, 149–150	175.30	R	P,OE																			R								R
		21-3, 34–35	186.75	R	P,O			R																R								R
		22,CC	202.60	R	P,E			R																R								R
		23-4, 43–44	207.53	B																												
		24-2, 77–78	214.38	F	P,O			R																R								F
		25,CC	231.40	R	P,E																										R	R
		26-4, 44–45	236.35	R	P,O			R																								F
late Olig.	*D. bisectus*	27-1, 19–20	241.20	C	M																			F								F
		27,CC	250.70	C	M,E																			F								C
		Hole 569A																														
early Miocene–late Olig.	*D. deflandrei–C. abisectus*	1-1, 99–100	247.00	F	M																			R								F
late Olig.	*D. bisectus*	2-1, 147–148	256.98	F	M																											F
		4,CC	284.30	R	M																			R							R	F
	C. floridanus–S. distentus	6-1, 42–43	294.33	F	P,O																			R								F
		7-1, 42–43	303.93	F	P,O																			R								F
e. Olig.	*S. predistentus*	7,CC	313.10	C	M																			F								C
late Eocene	*D. barbadiensis*	8-1, 74–75	313.85	C	M																			F								C
		8,CC	314.88	C	M																											
mid. Eocene	*D. saipanensis*	9-1, 18–19	332.49	F	P,O																			F								
		9,CC	334.18	F	P,O																			F								
early Eocene	*D. lodensis* (?)	10-1, 1–2	351.42	F	P,O																											

Note: See note to Table 1 for explanation of abbreviations.

Table 6. (Continued).

Discoaster deflandrei	*Discoaster barbadiensis*	*Discoaster exilis*	*Helicosphaera californica*	*Helicosphaera ampliaperta*	*Discolithina vigintiforata*	*Helicosphaera intermedia*	*Helicosphaera euphratis*	*Recticulofenestra gartneri*	*Triquetrorhabdulus milowii*	*Discoaster calculosus*	*Discoaster druggi*	*Discoaster saundersi*	*Sphenolithus moriformis*	*Reticulofenestra pseudoumbilica*	*Triquetrorhabdulus carinatus*	*Dictyococcites minutus*	*Sphenolithus conicus*	*Helicosphaera bramlettei*	*Cyclicargolithus abisectus*	*Dictyococcites scripsae*	*Dictyococcites bisectus*	*Micula staurophora*	*Helicosphaera recta*	*Sphenolithus ciperoensis*	*Syracosphaera pulchra*	*Coccolithus eopelagicus*	*Helicosphaera compacta*	*Sphenolithus predistentus*	*Discolithina multipora*	*Discoaster distinctus*	*Discoaster tanii nodifer*	*Ellipsolithus subdistichus*	*Cribrocentrum reticulatum*	*Discoaster saipanensis*	*Reticulofenestra samodurovii*	*Reticulofenestra umbilica*	*Coccolithus formosus*	*Discoaster tanii tanii*	*Helicosphaera lophota*	*Chiasmolithus grandis*	*Sphenolithus radians*	*Discoaster binodosus*	*Discoaster lodoensis*	*Chiasmolithus solitus*	*Coccolithus crassus*	*Calcidiscus gammation*	*Zygrhablithus bijugatus*	*Discoasteroides kuepperi*
R	R																																															
		R	R	R	R	R																																										
F				C			R	F																																								
F						R	R	R	R	R																																						
F								F			R	R	R																																			
F					R			F				R		R	R																																	
R													R			R																																
F					R								R		R																																	
F						R		R					R	R	R																																	
R								R																																								
R							R	F					R		R		R																															
R						R		R					R				R																															
R	R														R			R	R	F																												
F							R						R		F		R	F	R	F	R																											
F	R						R						F		F		R	R	F		V	R	R	R																								
F	R						R	F					F	R				F	R				R																									
R							R						F		F		R		R	R				R	R																							
R	R						R											R	R		R		R		R																							
							R						R					R	R		R			R		R																						
R							R	R					R														V																					
								F					F				R	F		F	F					R	F	R																				
R	F					R							F							F	F					R		R	R	R	R	R	R	F	F	F	R												
	F																			F	C												C	F	F	R	F	R											
	F																			F	F					R								F	F	F	R		R	R	R								
	F																			F	F					R								F	F	F						R							
	F												F																								F				F		F	R	R	R	R	R

the burrows of a highly bioturbated sediment. They contain *Discoaster deflandrei, Dictyococcites scrippsae, Helicosphaera recta*, and *H. bramlettei*, lack *Cyclicargolithus abisectus* and *Dictyococcites bisectus*, and are most indicative of the lower Miocene *Discoaster deflandrei* Subzone.

Samples 569-27-1, 19 cm through 569-27,CC (250.7 m) are upper Oligocene, and are assigned to the *Dictyococcites bisectus* Subzone. Age-diagnostic species include *C. floridanus, D. deflandrei, T. carinatus, D. bisectus, H. recta, C. abisectus, Sphenolithus ciperoensis*, and *H. bramlettei.*

Hole 569A (12°56.22′N, 90°50.81′W; water depth 2795 m)

Sample 569A-1-1, 99 cm, is probably lower Miocene (*Discoaster deflandrei* Subzone), and contains *D. deflandrei, H. bramlettei*, and *Dictyococcites scrippsae*.

Samples 569A-2-1, 147 cm through 569A-6-1, 43 cm are upper Oligocene, and are assigned to the *D. bisectus* Subzone. They contain the species *C. floridanus, D. deflandrei, Helicosphaera intermedia, C. abisectus*, and *H. recta*. Sample 569A-7,CC contains frequent, well-developed *S. predistentus*, and is assigned to the upper lower Oligocene *Sphenolithus predistentus* Zone. This zone overlies upper Eocene sediments (Core 569A-8), which suggests the presence of a hiatus encompassing the lower lower Oligocene (*Helicosphaera reticulata* Zone).

Samples 569A-8-1, 74 cm through 569A-8,CC are upper Eocene, and are assigned to the *Discoaster barbadiensis* Zone. *Discoaster barbadiensis, Recticulofenestra umbilica*, and *D. scrippsae* are present, along with rare *Coccolithus formosus* and common *Cribrocentrum reticulatum*. Sample 569A-9-1, 18–19 cm contains the contact of a heavily burrowed and possibly disturbed base of a light gray calcareous mudstone, which overlies the dark gray mudstone samples from 569A-9,CC. Rare specimens of *Chiasmolithus grandis* are present, which if not reworked, would suggest a slightly older age (upper middle Eocene *Discoaster saipanensis* Subzone) for all of Core 569A-9.

Core 569A-10 (360.9 m) penetrated metadiabase basement and contains only several centimeters of disturbed, muddy light gray limestone fragments at the top of Section 569A-10-1. This limestone contains highly recrystallized specimens of *Discoaster lodoensis, Coccolithus crassus, C. gammation, Chiasmolithus solitus, D. barbadiensis*, and *Sphenolithus radians*. This assemblage is most indicative of the upper lower Eocene *Discoaster lodoensis* Zone, but extremely poor preservation may have destroyed key species which could make it as young as the lower middle Eocene *Discoaster sublodoensis* Zone. A second Paleogene hiatus is therefore suggested, encompassing most of the middle Eocene (*Discoaster bifax* Subzone to possibly *Discoaster sublodoensis* Zone), between Cores 569A-9 and 569A-10.

Core 569A-11 recovered metabasalt mixed with a piece of upper middle Eocene limestone displaced from upsection.

Site 570 (13°17.12′N, 91°23.57′W; water depth 1698 m)

Site 570 was drilled near a relatively shallow, high-intensity magnetic anomaly on the upper slope of the Guatemalan MAT, 40 km upslope from the trench axis and approximately 40 km southwest of the Esso Petrel #1 well (Seely, 1979). Pleistocene through lower Eocene sediments were recovered to a depth of approximately 360 m, and contain age-diagnostic nannofossils which overlie 10 m of age-indeterminate conglomerate above 32 m of penetrated serpentinite basement.

Calcareous nannofossils are well preserved but nondiverse throughout the Pleistocene mudstone, well preserved and abundant throughout the Pliocene and upper Miocene sediment, and marginally preserved in rare to common abundance within the lower Eocene sandy mudstone and limestone (Table 7).

Reworking of Pliocene nannofossils occurs sporadically throughout the Pleistocene, and becomes especially prevalent in Sample 570-18,CC. Several Paleocene species were also observed in the lower Eocene sediments sampled at 570-36,CC and 570-37-1, 28 cm.

Samples 570-1-2 through 570-23-4, 47 cm are Pleistocene. Species diversity is low throughout this interval, and zonal markers such as *Pseudoemiliania lacunosa, Helicosphaera sellii*, and *Calcidiscus macintyrei* occur inconsistently. Small *Gephyrocapsa* spp. are abundant and *Gephyrocapsa oceanica* is absent in Samples 570-6,CC through 570-8,CC, which suggests assignment to the small *Gephyrocapsa* Zone. Significant reworking of *D. brouweri* occurs in 570-18,CC.

Samples 570-23-6, 36 cm through 570-25-4, 36 cm are assigned to the upper Pliocene *Discoaster brouweri* Zone. They contain *D. brouweri, D. pentaradiatus*, and *Helicosphaera sellii*. Lack of the consistent presence of *Discoaster tamalis* and *Discoaster surculus* restricts subzonation.

Samples 570-25,CC and 570-26,CC are lower Pliocene, and contain *Reticulofenestra pseudoumbilica, Sphenolithus neoabies, D. brouweri*, and *D. pentaradiatus*, indicative of the *Reticulofenestra pseudoumbilica* Zone. Section 570-27-1 contains silty mud interbedded with gas hydrate. The silty mud matrix is assigned to the lower Pliocene *Ceratolithus acutus* Zone, and contains well-preserved specimens of *C. acutus, Discoaster surculus, Sphenolithus neoabies, R. pseudoumbilica*, and *D. pentaradiatus*. Fractured siliceous dolomite interbedded with gas hydrate in 570-27,CC (258.8 m) is barren of nannofossils.

Samples 570-28-1, 43 cm through 570-35-1, 30 cm are upper Miocene, contain *Discoaster quinqueramus, D. berggrenii, D. surculus* (large morphotype), and rare *D. loeblichii*, and are assigned to the *Discoaster quinqueramus* Zone.

Silty mud matrix sampled from decomposed hydrates of Samples 570-35-4, 5 cm through 570-35-4, 40 cm, just above a thin conglomerate, contains rare *Discoaster exilis, S. neoabies*, and *Discoaster variabilis*, which are indicative of the middle Miocene. Sample 570-35,CC

(335.6 m) is lower Miocene, contains *Helicosphaera ampliaperta, H. intermedia, Discoaster deflandrei*, and *Reticulofenestra gartneri*, and is assigned to the *S. belemnos* Zone or upper *T. carinatus* Zone. Two successive hiatuses (within Core 570-35) representing 3 m.y. or more duration probably separate the upper and middle Miocene, and middle and lower Miocene sediment.

A sandy mudstone sampled in 570-36-1, 125 cm and 570-36-2, 44 cm also provided the matrix support for a gas hydrate. This interval is lower Eocene and contains *Discoaster barbadiensis, D. lodoensis, Tribrachiatus orthostylus*, and *Coccolithus* sp. cf. *C. crassus*, which are indicative of the *Discoaster lodoensis* Zone. A hiatus, which spans the Oligocene through middle Eocene (at least 27 m.y.), is therefore present between Cores 570-35 and 570-36. Hard greenish limestone recovered from Sample 570-36,CC (345.2 m) is also lower Eocene (*D. lodoensis* Zone), and contains abundant recrystallized specimens of those species present in the softer lithology above, along with *Chiasmolithus solitus, Neococcolithus distentus, Lophodolithus mochloporus*, and others.

Limestone sampled in 570-37-1, 42 cm and 570-38-1, 55 cm is lower Eocene, contains *Discoaster diastypus* along with *T. orthostylus* and *Discoaster binodosus*, and is assigned to the *Discoaster diastypus* Zone. Rare reworking of several Paleocene species occurs within both the sandy mud and the limestone lithologies from Samples 570-36,CC to 570-37-1, 28 cm.

Samples 570-38,CC through 570-39,CC are essentially barren of nannofossils. A soft brown mudstone lithology in 570-38,CC contains very rare nannofossil specimens of the Cretaceous species *Watznaueria barnesae* and *Micula staurophora* (species which are commonly reworked) mixed with sporadic, long-ranging Tertiary nannofossil species and Miocene foraminifers. Downhole contamination of this sediment is a distinct possibility. Cores 570-40 through 570-42 (383.3–401.9 m) recovered serpentinite and are barren of nannofossils.

TAXONOMIC NOTES

One new species of *Discoaster* was observed on DSDP Leg 84. All other calcareous nannofossil species considered in this study are listed in the Appendix; these are adequately described and discussed in the literature.

Discoaster tuberi n. sp.
(Plate 1, Figs. 1–9)

Description. Asterolith with six slightly tapered and bent rays, which terminate in short, blunt bifurcations. A large, flaring stellate knob is present on one side and dominates the central area, which is 25 to 30% of the asterolith diameter. Knob rays are usually aligned with the rays of the asterolith. A second small knob on the opposite side of the central area is formed by the termination of low ridges, which extend radially along the periphery of each asterolith ray.

Remarks. *Discoaster tuberi* is most similar in outline and structure to *D. exilis*. It differs from *D. exilis*, however, by its more prominent, flaring stellate knob. *D. tuberi* also possesses two knobs on opposite sides, whereas only a single knob was originally described by Martini and Bramlette (1963) in the original species description of *D. exilis*. Illustrations of *D. exilis* in side view by Martini and Bramlette (1963) and in this chapter (Plate 1, Figs. 10–12) do show a definite thickening of the central area which may be the remnant (or predecessor) of two central knobs, suggesting the close, but morphologically distinct, relationship between this species and *D. tuberi*. *D. tuberi* differs from *D. signus* by its short bifurcations, (present even in well-preserved samples containing delicate *D. signus* morphotypes with intact bifurcations), rays which are consistently thicker, tapered and bent, and development of a wider central area with a flaring, through-going knob. *D. tuberi* differs from both *D. bollii* and *D. sanmiguelensis* by its longer rays and smaller central area. *D. sanmiguelensis* also differs by its possession of one central-area knob. *D. tuberi* differs from Eocene *Discoaster* species which possess two knobs, such as *D. bifax* and *D. diastypus*, by its maximum number of free rays (six).

Occurrence. *D. tuberi* is frequent to common in the middle Miocene *Sphenolithus heteromorphus* (CN4) Zone sediment penetrated on Leg 84 at Site 568. A thin interval of *S. heteromorphus* Zone sediment containing frequent *D. tuberi* was also recovered at Site 569. Rare specimens of *D. tuberi* were also noted in the upper *Helicosphaera ampliaperta* (CN3) sediment at this site; they may represent its first evolutionary appearance. Specimens of *D. tuberi* were not observed in sediments younger than the *S. heteromorphus* Zone at any of the Leg 84 sites.

D. tuberi may be restricted in its occurrence to low-latitude, lower middle Miocene (upper CN3–CN4) hemipelagic sediments. It is absent in numerous wells and surface sections containing lower to middle Miocene sediments examined by the author throughout California and the Southern California borderland (north of 32° latitude). *D. tuberi* may have been taxonomically combined with *D. exilis* s. ampl. and *D. signus* s. ampl. in previous studies on low-latitude lower to middle Miocene sediment, especially if it was a rare assemblage constituent and was not observed in diagnostic side view.

Size. 8–14 μm

Holotype. USNM 371078 (Plate 1, Fig. 1-4)

Isotype. USNM 371079 (Plate 1, Fig. 5-6)

Type locality. Landward slope of the Middle America Trench offshore Guatemala, eastern equatorial Pacific, DSDP Sample 569-10,CC (87.40 m)

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Table 7. Distribution of calcareous nannofossils at Site 570.

Age		Zone or subzone	Sample (interval in cm)	Sub-bottom depth (m)	Abundance	Preservation	*Gephyrocapsa omega*	*Gephyrocapsa oceanica*	*Gephyrocapsa* spp. sensu Gartner, 1977—small	*Helicopshaera sellii*	*Calcidiscus leptoporus*	*Crenalithus doronicoides*	*Helicosphaera carteri*	*Helicosphaera wallichi*	*Pseudomiliania lacunosa*	*Calcidiscus macintyrei*	*Ceratolithus cristatus*	*Umbilicosphaera mirabilis*	*Syracosphaera histrica*	*Discoaster pentaradiatus*	*Sphenolithus neoabies*	*Discoaster brouweri*
Holocene–late Pleistocene		*Emiliania huxleyi–Pseudoemiliania lacunosa*	1-2, 36–37	1.87	F	P,O	R	F	F	R	R	F	F									
			1,CC	4.80	C	M	F	C	C		R	C	F	R	F	R						
			2-4, 36–37	9.67	F	P	R	F	F		R		F		R	R	R					
			3-2, 75–76	19.76	C	M,O	F	C	C		F	F	C		R			R				
			3,CC	27.20	F	M		F	F		F	F	F	R								
			4-2, 25–26	28.95	F	P		R	F		R	F	F	R								
			4,CC	36.80	F	M		R	F		R	F	R		F							
			5-4, 51–52	41.82	F	P	R	R	F		R	F	R									
			5,CC	46.40	C	M,E		R	C	R	R	C	F		R							
			6-6, 36–37	54.27	C	P		R	F		R	C	F		R	R		R				
early Pleistocene		small *Gephyrocapsa*	6,CC	56.00	A	M			A		F	C	F	R					R	R		
			7-4, 46–47	60.97	C	M		R	A		R	C	F							R	R	
			8-2, 36–37	67.57	A	M			A		R	C	R			R						R
			8,CC	75.40	A	M,E			A		R	C	F									R
		small *Gephyrocapsa–Calcidiscus macintyrei*	9-1, 18–19	75.59	C	P			C		R	C	F									
			10-2, 36–37	86.96	F	M		R	F	F	F	F	F									
			11-2, 17–18	96.38	R	P,O			R		R		F									
			12,CC	113.90	A	M,E			A		R	C	F						R			
			14-2, 129–130	126.39	C	P			C		F	F	F									
			15-2, 127–128	136.08	F	P,O		R	F		R	F	R									
			16-2, 55–56	145.06	F	P,O		R	F		F	R	R		R							
			17-2, 94–95	155.15	F	M		F	C		R	F	R					R		R		R
			18,CC	172.10	F	M,E				R		F	F									R
			19-4, 68–69	177.28	C	M,E			C		R		R	R				R				
			20-2, 38–39	183.69	F	M		R	F		F		R	R	F			R				
			21,CC	201.20	F	M,E					F		F					R				
			22-2, 9–10	202.80	F	P,E			F	R	F		F			R		F				
			23-4, 47–48	215.68	C	M			C	R	F	C	F					R				
Pliocene	l.	*Discoaster brouweri*	23-6, 36–37	218.57	C	M,E				F	F	R	F					R		F		C
			24-4, 33–34	225.04	F	P,E					R	F	A		R					R		F
			25-4, 35–36	234.56	F	M,E					F	F	[illegible]			F				F		R
		R. pseudoumbilica	26-1, 23–24	239.64	F	M,E					F		[illegible]							F	C	F
	e.	*C. acutus*	26-4, 23–24	244.14	F	M,E					R					R				F	C	F
			27-1, 49–50	249.60	C	M,E				R		F								C	C	F
			27,CC	258.80	B																	
Miocene	l.	*Discoaster quinqueramus*	28-1, 43–44	259.23	C	M					F		R			R					F	R
			29-2, 56–57	270.47	C	M,E						R									F	
			30-1, 8–9	278.09	C	M,E										R					C	
			31-1, 143–144	289.03	F	M,E						R									F	
			32-1, 54–55	297.75	C	M						R										F
			33,CC	316.40	C	M,E					R	F	R								C	R
			35-1, 29–30	326.60	F	M							R								F	R
	m.	*Discoaster exilis*	35-4, 5–6	330.56	R	M							R								R	
			35-4, 39–40	330.90	R	M							R									
	e.	*S. belemnos–D. deflandrei*	35-5, 45–46	332.46	R	M							R									
			35,CC	335.60	R	R,E							R									
early Eocene		*D. lodoensis*	36-2, 10–11	337.21	R	P,O																
			36,CC	345.80	F	P,O																
		D. diastypus	37-1, 42–43	346.23	C	M,O																
			38-1, 54–55	355.34	R	P,O																

Note: See note to Table 1 for explanation of abbreviations.

Table 7. (Continued).

Coccolithus pelagicus	*Discolithina japonica*	*Helicosphaera neogranulata*	*Ceratolithus rugosus*	*Discoaster decorus*	*Reticulofenestra pseudoumbilica*	*Ceratolithus acutus*	*Discoaster surculus*	*Discoaster intercalaris*	*Discoaster berggrenii*	*Discoaster quinqueramus*	*Discoaster calcaris*	*Discoaster bollii*	*Discoaster variabilis*	*Discoaster exilis*	*Coccolithus miopelagicus*	*Helicosphaera intermedia*	*Triquetrorhabdulus carinatus*	*Helicosphaera ampliaperta*	*Cyclicargolithus floridanus*	*Discoaster deflandrei*	*Reticulofenestra gartneri*	*Coronocyclus nitescens*	*Discolithina vigintiforata*	*Sphenolithus moriformis*	*Cruciplacolithus staurion*	*Coccolithus crassus*	*Coccolithus formosus*	*Sphenolithus radians*	*Discoaster binodosus*	*Lophodolithus mochlophorus*	*Discoaster lodoensis*	*Coccolithus eopelagicus*	*Chiphragmolithus acanthodes*	*Neochiastozygus distentus*	*Ellipsolithus macellus*	*Discoaster barbadiensis*	*Chiasmolithus solitus*	*Tribrachiatus orthostylus*	*Discoaster diastypus*
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							R		F	C	A																												
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R														R	R	R																							
R																	R	R	R	R	R	R																	
R																R		R	R	R	R	R	R	R															
R																						R			R	R	R	R	R										
F																								R		R	F	F		R	R	R	R	R	R	R	R	F	
F																						R					F	F	R					R	R	R		R	R
																											R	R									R	R	R

APPENDIX
Calcareous Nannofossils Considered in this Chapter

Broinsonia enormis (Shumenko, 1968) Manivit, 1971
Broinsonia parca (Stradner, 1963) Bukry, 1969
Calcidiscus gammation (Bramlette and Sullivan, 1961) Loeblich and Tappan, 1978
Calcidiscus leptoporus (Murray and Blackman, 1898) Loeblich and Tappan, 1978
Calcidicus macintyrei (Bukry and Bramlette, 1969) Loeblich and Tappan, 1978
Catinaster mexicanus Bukry, 1971
Ceratolithoides aculeus (Stradner, 1961) Prins and Sissingh, 1977
Ceratolithus acutus Gartner and Bukry, 1974
Ceratolithus cristatus Kamptner, 1950
Ceratolithus rugosus Bukry and Bramlette, 1968
Chiasmolithus consuetus (Bramlette and Sullivan, 1961) Hay and Mohler, 1967
Chiasmolithus grandis (Bramlette and Riedel, 1954) Radomski, 1968
Chiasmolithus solitus (Bramlette and Sullivan, 1961) Locker, 1968
Chiasmolithus titus Gartner, 1970
Chiphragmalithus acanthodes Bramlette and Sullivan, 1961
Coccolithus crassipons Bouché, 1962
Coccolithus crassus Bramlette and Sullivan, 1961
Coccolithus eopelagicus (Bramlette and Riedel, 1954) Bramlette and Sullivan, 1961
Coccolithus formosus (Kamptner, 1963) Wise, 1973
Coccolithus miopelagicus Bukry, 1971
Coccolithus pelagicus (Wallich, 1877) Schiller, 1930
Coronocyclus nitescens (Kamptner, 1963) Bramlette and Wilcoxon, 1967
Crenalithus doronicoides (Black and Barnes, 1961) Roth, 1973
Cretarhabdus crenulatus Bramlette and Martini, 1964
Cribrocentrum reticulatum (Gartner and Smith, 1967) Perch-Nielsen, 1971
Cribrosphaerella ehrenbergii (Arkhangelsky, 1912) Deflandre, 1952
Cricolithus jonesii Cohen, 1965
Cruciplacolithus staurion (Bramlette and Sullivan, 1961) Gartner, 1971
Cyclicargolithus abisectus (Muller, 1970) Bukry, 1973
Cyclicargolithus floridanus (Roth and Hay, 1967) Bukry, 1971
Dictyococcites antarcticus Haq, 1976
Dictyococcites bisectus (Hay, Mohler and Wade, 1966) Bukry and Percival, 1971
Dictyococcites scrippsae Bukry and Percival, 1971
Discoaster adamanteus Bramlette and Wilcoxon, 1967
Discoaster asymmetricus Gartner, 1969
Discoaster barbadiensis Tan, 1927
Discoaster berggrenii Bukry, 1971
Discoaster bifax Bukry, 1971
Discoaster binodosus Martini, 1958
Discoaster bollii Martini and Bramlette, 1963
Discoaster brouweri Tan, 1927
Discoaster calcaris Gartner, 1967
Discoaster calculosus Bukry, 1971
Discoaster challengeri Bramlette and Riedel, 1954
Discoaster decorus (Bukry, 1971) Bukry, 1973
Discoaster deflandrei Bramlette and Riedel, 1954
Discoaster diastypus Bramlette and Sullivan, 1961
Discoaster distinctus Martini, 1958
Discoaster druggii Bramlette and Wilcoxon, 1967
Discoaster elegans Bramlette and Sullivan, 1961
Discoaster exilis Martini and Bramlette, 1963
Discoaster germanicus Martini, 1958
Discoaster icarus Stradner, 1972
Discoaster intercalaris Bukry, 1971
Discoaster lodoensis Bramlette and Riedel, 1954
Discoaster mohleri Bukry and Percival, 1971
Discoaster multiradiatus Bramlette and Riedel, 1954
Discoaster pentaradiatus Tan, 1927
Discoaster quinqueramus Gartner, 1969
Discoaster saipanensis Bramlette and Riedel, 1954
Discoaster sanmiguelensis Bukry, 1981
Discoaster saundersi Hay, 1967
Discoaster signus Bukry, 1971
Discoaster surculus Martini and Bramlette, 1963
Discoaster tanii nodifer Bramlette and Riedel, 1954
Discoaster tanii ornatus Bramlette and Wilcoxon, 1967
Discoaster tanii tanii Bramlette and Riedel, 1954
Discoaster tuberi Filewicz, n. sp.
Discoaster variabilis Martini and Bramlette, 1963
Discoasteroides kuepperi (Stradner, 1959) Bramlette and Sullivan, 1961
Discolithina anisotrema (Kamptner, 1953) Bramlette and Wilcoxon, 1967
Discolithina japonica Takayama, 1967
Discolithina multipora (Kamptner, 1948) Martini 1965
Discolithina plana (Bramlette and Sullivan, 1961) Levin, 1965
Discolithina vigintiforata (Kamptner, 1948) Loeblich and Tappan, 1966
Eiffellithus eximius (Stover, 1966) Perch-Nielsen, 1968
Eiffellithus turriseiffeli (Deflandre, 1954) Reinhardt, 1965
Ellipsolithus macellus (Bramlette and Sullivan, 1961) Sullivan, 1964
Ellipsolithus subdistichus Roth and Hay, 1967
Emiliania huxleyi (Lohman, 1902) Hay and Mohler, 1967
Fasciculithus tympaniformis Hay and Mohler, 1967
Gephyrocapsa oceanica Kamptner, 1943
Gephyrocapsa omega Bukry, 1973
small Gephyrocapsa spp. sensu Gartner, 1977
Helicosphaera ampliaperta Bramlette and Wilcoxon, 1967
Helicosphaera bramlettei (Müller, 1970) Jafar and Martini, 1975
Helicosphaera californica Bukry, 1981
Helicosphaera carteri (Wallich, 1877) Kamptner, 1954
Helicosphaera compacta Bramlette and Wilcoxon, 1967
Helicosphaera euphratis Haq, 1966
Helicosphaera intermedia Martini, 1965
Helicosphaera lophota (Bramlette and Sullivan, 1961) Jafar and Martini, 1975
Helicosphaera minuta Müller, 1981
Helicosphaera neogranulata (Gartner, 1977) Haq and Berggren, 1978
Helicosphaera obliqua Bramlette and Wilcoxon, 1967
Helicosphaera recta (Haq, 1966) Jafar and Martini, 1975
Helicosphaera rhomba (Bukry, 1971) Jafar and Martini, 1975
Helicosphaera scissura Miller, 1981
Helicosphaera sellii Bukry and Bramlette, 1969) Jafar and Martini, 1975
Helicosphaera seminulum (Bramlette and Sullivan, 1961) Jafar and Martini, 1975
Helicosphaera wallichii (Lohman, 1902) Okada and McIntyre, 1976
Lophodolithus mochlophorus Deflandre in Deflandre and Fert, 1954
Lucianorhabdus cayeuxi Deflandre, 1959
Manivitella pemmatoidea (Deflandre *ex* Manivit, 1965) Thierstein, 1971
Microrhabdulus decoratus Deflandre, 1959
Micula murus (Martini, 1961) Bukry, 1973
Micula staurophora (Gardet, 1955) Stradner, 1963
Nannoconus sp.
Neochiastozygus concinnus (Martini, 1961) Perch-Nielsen, 1971
Neochiastozygus distentus (Bramlette and Sullivan, 1961) Perch-Nielsen, 1971
Neococcolithites dubius (Deflandre, 1954) Black, 1967
Orthorhabdus serratus Bramlette and Wilcoxon, 1967
Orthorhabdus sp.
Prediscosphaera cretacea (Arkhangelsky, 1912) Gartner, 1968
Pseudoemiliania lacunosa (Kamptner, 1963) Gartner, 1969
Reticulofenestra gartneri Roth and Hay, 1967
Reticulofenestra pseudoumbilica (Gartner, 1967) Gartner, 1969
Reticulofenestra samodurovii (Hay, Mohler and Wade, 1966) Roth, 1970
Reticulofenestra umbilica (Levin, 1966) Martini and Ritzkowski, 1968
Rhabdosphaera stylifer Lohman, 1902
Rhabdosphaera tenuis Bramlette and Sullivan, 1961
Sphenolithus abies Deflandre, 1954
Sphenolithus belemnos Bramlette and Wilcoxon, 1967
Sphenolithus ciperoensis Bramlette and Wilcoxon, 1967
Sphenolithus conicus Bukry, 1971
Sphenolithus heteromorphus Deflandre, 1953
Sphenolithus moriformis (Brönniman and Stradner, 1960) Bramlette and Wilcoxon, 1967
Sphenolithus neoabies Bukry and Bramlette, 1969

Sphenolithus predistentus Bramlette and Wilcoxon, 1967
Sphenolithus radians Deflandre, 1952
Sphenolithus spiniger Bukry, 1971
Syracosphaera histrica Kamptner, 1941
Syracosphaera pulchra Lohman, 1902
Thoracosphaera saxae Stradner, 1961
Thoracosphaera sp.
Toweius sp.
Tranolithus orionatus Štover, 1966
Transversopontis pulcher (Deflandre, 1954) Perch-Nielsen, 1967
Tribrachiatus orthostylus Shamrai, 1963
Triquetrorhabdulus auritus Stradner and Allram, 1982
Triquetrorhabdulus carinatus Martini, 1965
Triquetrorhabdulus milowii Bukry, 1971
Umbilicosphaera sibogae (Weber-von Bosse, 1901) Gaarder, 1970
Uniplanarius gothicus (Deflandre, 1959) Hattner and Wise, 1980
Uniplanarius trifidus (Stradner, 1961) Hattner and Wise, 1980
Watznaueria barnesae (Black, 1959) Perch-Nielsen, 1968
Zygodiscus elegans Gartner, 1968
Zygrhablithus bijugatus (Deflandre, 1954) Deflandre, 1959

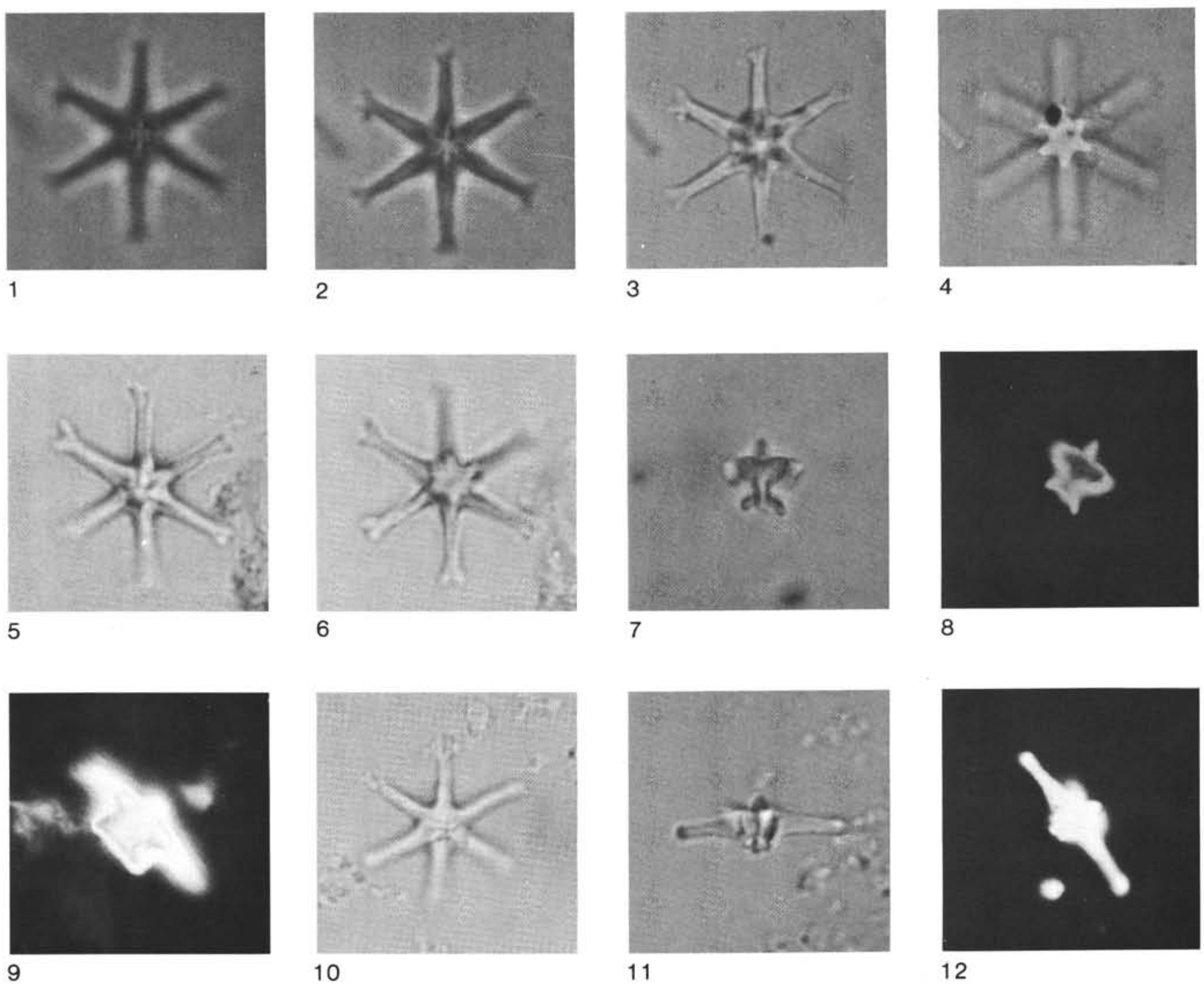

Plate 1. Miocene *Discoaster* species from the landward slope of the Middle America Trench offshore Guatemala. (All figures are magnified X2000 in transmitted light, except Figures 8, 9, and 12, which are illustrated in polarized light at 45°.) **1–9.** *Discoaster tuberi* n. sp., (1–4) holotype USNM 371078, Sample 569-10,CC, high to low focus sequence, (5–6) isotype USNM 371079, Sample 568-31-1, 110 cm, high and low focus, (7–8) side view of knob detached from rays, Sample 569-10,CC, (9) side view showing the flaring, through-going knob and slightly bent rays, Sample 568-31-1, 110 cm. **10–12.** *Discoaster exilis* Martini and Bramlette, (10) Sample 568-31-1, 110 cm, (11–12) side view showing thickening of the central area, Sample 568-30,CC.