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3. EOCENE CALCAREOUS NANNOFOSSILS FROM THE IBERIA ABYSSAL PLAIN[1]

L. Liu[2]

ABSTRACT

Five sites were drilled on the Iberia Abyssal Plain, west of the Iberian Peninsula. Four holes (897C, 897D, 899B, and 900A) yielded Eocene sediments that consist of turbidites and contourites. The Eocene section above the continental crust at Site 900 is continuous (from nannofossil Zones NP10 to NP20) and considerably expanded because of the site's relatively shallow depth, which remained consistently above the carbonate compensation depth (CCD). Sites 897 and 898, situated in deeper water above the ocean/continent transition, on the other hand, have noncontinuous, relatively short Eocene sections (from Zones NP14 to NP20 at Site 897 and from Zones NP19 to NP20 at Site 899). Nannofossils are abundant, diverse, and moderately to poorly preserved; they provide the primary means of dating the Eocene sediments recovered during Leg 149.

INTRODUCTION

Five sites were drilled during Ocean Drilling Program (ODP) Leg 149 on the Iberia Abyssal Plain (Fig. 1) to sample the upper crust within the ocean/continent transition of the plain in order to establish its nature and test predictions based on geophysical observations (Whitmarsh et al., 1993). Eocene sediments were recovered using the rotary core barrel from four holes (897C, 897D, 899B, and 900A) among the eight drilled at the five sites. The Eocene section recovered at Site 900 is continuous and considerably expanded because of its relatively shallow-water depth above the continental crust, where it has remained consistently above the carbonate compensation depth (CCD). Sites 897 and 899, situated above the ocean/continent transition, are at a deeper water depth and, therefore, have noncontinuous, relatively short Eocene sections. Nannofossils have proven valuable for dating the Eocene pelagic sediments, although their preservation is normally moderate or poor. Reworking is evident throughout the Eocene sections in each hole. However, the light-colored, hemipelagic and pelagic sediments (Bouma unit Tf) that occupy the uppermost part of turbidite sequences were deposited above the CCD under highly productive waters and provide reliable nannofossil biostratigraphic data. The purpose of this study is to document the calcareous nannofossils from Eocene sediments recovered during Leg 149 and to establish their biostratigraphic framework.

METHODS

Smear slides were prepared directly from raw samples and were examined using phase contrast and polarizing light microscopy in order to define the relative abundance of each nannofossil species. Selected sandy samples were processed by the settling method to concentrate the nannofossils.

The relative abundance of individual species and the total abundance for each sample" were tabulated for the range charts using a light microscope with a magnification of 1560×. The letters used on the range charts and the corresponding definitions are as follows:

V = very abundant; more than 10 specimens per field of view;
A = abundant; 1 to 10 specimens per field of view;
C = common; 1 specimen per 2 to 10 fields of view;
F = few; 1 specimen per 11 to 50 fields of view; and
R = rare; 1 specimen per 51 to 200 fields of view.

Preservation of the calcareous nannofossil assemblage was recorded as follows:

G = good; individual specimens exhibit little or no dissolution or overgrowth; diagnostic characteristics are preserved and nearly all of the specimens can be identified;
M = moderate; individual specimens show evidence of dissolution or overgrowth; some specimens cannot be identified to the species level; and
P = poor; individual specimens exhibit considerable dissolution or overgrowth; many specimens cannot to identified to the species level.

Calcareous nannofossil species considered in this paper are listed in the Appendix, where they are arranged alphabetically by generic epithets. Bibliographic references for these taxa can be found in Perch-Nielsen (1985).

ZONATION

A combination of the nannofossil zonal schemes of Martini (1971), Martini and Muller (1986), and Okada and Bukry (1980) is used for Leg 149 sediments (Table 1). Most zonal markers of Martini (1971) and Okada and Bukry (1980) can be recognized, although some zonal boundaries cannot be located owing to the absence or rare occurrence of some zonal markers.

The Paleocene/Eocene boundary is defined in this study by the first occurrence (FO) of *Tribrachiatus bramlettei,* which marks the NP9/10 boundary of Martini's (1971) zonal scheme. *Discoaster diastypus,* used by Okada and Bukry (1980) to define this boundary, is not present in Leg 149 cores.

The Eocene/Oligocene boundary is determined in this study by the extinction of rosette-shaped discoasters such as *Discoaster barbadiensis* and *Discoaster saipanensis.* The boundary so determined could be slightly higher than its true position owing to problems from reworking.

The lower/middle Eocene boundary (NP13/14) is defined by the FO of *Discoaster sublodoensis.* The middle/upper Eocene boundary (NP17/18) is more difficult to determine, because the zonal markers (*Chiasmolithus oamaruensis* and *Isthmolithus recurvus*) are generally rare.

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[2]Department of Geology, Florida State University, Tallahassee, FL 32306, U.S.A. li@geomag.gly.fsu.edu

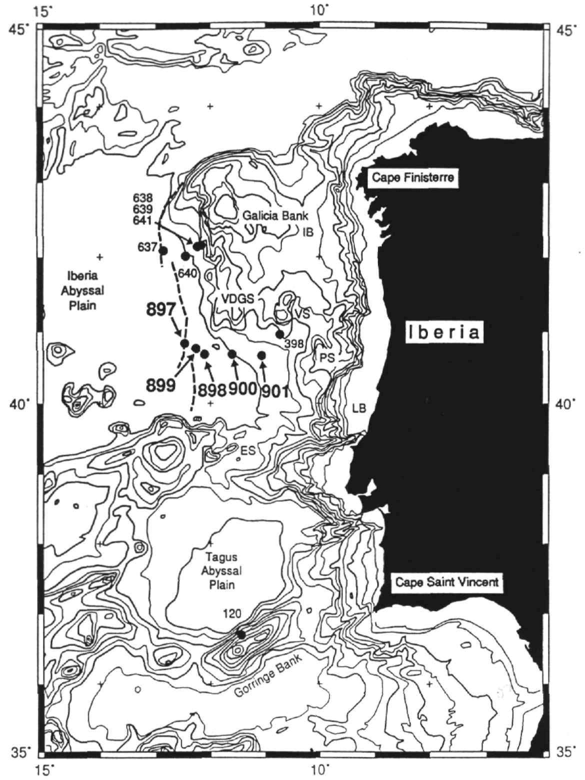

Figure 1. Location of ODP Leg 149 Sites 879-901 and previously drilled DSDP/ODP sites.

Table 1. Eocene calcareous nannofossil biostratigraphic scheme used in this study.

Age		Zones of Okada and Bukry (1980)				Zones of Martini (1971)		Events (this study)
Eocene	late	CP15	*D. barbadiensis*	CP15b	*I. recurvus*	NP19/20	*I. recurvus*	┘ *I. recurvus*
				CP15a	*C. oamaruensis*	NP18	*C. oamaruensis*	┘ *C. oamaruensis*
	middle	CP14	*R. umbilicus*	CP14b	*D. saipanensis*	NP17	*D. saipanensis*	┐ *C. solitus*
				CP14a	*D. bifax*	NP16	*D. tani nodifer*	┘ *R. umbilicus* ┘ *D. bifax*
		CP13	*N. quadrata*	CP13c	*C. staurion*	NP15	*N. fulgens*	
				CP13b	*C. gigas*			┘ *C. gigas*
				CP13a	*D. strictus*			┘ *N. fulgens*
		CP12	*D. sublodoensis*	CP12b	*R. inflata*	NP14	*D. sublodoensis*	┘ *R. inflata*
				CP12a	*D. kuepperi*			┘ *D. sublodoensis*
	early	CP11	*D. lodoensis*			NP12/13	*D. lodoensis*	
		CP10	*T. orthostylus*					┘ *D. lodoensis*
		CP9	*D. diastypus*	CP9b	*D. binodosus*	NP11	*D. binodosus*	┐ *T. contortus*
				CP9a	*T. contortus*	NP10	*T. contortus*	┘ *T. bramlettei*

┘ First occurrence
┐ Last occurrence

Some difficulties exist for the middle Eocene zonation (Zones NP14 to NP17, or CP12 to CP14). According to Martini (1971), Zone NP15 (*Nannotetrina fulgens* Zone) is defined as the interval from the FO of *N. fulgens* to the last occurrence (LO) of *Rhabdosphaera gladius*. However, *R. gladius* is very rare in the sediments retrieved on Leg 149; only one specimen was found (Sample 149-900A-65R-2, 48-49 cm; Pl. 2, Fig. 20). Therefore, *R. gladius* cannot be used here as a zonal marker. Bukry (1973) used the first appearance of *Reticulofenestra umbilicus* and *Discoaster bifax* to mark the top of Zone NP15. Although there is some controversy about using the FO of *Reticulofenestra umbilicus* to mark the boundary between Zones NP15/16 (Martini and Muller, 1986), I still use specimens greater than 14 µm to define the NP15/16 boundary as suggested by Wise and Mostajo (1983).

HOLE SUMMARIES

Hole 897C

Eocene sediments in Hole 897C (40°50.33'N, 12°28.44'W, water depth = 5315.2 m) were recognized between Samples 149-897C-51R-1, 11-12 cm, and 59R-2, 14-15 cm, and consist mainly of nannofossil chalk, calcareous claystone, claystone, siltstone, and sandstone. Calcareous nannofossils are abundant in most samples; their preservation is either poor or moderate (Tables 2, 3).

Sample 149-897C-50R-3, 71-72 cm, is considered the first sample below the Eocene/Oligocene boundary, based on the LO of *Discoaster barbadiensis* and *Discoaster saipanensis*.

The interval from Samples 149-897C-51R-1, 11-12 cm, through 54R-2, 52-53 cm, is between the FO of the *Isthmolithus recurvus* and the LO of *Discoaster barbadiensis* and *Discoaster saipanensis* and is assigned to the *Isthmolithus recurvus* Zone (NP19/20, CP15b). The assemblage is dominated by *Coccolithus pelagicus, Cyclicargolithus floridanus, Cyclicargolithus formosus, Dictyococcites bisectus,* and *Zygrhablithus bijugatus.*

Samples 149-897C-54R-2, 136-137 cm, to 51R-1, 11-12 cm, are placed in the *Chiasmolithus oamaruensis* Zone (NP18, CP15a), based on the absence of *Isthmolithus recurvus* and the occurrence of *Chiasmolithus oamaruensis.* The last occurrence of *Sphenolithus obtusus* is in Sample 149-897C-54R-3, 2-3 cm, within this zone. The dominant species are *Coccolithus pelagicus, Cribrocentrum reticulatum, Cyclicargolithus floridanus, Cyclicargolithus formosus, Dictyococcites bisectus, Discoaster barbadiensis,* and *Lanternithus minutus.*

Samples 149-897C-55R-1, 74-75 cm, to 55R-3, 75-76 cm, are assigned to the *Discoaster saipanensis* Zone (NP17, CP14b) based on the absence of both *Chiasmolithus oamaruensis* and *Chiasmolithus solitus.* The dominant species are similar to that of Zone NP18.

The *Discoaster tani nodifer* Zone (NP16) or *Discoaster bifax* Subzone (CP14a) encompasses the interval from Samples 149-897C-55R-4, 67-68 cm, to 57R-5, 70-71 cm, based on the co-occurrence of *Chiasmolithus solitus* and *Reticulofenestra umbilicus* (>14 µm). *Rhabdosphaera gladius,* used by Martini (1971) to divide Zones NP15 and NP16, was not found is this hole. Therefore, Zones NP15 and NP16 are not distinguishable. The FO of *Cribrocentrum reticulatum* is observed in Sample 149-897C-57R-2, 128-129 cm.

Okada and Bukry (1981) proposed both the FO *of Reticulofenestra umbilicus* and the LO of *Discoaster bifax* to divide Zones CP13 and CP14, but the FO *of Discoaster bifax* in the Leg 149 sediments (see also Hole 900A) is always earlier than the FO of *Reticulofenestra umbilicus.* In addition, *Discoaster bifax* is normally rare and hard to recognize in the Leg 149 sediments. Therefore, as stated previously, I use the FO of *Reticulofenestra umbilicus* to divide the Zones CP13/14 boundary rather than the FO of *Discoaster bifax.*

The interval between Samples 149-897C-58R-1, 144-145 cm, and 59R-2, 14-15 cm, is assigned to the *Nannotetrina fulgens* Zone (NP15 or CP13) based on the FO of *Nannotetrina fulgens* and the absence of *Reticulofenestra umbilicus.* The last *Chiasmolithus gigas* appears in Sample 149-897C-59R-2, 14-15 cm.

Hole 897D

Hole 897C was terminated owing to a stuck drill pipe; therefore, Hole 897D (40°50.31'N, 12°28.51'W, water depth = 5315.8 m) was drilled to acquire additional sediment just below the total depth of Hole 897C. The first three cores of Hole 897D are middle Eocene in age and consist mainly of nannofossil claystone and claystone. Calcareous nannofossils are mostly abundant or common in these middle Eocene samples but are normally poorly preserved (Table 4).

Samples 149-897D-1R-1, 146-147 cm, to 3R-2, 47-48 cm, are assigned to the *Nannotetrina fulgens* Zone (NP15 or CP13) based on the occurrence of *Nannotetrina fulgens* and the absence of *Reticulofenestra umbilicus.* The LO of *Rhabdosphaera gladius* is not an applicable datum owing to the absence of this taxon. *Discoaster bifax* is present from Samples 149-897D-1R-3, 146-147 cm, to 1R-3, 22-23 cm. The FO of *Chiasmolithus gigas* is in Sample 149-897D-2R-CC in Zone CP13. The FO of *Sphenolithus furcatolithoides* is in Sample 149-897D-2R-4, 4-5 cm, which is slightly higher than the FO of *Chiasmolithus gigas.*

Samples 149-897D-3R-2, 140-141 cm, to 3R-4, 22-23 cm, are assigned to the *Discoaster sublodoensis* Zone (NP14, CP12b) based on the occurrence of *Discoaster sublodoensis* and the absence of *Nannotetrina fulgens.* Few *Rhabdosphaera inflata* were recognized in this interval. Therefore, according to Okada and Bukry's (1980) zonation scheme, this interval is placed in the *Rhabdosphaera inflata* Subzone (CP12b).

Hole 899B

Only one core (Core 14R) retrieved in Hole 899B (40°46.347'N, 12°16.063'W, water depth = 5291.0 m) belongs to the Eocene (Table 5). Calcareous nannofossils are generally abundant in these samples, and their preservation is moderate. *Isthmolithus recurvus, Discoaster barbadiensis,* and *Discoaster saipanensis* are found in all samples from this core, and it is assigned to the *Isthmolithus recurvus* Zone (NP19/CP15b). The dominant species are *Coccolithus pelagicus, Cyclicargolithus floridanus, Coccolithus formosus,* and *Sphenolithus moriformis.*

Hole 900A

Hole 900A (46°40.994'N, 11°36.252'W, water depth = 5036.8 m) contains the thickest and most complete Eocene section of the Leg 149 holes (Tables 6, 7). These sediments consist of nannofossil chalk, nannofossil claystone, claystone, clay siltstone, silt sandstone, and fine sandstone, all of which were deposited as turbidites or contourites. Calcareous nannofossils are generally abundant or common in these samples, and their preservation is moderate or poor.

Sample 149-900A-53R-1, 113-114 cm, is considered the first sample below the Eocene/Oligocene boundary because *Discoaster barbadiensis* and *Discoaster saipanensis* were not found in the samples above.

The *Isthmolithus recurvus* Zone (NP19/20, CP15b) extends from Samples 149-900A-53R-1, 113-114 cm, to 55R-CC, based on the co-occurrence of *Discoaster barbadiensis, Discoaster saipanensis,* and *Isthmolithus recurvus.* Nannofossils are moderately preserved. The nannofossil assemblage is dominated by *Coccolithus pelagicus, Cyclicargolithus floridanus, Cyclicargolithus formosus, Dictyococcites bisectus, Lanternithus minutus, Sphenolithus moriformis,* and *Zygrhablithus bijugatus.*

Samples 149-900A-56R-1, 37-38 cm, to 57R-4, 31-32 cm, are placed in the *Chiasmolithus oamaruensis* Zone (NP18, CP15b) based on the occurrence of *Chiasmolithus oamaruensis* and the absence of *Isthmolithus recurvus.* The LO of *Sphenolithus obtusus* is in Sample 149-900A-57R-2, 101-102 cm. Nannofossil assemblages in this zone are moderately preserved, and the dominant species are the same as in NP 19/20. The boundary between the middle Eocene and the upper Eocene is placed between Samples 149-900A-57R-4, 31-32 cm, and 57R-5, 34-35 cm.

Samples 149-900A-57R-5, 34-35 cm, to59R-l, 119-120 cm, are assigned to the *Discoaster saipanensis* Zone (NP17, CP14b) based on the absence of both *Chiasmolithus oamaruensis* and *Chiasmolithus solitus.*

Samples 149-900A-59R-2, 26-27 cm, to 63R-CC, are placed in the *Discoaster tani nodifer* Zone (NP16) or the *Discoaster bifax* Subzone (CP14a) based on the co-occurrence of *Chiasmolithus solitus* and *Reticulofenestra umbilicus.* Only one specimen of *Rhabdosphaera gladius* was found in Sample 149-900A-65R-2,48-49 cm (PI. 2, Fig. 20). The LO of *Rhabdosphaera gladius* is not used to mark the top of NP15. Instead, the FO of *R. umbilicus* is used here to mark CP13/14 boundary.

Samples 149-900A-64R-1, 142-143 cm, to 70R-1, 11-12 cm, are assigned to the *Nannotetrina fulgens* Zone (NP15 or CP13) based on the occurrence of *N. fulgens* and the absence of *Reticulofenestra umbilicus.* The other nannofossil events in this interval are the FO of *Discoaster bifax* in Sample 149-900A-68R-1, 83-84 cm, and the FO of *Chiasmolithus gigas* in Sample 149-900A-69R-2, 107-108 cm, where the lowest occurrence of *Sphenolithus furcatolithoides* was found.

Samples 149-900A-70R-2, 48-49 cm, to 74R-2, 46-47 cm, are assigned to the *Discoaster sublodoensis* Zone (NP14, CP12) based on the occurrence of *Discoaster sublodoensis* and the absence of *Nannotetrina fulgens.* The LO of *Rhabdosphaera inflata* is in Sample 149-900A-70R-2,48-49 cm, just below the boundary between Zones NP14 and NP15. However, the first *Rhabdosphaera inflata* was found in Sample 149-900A-74R-1, 38-39 cm, just one sample above the first *Discoaster lodoensis.* Therefore, if the FO of *Rhabdosphaera inflata* is used to subdivide Zone CP12, then CP12a is represented by only Sample 149-900A-74R-2, 46-47 cm.

The short interval from Samples 149-900A-75R-1, 56-57 cm, to 76R-1, 34-35 cm, is placed in the *Discoaster lodoensis* Zone (NP12/13, CP10-11), based on the occurrence of *Discoaster lodoensis* and the absence of *Discoaster sublodoensis.* The FO of *Toweius crassus* was used by Okada and Bukry (1980) to divide the *Tribrachiatus orthostylus* (CP10) and *Discoaster orthostylus* (CP11) Zones. However, *Toweius crassus* is not present in the Leg 149 sediments; therefore, Zones CP10 and CP11 cannot be distinguished. The dominant species in this interval are *Coccolithus pelagicus, Discoaster lodoensis,* and *Reticulofenestra dictyoda.*

A short interval from Samples 149-900A-77R-2, 120-121 cm, to 77R-3, 3-4 cm, is assigned to the combined *Tribrachiatus contortus* (NP10, CP9a) and *Discoaster binodosus* Zones (NP11, CP9b), based on the occurrence of *Tribrachiatus bramlettei* and the absence of *Discoaster lodoensis.*

DISCUSSION

According to Martini and Muller (1986), the top of the Eocene is approximated by the extinction of the rosette-shaped discoasters *Discoaster saipanensis* and *Discoaster barbadiensis.* They also suggested the LO of *Cribrocentrum reticulatum* for this boundary in regions where discoasters are absent owing to either low surface-water temperatures or shallow-water environments; the LO of *Cribrocentrum reticulatum* is just below the extinction of *Discoaster saipanensis.* Leg 149 is located in the middle latitudes with common occurrences of both rosette-shaped discoasters and *Cribrocentrum reticulatum.* In Hole 897C, *Cribrocentrum reticulatum* disappears abruptly and the abundance of *Discoaster barbadiensis* and *Discoaster saipanensis* decreases sharply. However, the rosette-shaped discoasters were easily found in Samples 149-897C-50R-4, 26-27 cm, and 50R-3, 71-72 cm. (They are very rare above Sample 50R-3, 71-72 cm). Therefore, the Eocene/Oligocene boundary can be placed above Sample 149-897C-50R-4, 26-27 cm. In Holes 899B and 900A, the extinction of *Cribrocentrum reticulatum* also occurs just below the extinction of the rosette-shaped discoasters.

The LO of *Sphenolithus obtusus* is higher than the FO of *Chiasmolithus oamaruensis* and lower than the FO of *Isthmolithus recurvus.* Because reworking is quite common in the Eocene sections and

Table 2. Distribution of calcareous nannofossils, Hole 897C.

Age	Nannofossil zone: Martini (1971)	Nannofossil zone: Okada and Bukry (1980)	Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	*Blackites spinosus*	*Blackites tenuis*	*Braarudosphaera bigelowii*	*Bramletteius serraculoides*	*Calcidiscus protoannulus*	*Campylosphaera dela*	*Chiasmolithus grandis*	*Chiasmolithus oamaruensis*	*Chiasmolithus titus*	*Clausicoccus fenestratus*	*Coccolithus eopelagicus*	*Coccolithus pelagicus*	*Corannulus germanicus*	*Coronocyclus nitiscens*	*Cribrocentrum reticulatum*	*Cruciplacolithus cruciformis*
			149-897C																			
late Eocene	NP19/20	CP15b	50R-3, 71–72	526.91	A	M	F	R	R	F	F	.	.	F	R	R	F	A	.	.	.	.
			50R-4, 26–27	528.36	A	M	F	F	R	F	F	.	.	F	R	F	F	A	.	.	.	.
			51R-1, 11–12	532.91	A	M	F	F	.	F	F	.	.	F	R	F	F	A	.	.	R	.
			51R-2, 46–47	534.76	A	M	F	F	F	F	F	.	.	C	R	F	F	A	F	.	F	.
			51R-2, 67–68	534.97	A	M	F	F	.	R	F	.	.	C	R	R	F	A	.	.	F	.
			51R-3, 31–32	536.11	A	M	F	F	R	F	F	.	.	F	R	R	F	A	.	.	F	.
			51R-3, 91–92	536.71	A	M	F	F	R	C	F	.	.	R	.	R	F	A	R	R	F	.
			52R-1, 37–38	542.77	A	P	F	F	F	F	F	.	.	R	.	F	F	A	R	.	F	R
			52R-1, 101–102	543.41	A	M	R	R	R	F	C	.	.	F	R	F	F	A	.	.	F	R
			52R-2, 27–28	544.17	A	M	F	F	F	R	C	.	.	F	.	F	C	A	.	.	F	.
			52R-2, 115–116	545.05	A	M	F	F	R	R	C	.	.	F	R	F	C	A	F	R	C	.
			52R-3, 79–80	546.19	A	P	F	F	R	R	C	.	.	R	R	R	F	A	R	.	F	F
			53R-1, 56–57	552.66	A	M	F	F	.	F	C	.	.	R	.	F	C	A	.	.	C	F
			53R-1, 120–121	553.30	A	M	F	F	.	F	C	.	.	R	R	F	F	A	R	.	C	R
			53R-2, 45–46	554.05	A	M	F	F	.	R	C	.	.	F	.	F	C	A	.	.	C	R
			53R-2, 118–119	554.78	A	M	F	F	.	R	C	R	.	R	R	F	C	A	.	.	C	R
			53R-3, 15–16	555.25	A	M	F	F	.	F	C	R	.	F	.	F	F	A	.	.	C	F
			53R-3, 79–80	555.89	A	M	F	F	R	F	F	.	.	F	.	F	F	A	.	.	C	R
			53R-CC	561.80	A	M	F	F	.	R	F	.	.	F	.	F	C	A	.	.	C	R
			54R-1, 19–20	561.99	A	M	F	F	R	R	F	.	.	F	.	F	F	A	F	.	C	R
			54R-1, 95–96	562.75	A	M	F	F	R	R	F	.	F	F	.	F	C	A	.	.	C	F
			54R-2, 52–53	563.82	A	M	F	F	R	C	F	.	R	F	.	F	C	A	.	R	C	F
	NP18	CP15a	54R-2, 136–137	564.66	A	M	F	F	.	F	F	.	F	F	.	C	F	A	.	.	A	F
			54R-3, 2–3	564.82	A	M	F	F	.	F	F	.	F	R	.	F	F	A	.	.	A	F
			54R-3, 76–77	565.56	F	M	R	R	.	F	F	R	R	R	.	R	R	F	.	.	F	R
			54R-4, 1–2	566.31	A	M	F	F	F	F	R	.	F	R	R	F	F	A	.	.	C	F
			54R-4, 67–68	566.97	A	P	F	.	R	R	R	.	F	.	R	C	F	A	.	.	C	R
			55R-1, 38–39	571.88	A	M	F	F	R	F	F	R	F	R	R	C	F	A	.	.	C	R

Note: V = very abundant; A = abundant; C = common; F = few; R = rare; G = good; M = moderate; P = poor; r = rare (reworked).

makes LO datums difficult determined, I prefer to use the FO of *Chiasmolithus oamaruensis* rather than the LO of *Sphenolithus obtusus* to mark the upper/middle Eocene boundary.

The LO of *Chiasmolithus solitus* was found to be diachronous and thus not useful in a number of Deep Sea Drilling Project (DSDP) sections (Beckman et al., 1981). Bukry (1973) proposed the LO of *Discoaster bifax* as an alternative to the LO of *Chiasmolithus solitus* to subdivide the interval between the FO of *Reticulofenestra umbilicus* and the FO of *Chiasmolithus oamaruensis*. However, *Discoaster bifax* is not common in the Leg 149 Eocene sediments as well as in several other DSDP sections (Beckman et al., 1981); it is, therefore, not always a reliable nannofossil event. In this report, I still use the LO of *Chiasmolithus solitus* to approximate the boundary between Zones NP16andNP17.

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Table 2 (continued).

Cyclicargolithus floridanus	*Cyclicargolithus formosus*	*Dictyococcites bisectus*	*Dictyococcites retiformis*	*Discoaster barbadiensis*	*Discoaster binodosus*	*Discoaster saipanensis*	*Discoaster tani nodifer*	*Discoaster tani tani*	*Helicosphaera bramlettei*	*Helicosphaera compacta*	*Helicosphaera reticulata*	*Helicosphaera wilcoxonii*	*Isthmolithus recurvus*	*Lanternithus minutus*	*Micrantholithus altus*	*Micrantholithus* spp.	*Neococcolithes dubius*	*Pedinocyclus larvalis*	*Pemma angulatum*	*Pemma basquensis*	*Pemma papillatum*	*Pentaster* sp.	*Pontosphaera multipora*	*Pyrocyclus hermosus*	*Reticulofenestra hillae*	*Reticulofenestra* spp. (small)	*Reticulofenestra umbilicus*	*Rhabdolithus gladius*	*Rhabdosphaera rudis*	*Scapholithus fossilis*	*Sphenolithus moriformis*	*Sphenolithus obtusus*	*Sphenolithus predistentus*	*Sphenolithus radians*	*Thoracosphaera* spp.	*Transversopontis obliquipons*	*Transversopontis pulcheroides*	*Transversopontis sigmoidalis*	*Zygrhablithus bijugatus*
C	C	C	R	R	.	F	F	F	R	F	R	.	F	F	.	.	.	.	.	.	.	.	R	F	F	A	C	.	.	.	C	.	R	.	R	.	R	.	F
C	C	C	R	F	.	F	F	F	R	F	R	.	F	F	.	.	.	.	.	.	.	.	R	F	F	A	C	.	.	.	C	.	R	.	R	.	R	.	F
A	C	C	R	C	.	F	F	F	R	F	R	.	F	F	.	.	.	.	.	.	.	.	R	F	F	A	C	.	.	.	A	.	R	.	F	.	R	.	C
A	A	C	R	C	.	F	F	F	R	F	F	.	F	F	.	.	.	.	.	.	F	R	R	F	F	A	C	.	R	.	A	.	.	.	F	.	.	.	A
C	A	C	R	C	.	C	F	F	R	F	R	R	R	F	.	.	.	.	.	.	.	.	.	.	C	A	C	.	.	.	C	.	.	R	F	.	.	.	A
C	C	C	.	C	.	F	R	F	.	R	R	R	R	F	.	.	.	.	.	.	R	.	R	R	C	A	C	.	.	.	C	.	.	.	F	.	.	.	C
F	F	C	R	C	.	F	R	F	.	R	.	.	R	F	.	.	.	.	.	.	R	R	.	R	F	C	C	.	.	.	C	.	.	.	F	.	.	.	C
F	F	A	R	F	.	F	F	F	R	F	R	.	R	F	.	.	.	.	.	.	F	R	R	.	F	C	C	.	.	.	C	.	.	.	F	.	.	.	C
F	C	A	.	F	.	F	R	F	.	F	.	.	R	F	.	.	.	.	.	.	.	.	.	R	F	C	F	.	.	.	C	.	.	.	F	.	.	.	C
F	C	A	R	C	.	C	F	F	R	R	R	.	F	F	.	.	R	.	.	.	F	.	.	.	F	C	C	.	.	.	C	.	.	.	F	.	.	.	C
F	A	A	R	F	.	F	R	R	R	F	R	.	R	F	.	.	.	.	.	.	R	.	.	.	F	C	F	.	.	.	A	.	.	.	F	.	.	.	C
C	C	A	R	F	.	F	R	R	R	R	.	.	R	C	.	.	.	.	.	.	R	.	F	F	F	C	C	.	R	R	A	.	.	.	F	.	.	.	C
F	C	A	R	C	R	F	F	F	F	F	R	R	R	F	.	.	R	.	.	.	.	.	R	R	F	C	C	.	.	.	C	.	.	.	F	.	.	.	F
F	C	A	R	F	R	F	F	F	F	F	R	.	R	F	.	.	.	.	.	.	R	.	F	R	F	A	C	.	.	.	C	.	.	.	F	.	R	R	C
F	C	A	.	C	.	F	F	F	F	F	.	.	R	F	.	.	.	.	.	.	.	.	F	.	C	A	C	.	.	.	C	.	.	.	F	.	R	.	F
F	C	A	R	F	.	F	F	F	F	F	R	R	R	C	.	.	.	R	R	.	.	.	F	.	F	C	C	.	R	.	C	.	R	R	F	.	.	.	F
F	C	A	.	C	.	C	F	F	F	F	.	R	.	C	.	.	.	.	.	.	R	.	F	.	F	C	F	.	R	.	C	.	.	.	F	.	R	.	C
F	C	A	R	C	.	C	F	F	F	F	F	R	R	A	.	.	.	.	.	R	F	.	F	R	F	C	F	.	.	.	C	.	.	.	F	.	R	.	F
F	C	A	.	C	R	F	R	R	F	F	F	R	.	C	R	.	R	.	.	.	.	.	F	.	C	C	F	.	R	.	A	.	.	R	F	.	.	.	F
F	C	C	R	C	.	F	R	R	F	F	F	.	R	C	.	.	.	.	.	R	F	.	F	R	F	C	F	.	R	.	C	.	.	R	F	.	R	.	C
F	C	C	R	C	R	C	R	R	F	F	R	.	R	C	R	R	.	.	.	.	R	R	R	R	F	C	F	.	.	.	C	.	.	R	F	.	.	.	C
F	C	C	R	C	F	F	F	F	F	F	F	.	R	C	.	.	R	R	.	.	F	.	R	R	F	C	F	r	.	.	C	.	.	.	F	.	.	.	C
F	C	C	R	C	F	F	F	R	R	F	R	.	.	C	.	.	.	.	.	.	F	.	R	R	C	C	F	.	.	.	C	.	.	R	F	R	.	.	C
C	C	C	R	C	F	F	F	R	R	F	R	.	.	C	.	.	.	.	.	.	.	.	R	R	F	C	F	.	.	.	A	F	.	.	F	.	.	.	C
F	F	F	.	C	R	F	R	R	R	R	.	.	.	R	.	.	R	.	.	.	.	.	R	.	R	F	R	.	.	.	F	R	.	.	R	.	.	.	F
C	C	C	.	C	F	F	F	F	R	F	R	.	.	C	.	.	R	.	.	.	F	.	R	R	C	C	F	.	.	.	C	F	.	.	F	.	R	.	C
A	C	C	R	C	F	F	F	F	R	F	R	.	.	F	R	R	.	.	.	R	F	.	.	R	C	C	C	.	.	.	C	C	.	R	F	.	.	.	C
A	C	C	R	C	F	F	F	F	R	F	R	R	.	C	.	.	.	.	.	.	R	.	R	R	C	C	C	.	.	.	A	F	.	R	F	.	.	.	C

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APPENDIX

Eocene Nannofossil Species Considered in this Report

Eocene species are arranged in alphabetical order of generic epithets.

Blackites spinosus (Deflandre & Pert, 1954) Hay & Towe (1962)
Blackites tenuis Bramlette & Sullivan (1961)
Braarudosphaera bigelowii (Gran & Braarud, 1935) Deflandre (1947)
Bramletteius serraculoides Gartner (1969)
Calcidiscus protoannulus (Gartner, 1971) Loeblich & Tappan (1978)
Campylosphaera dela (Bramlette & Sullivan, 1961) Hay & Mohler (1967)
Chiasmolithus consuetus (Bramlette & Sullivan, 1961) Hay & Mohler (1967)
Chiasmolithus expensus (Bramlette & Sullivan, 1961) Gartner (1970)
Chiasmolithus gigas (Bramlette & Sullivan, 1961) Radomski (1968)
Chiasmolithus grandis (Bramlette & Sullivan, 1961) Radomski (1968)
Chiasmolithus nitidus Perch-Nielsen (1971)
Chiasmolithus oamaruensis (Deflandre, 1954) Hay, Mohler & Wade (1966)
Chiasmolithus solitus (Bramlette & Sullivan, 1961) Locker (1968)
Chiasmolithus titus Gartner (1970)
Clausicoccus fenestratus (Deflandre & Pert, 1954) Prins (1979)
Coccolithus eopelagicus (Bramlette & Riedel, 1954) Bramlette & Sullivan (1961)
Coccolithus formosus (Kamptner, 1963) Wise (1973)
Coccolithus pelagicus (Wallich, 1877) Schiller (1930)
Corannulus germaricus Stradner (1962)
Coronocyclus nitiscens (Kamptner, 1963) Bramlette & Wilcoxon (1967)
Cribrocentrum reticulatum (Gartner & Smith, 1967) Perch-Nielsen (1971)
Cruciplacolithus cruciformis (Hay & Towe, 1962) Roth (1970)
Cruciplacolithus staurion Bramlette & Sullivan (1961)
Cyclicargolithus floridanus (Roth & Hay *in* Hay et al., 1967) Bukry (1971)
Dictyococcites bisectus (Hay, Mohler, & Wade, 1966) Bukry & Percival (1971)
Discoaster barbadiensis Tan (1927)
Discoaster bifax Bukry (1971)
Discoaster binodosus Martini (1958)
Discoaster lodoensis Bramlette & Riedel (1954)
Discoaster multiradiatus Bramlette & Riedel (1954)
Discoaster saipanensis Bramlette & Riedel (1954)
Discoaster sublodoensis Bramlette & Sullivan (1961)

Table 3. Distribution of calcareous nannofossils, Hole 897C.

Age	Nannofossil zone: Martini (1971)	Nannofossil zone: Okada and Bukry (1980)	Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	*Blackites spinosus*	*Blackites tenuis*	*Braarudosphaera bigelowii*	*Bramletteius serraculoides*	*Calcidiscus protoannulus*	*Campylosphaera dela*	*Chiasmolithus expansus*	*Chiasmolithus gigas*	*Chiasmolithus grandis*	*Chiasmolithus nitidus*	*Chiasmolithus solitus*	*Chiasmolithus titus*	*Clausicoccus fenestratus*	*Clausicoccus* sp.	*Coccolithus eopelagicus*	*Coccolithus pelagicus*	*Corannulus germaricus*	*Cribrocentrum reticulatum*	*Cruciplacolithus cruciformis*	*Cyclicargolithus floridanus*	*Cyclicargolithus formosus*	*Dictyococcites bisectus*	*Dictyococcites retiformis*	*Discoaster barbadiensis*
			149-897C																											
middle Eocene	NP17	CP14b	55R-2, 74–75	573.74	A	M	R	R	R	F	F	.	.	.	F	.	.	.	F	R	F	A	.	F	.	A	C	C	.	C
			55R-3, 75–76	575.25	A	M	R	R	F	F	F	F	.	.	F	.	.	R	R	R	C	A	.	F	.	C	C	C	.	C
	NP16	CP14a	55R-4, 67–68	576.67	A	M	R	R	F	F	F	F	.	.	F	.	R	R	F	R	C	A	.	F	.	C	C	C	.	C
			55R-CC	581.20	A	M	R	R	.	.	F	F	.	.	F	.	R	R	R	F	F	A	R	F	.	C	C	C	R	F
			56R-1, 81–82	581.91	A	M	.	.	R	R	F	F	.	.	F	R	R	R	F	F	F	A	.	F	R	A	C	C	R	F
			56R-2, 38–39	582.98	A	M	R	.	F	R	F	F	R	.	F	R	C	R	F	F	F	A	.	F	.	C	C	C	R	F
			56R-3, 52–53	584.62	A	P	.	.	R	.	F	F	.	.	F	R	F	R	F	F	F	C	.	F	.	F	C	C	.	C
			56R-6, 86–87	587.96	A	P	R	R	.	R	F	F	.	.	F	R	C	R	F	F	C	A	.	F	.	F	C	F	.	C
			56R-6, 96–97	589.56	A	M	.	.	F	.	F	F	.	.	F	.	F	R	F	F	C	V	.	F	R	F	C	F	.	F
			57R-1, 96–97	591.66	A	M	R	.	R	F	F	F	R	.	C	R	C	R	F	F	F	A	.	F	.	A	C	F	.	C
			57R-2, 128–129	593.48	A	M	R	R	.	F	F	F	R	.	F	R	F	R	F	F	F	A	.	F	.	C	C	F	.	C
			57R-4, 85–86	596.05	A	M	R	R	.	F	F	F	F	.	F	.	C	.	R	F	F	A	.	.	.	A	C	F	.	F
			57R-5, 70–71	597.40	A	M	R	.	.	F	F	F	R	.	F	R	C	R	F	F	F	A	.	.	.	A	C	F	.	F
	NP15	CP13	58R-1, 144–145	601.94	A	M	.	R	R	F	F	F	F	.	F	R	C	R	F	F	F	A	.	.	.	A	C	F	R	F
			58R-2, 113–114	603.13	A	M	R	.	.	R	F	F	F	.	F	R	C	R	F	F	F	A	.	.	.	C	C	F	R	F
			58R-2, 133–134	603.33	A	P	R	.	R	.	F	F	R	.	F	R	C	.	F	F	F	V	.	.	.	A	C	F	R	F
			58R-3, 96–97	604.46	A	P	R	R	.	.	F	F	F	.	F	R	C	R	F	F	F	A	.	.	.	C	C	R	R	F
			59R-2, 14–15	611.74	A	P	R	R	R	R	F	F	F	F	F	R	C	R	F	F	F	A	.	.	.	C	C	R	R	F

Note: V = very abundant; A = abundant; C = common; F = few; R = rare; G = good; M = moderate; P = poor.

Discoaster tani nodifer Bramlette & Riedel (1954)
Discoaster tani tani Bramlette & Riedel (1954)
Ellipsolithus distichus (Bramlette & Sullivan, 1961) Sullivan (1964)
Helicosphaera bramlettei Müller (1970)
Helicosphaera compacta Bramlette & Wilcoxon (1967)
Helicosphaera reticulata Bramlette & Wilcoxon (1967)
Helicosphaera salebrosa Perch-Nielsen (1971)
Helicosphaera seminulum Bramlette & Sullivan (1961)
Helicosphaera wilcoxonii Gartner (1971)
Isthmolithus recurvus Deflandre (1954)
Lanternithus minutus Stradner (1962)
Markalius inversus (Deflandre *in* Deflandre & Pert, 1954) Bramlette & Martini (1964)
Micrantholithus altus Bybell & Gartner (1972)
Nannotetrina alata (Martini, 1960) Haq & Lohmann (1967)
Nannotetrina cristata (Martini, 1958) Perch-Nielsen (1971)
Nannotetrina fulgens (Stradner, 1960) Achuthan & Stradner (1969)
Neochiastozygus distentus (Bramlette & Sullivan, 1961) Perch-Nielsen (1971c)
Neococcolithus dubius (Deflandre, 1954) Black (1967)
Pedinocyclus larvalis (Bukry & Bramlette, 1969) Loeblich & Tappan (1973)
Pemma angulatum Martini (1959)
Pemma basquensis (Martini, 1959) Baldi-Beke (1971)
Pemma papillatum Martini (1959)
Pontosphaera multipora (Kamptner, 1948) Roth (1970)
Pseudotriquetrorhabdulus inversus (Bukry & Bramlette, 1969) Wise *in* Wise & Constans(1976)
Pyrocyclus hermosus Roth & Hay *in* Hay et al. (1967)
Reticulofenestra dictyoda (Deflandre *in* Deflandre & Pert, 1954) Stradner *in* Stradner & Edwards (1968)
Reticulofenestra hillae Bukry & Percival (1971)
Reticulofenestra umbilicus (Levin, 1965) Martini & Ritzkowski (1968)
Rhabdosphaera gladius Locker (1967)
Rhabdosphaera inflata Bramlette & Sullivan (1961)
Rhabdosphaera rudis Bramlette & Sullivan (1961)
Scapholithus fossilis Deflandre *in* Deflandre & Pert (1954)
Sphenolithus editus Perch-Nielsen *in* Perch-Nielsen et al. (1978)
Sphenolithus furcatolithoides Locker (1967)
Sphenolithus moriformis (Brönnimann & Stradner, 1960) Bramlette & Wilcoxon (1967)
Sphenolithus obtusus Bukry (1971)
Sphenolithus predistentus Bramlette & Wilcoxon (1967)
Sphenolithus pseudoradians Bramlette & Wilcoxon (1967)
Sphenolithus radians Deflandre in Grasse (1952)
Transversopontis duovacus (Bramlette & Sullivan, 1961) Locker (1973)
Transversopontis obliquipons (Deflandre *in* Deflandre & Pert, 1954) Hay, Mohler, & Wade (1966)
Transversopontis pulcheroides (Sullivan, 1964) Baldi-Beke (1971)
Transversopontis sigmoidalis Locker (1967)
Tribrachiatus bramlettei (Brönnimann & Stradner, 1960) Proto Decima et al. (1975)
Tribrachiatus contortus (Stradner, 1958) Bukry (1972)
Tribrachiatus orthostylus Shamrai (1963)
Zygrhablithus bijugatus (Deflandre *in* Deflandre & Pert, 1954) Deflandre (1959)

Table 3 (continued).

Discoaster bifax	*Discoaster binodosus*	*Discoaster lodoensis*	*Discoaster saipanensis*	*Discoaster tani nodifer*	*Discoaster tani tani*	*Ericsonia robusta*	*Helicosphaera bramlettei*	*Helicosphaera compacta*	*Helicosphaera reticulata*	*Helicosphaera salebrosa*	*Helicosphaera seminulum*	*Lanternithus minutus*	*Markalius inversus*	*Micrantholithus* spp.	*Nannotetrina cristata*	*Nannotetrina fulgens*	*Neococcolithes dubius*	*Pedinocyclus larvalis*	*Pemma altus*	*Pemma angulata*	*Pemma papillatum*	*Pentaster* sp.	*Pontosphaera multipora*	*Pseudotriquetrorhabdulus inversus*	*Pyrocyclus hermosus*	*Reticulofenestra dictyoda*	*Reticulofenestra hillae*	*Reticulofenestra* spp. (small)	*Reticulofenestra umbilicus*	*Sphenolithus furcatolithoides*	*Sphenolithus moriformis*	*Sphenolithus obtusus*	*Sphenolithus pseudoradians*	*Sphenolithus radians*	*Thoracosphaera* spp.	*Transversopontis duovacus*	*Transversopontis pulcheroides*	*Zygrhablithus bijugatus*
.	F	.	F	F	F	.	R	F	R	.	.	F	.	.	.	.	.	.	.	.	F	.	R	.	.	F	F	C	F	.	A	F	R	R	F	.	.	C
.	F	.	F	F	R	.	F	.	.	.	.	F	.	.	.	.	.	.	.	R	F	.	.	.	R	C	F	C	F	.	C	F	R	.	F	.	.	C
.	F	.	F	F	R	R	R	F	R	.	.	F	.	.	.	.	.	.	R	.	F	.	.	R	R	C	F	C	C	.	C	C	.	R	F	.	.	C
.	F	R	F	F	R	.	.	F	R	R	R	F	.	.	.	.	.	.	.	.	.	.	.	F	.	C	F	C	F	.	C	C	R	R	F	.	.	C
.	F	.	F	F	R	R	R	F	R	R	.	F	.	.	.	.	.	.	.	.	.	.	R	F	.	C	F	C	C	.	C	F	R	F	F	.	.	C
.	F	.	F	F	F	.	R	F	.	R	.	C	.	.	.	.	.	.	R	R	F	.	.	F	R	C	F	C	C	R	C	F	R	R	F	.	.	A
.	F	.	F	F	R	.	.	R	.	R	.	C	.	R	.	.	.	.	R	.	F	R	.	F	R	F	R	C	F	R	C	R	R	.	F	.	.	C
.	F	.	F	R	R	.	R	R	.	R	.	F	.	.	.	.	R	.	.	.	R	.	R	F	R	C	F	A	C	F	C	R	.	F	F	.	.	C
.	F	.	F	F	R	.	R	.	R	.	.	F	R	R	.	.	R	.	F	.	C	.	.	F	R	C	F	A	C	F	C	R	R	.	F	R	.	A
.	F	.	F	F	R	R	R	.	.	.	.	F	R	.	.	.	R	.	.	.	.	.	.	F	.	C	F	C	C	F	C	F	R	R	F	.	.	C
.	F	.	F	R	R	.	.	.	R	R	.	F	R	.	.	.	.	.	.	.	.	.	R	F	R	C	F	C	C	F	C	F	.	.	F	.	R	F
F	F	R	F	R	R	.	F	.	.	F	.	R	.	.	R	.	R	.	.	.	.	.	.	F	R	A	.	A	F	F	C	F	R	R	F	R	.	C
F	F	.	F	F	R	.	R	.	.	R	.	F	.	.	R	.	R	.	.	.	.	.	.	F	.	C	.	A	R	F	C	C	R	F	F	.	R	C
F	F	.	R	F	R	.	R	.	.	.	.	F	R	R	F	.	R	.	.	.	R	.	.	C	R	C	.	A	.	F	C	F	.	R	F	.	.	C
R	R	.	F	F	R	.	R	.	.	R	.	F	.	.	F	F	R	.	.	.	F	.	.	C	.	C	.	A	.	F	F	R	R	F	F	.	R	C
R	R	.	F	R	R	.	R	.	.	R	.	F	.	.	F	F	R	R	.	.	.	.	.	C	R	C	.	A	.	F	C	.	.	F	F	R	R	F
R	R	.	F	F	R	.	F	.	.	R	.	F	.	.	F	F	.	.	.	.	F	.	.	C	R	C	.	A	.	F	C	.	R	F	F	.	.	C
.	F	.	F	F	R	.	R	.	.	.	.	F	.	R	F	R	R	R	.	.	C	R	.	C	R	A	.	A	.	C	C	.	R	F	F	.	.	A

Table 4. Distribution of calcareous nannofossils, Hole 897D.

Age	Nannofossil zone: Martini (1971)	Nannofossil zone: Okada and Bukry (1980)	Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	*Blackites spinosus*	*Blackites tenuis*	*Braarudosphaera bigelowii*	*Bramletteius serraculoides*	*Calcidiscus protoannulus*	*Campylosphaera dela*	*Chiasmolithus consuetus*	*Chiasmolithus expansus*	*Chiasmolithus gigas*	*Chiasmolithus grandis*	*Chiasmolithus nitidus*	*Chiasmolithus solitus*	*Chiasmolithus titus*	*Clausicoccus fenestratus*	*Clausicoccus* sp.
			149-897D																		
middle Eocene	NP15	CP13	1R-1, 146–147	597.46	A	M	R	.	R	F	F	F	.	R	R	F	R	C	R	F	F
			1R-2, 98–99	598.48	A	P	R	R	.	F	F	F	R	R	F	F	R	C	R	F	F
			1R-3, 22–23	599.22	A	M	R	R	R	F	F	F	R	R	R	F	R	C	R	F	F
			1R-4, 42–43	600.92	A	P	R	.	.	F	F	F	.	.	F	F	R	F	R	F	F
			2R-1, 42–43	607.22	A	P	R	.	R	F	F	F	.	R	R	F	R	F	R	F	F
			2R-2, 100–101	609.30	C	P	R	R	.	R	R	R	R	R	R	F	R	F	R	R	F
			2R-3, 97–98	610.77	C	P	.	.	.	.	R	R	.	.	.	R	R	R	R	R	R
			2R-4, 4–5	611.14	A	P	R	.	.	R	F	F	R	R	F	F	R	F	R	R	F
			2R-5, 8–9	612.68	A	P	R	.	F	.	F	F	.	R	R	F	R	F	R	F	R
			2R-5, 25–26	612.85	C	P	.	R	R	.	R	F	.	.	R	R	F	F	F	R	R
			2R-CC	616.50	A	P	R	R	.	.	R	F	.	.	R	R	F	F	F	R	R
			3R-1, 49–50	616.99	A	P	R	.	F	.	F	F	.	R	.	R	F	F	F	F	F
			3R-1, 130–131	617.80	A	P	R	.	F	.	F	F	.	R	.	R	F	F	F	F	F
			3R-2, 47–48	618.47	A	P	R	.	F	.	F	F	.	R	.	R	F	C	F	F	F
	NP14	CP12b	3R-2, 140–141	619.40	A	P	R	R	F	.	F	F	.	F	.	F	F	C	F	F	F
			3R-3, 70–71	620.20	A	P	R	.	F	.	F	F	.	F	.	F	F	C	F	F	F
			3R-3, 113–114	620.63	A	P	.	.	F	.	F	F	.	F	.	F	F	F	F	F	F
			3R-4, 22–23	621.22	A	P	.	.	R	.	R	F	.	R	.	F	F	F	F	F	F

Core, section, interval (cm)	*Coccolithus eopelagicus*	*Coccolithus pelagicus*	*Cyclicargolithus floridanus*	*Cyclicargolithus formosus*	*Dictyococcites bisectus*	*Dictyococcites retiformis*	*Discoaster barbadiensis*	*Discoaster bifax*	*Discoaster binodosus*	*Discoaster lodoensis*	*Discoaster multiradiatus*	*Discoaster saipanensis*	*Discoaster sublodoensis*	*Discoaster tani nodifer*	*Discoaster tani tani*	*Ericsonia robusta*	*Helicosphaera bramlettei*	*Helicosphaera salebrosa*	*Helicosphaera seminulum*	*Lanternithus minutus*
1R-1, 146–147	F	A	A	C	F	.	F	F	R	.	.	F	.	F	R	.	R	R	.	R
1R-2, 98–99	F	A	C	C	R	R	C	R	R	.	.	F	.	R	R	.	R	R	R	R
1R-3, 22–23	F	A	F	C	.	.	F	R	R	.	.	F	.	R	R	.	R	R	.	F
1R-4, 42–43	F	A	F	C	.	.	F	.	R	.	R	R	.	F	R	.	R	R	.	F
2R-1, 42–43	R	A	F	C	.	.	F	.	R	.	.	R	.	R	.	.	R	.	.	R
2R-2, 100–101	R	A	F	C	.	.	F	.	R	.	.	F	.	R	.	.	.	.	.	.
2R-3, 97–98	F	C	.	F	.	.	F	.	.	.	.	F	.	R		R	.	.	.	.
2R-4, 4–5	F	A	.	C	.	.	F	.	.	.	.	F	.	R	.	.	.	.	R	.
2R-5, 8–9	F	A	.	C	.	.	F	.	.	.	.	F	.	R	.	R	.	.	.	.
2R-5, 25–26	F	A	.	C	.	.	F	.	R	R	.	F	.	R	R	R	.	.	.	.
2R-CC	F	A	.	C	.	.	F	.	R	.	.	F	.	R	R	.	.	.	.	.
3R-1, 49–50	F	A	.	C	.	.	F	.	.	R	.	F	.	R	.	.	.	.	.	.
3R-1, 130–131	F	A	.	C	.	.	F	.	R	.	.	F	.	R	.	.	.	.	.	.
3R-2, 47–48	F	A	.	F	.	.	F	.	R	R	.	F	.	R	.	.	.	.	.	.
3R-2, 140–141	F	A	.	C	.	.	C	.	R	.	.	F	.	.		.	.	.	.	.
3R-3, 70–71	F	A	.	C	.	.	C	.	F	R	.	F	R	F	R	.	.	.	.	.
3R-3, 113–114	F	C	.	F	.	.	C	.	R	.	R	F	R	.	.	.	.	.	.	.
3R-4, 22–23	F	C	.	C	.	.	C	.	.	F	F	.	R	.	.	.	.	.	.	.

Core, section, interval (cm)	*Micrantholithus* spp.	*Nannotetrina alata*	*Nannotetrina cristata*	*Nannotetrina fulgens*	*Nannotetrina* sp.	*Neococcolithes dubius*	*Pedinocyclus larvalis*	*Pemma papillatum*	*Pentaster* sp.	*Pontosphaera multipora*	*Pseudotriquetrorhabdulus inversus*	*Pyrocyclus hermosus*	*Reticulofenestra dictyoda*	*Reticulofenestra* spp. (small)	*Rhabdosphaera inflata*	*Sphenolithus editus*	*Sphenolithus furcatolithoides*	*Sphenolithus moriformis*	*Sphenolithus radians*	*Thoracosphaera* sp.	*Tribrachiatus orthostylus*	*Zygrhablithus bijugatus*
1R-1, 146–147	.	.	F	R	.	R	.	F	.	.	C	.	A	A	.	.	F	C	.	F	.	C
1R-2, 98–99	.	.	F	F	.	R	.	R	.	.	C	.	A	A	.	R	F	F	R	F	.	C
1R-3, 22–23	.	.	F	F	.	R	.	R	.	.	C	.	A	C	.	.	F	F	R	F	.	C
1R-4, 42–43	.	.	F	R	.	.	R	.	.	.	C	.	A	A	.	R	C	F	.	F	.	C
2R-1, 42–43	.	.	F	.	.	.	.	F	.	R	F	.	C	C	.	.	F	F	R	F	.	C
2R-2, 100–101	.	.	R	R	.	.	.	R	.	R	F	.	C	C	.	.	R	F	R	F	.	C
2R-3, 97–98	.	.	R	.	R	R	.	.	.	.	R	.	C	F	.	.	R	F	R	R	.	F
2R-4, 4–5	.	R	F	R	R	R	.	.	.	.	C	R	A	C	.	.	R	C	R	R	.	C
2R-5, 8–9	.	R	F	R	R	R	.	F	.	.	F	R	A	C	.	.	.	F	.	R	.	F
2R-5, 25–26	.	.	F	R	R	.	R	R	.	.	F	R	A	F	.	.	.	F	.	F	R	R
2R-CC	.	F	F	F	R	R	.	R	.	R	C	.	A	A	R	.	.	F	.	F	.	F
3R-1, 49–50	R	R	R	R	R	R	.	F	.	R	A	.	A	A	.	.	.	F	.	F	.	C
3R-1, 130–131	R	R	R	R	R	R	.	F	R	.	C	.	C	C	.	.	.	F	.	F	.	C
3R-2, 47–48	R	R	R	R	R	.	.	C	.	.	A	.	A	A	R	.	.	F	.	R	.	A
3R-2, 140–141	R	R	F	.	R	R	.	R	.	.	C	.	A	C	F	.	.	F	.	R	.	A
3R-3, 70–71	.	R	F	.	R	R	.	.	.	.	C	.	A	C	F	.	.	F	.	F	.	A
3R-3, 113–114	.	.	.	.	R	R	.	C	R	.	C	.	A	C	F	.	.	R	.	R	.	C
3R-4, 22–23	R	.	R	R	.	R	.	R	.	.	F	.	A	C	F	.	.	F	.	F	R	C

Note: V = very abundant; A = abundant; C = common; F = few; R = rare; G = good; M = moderate; P = poor.

Table 5. Distribution of calcareous nannofossils, Hole 899B.

Age	Nannofossil zone: Martini (1971)	Nannofossil zone: Okada and Bukry (1980)	Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	*Blackites spinosus*	*Blackites tenuis*	*Bramletteius serraculoides*	*Calcidiscus protoannulus*	*Chiasmolithus oamaruensis*	*Chiasmolithus titus*	*Clausicoccus fenestratus*	*Coccolithus eopelagicus*	*Coccolithus pelagicus*	*Coronocyclus nitiscens*	*Cyclicargolithus floridanus*	*Cyclicargolithus formosus*	*Dictyococcites retiformis*	*Discoaster barbadiensis*	*Discoaster binodosus*	*Discoaster saipanensis*	*Discoaster tani nodifer*	*Discoaster tani tani*	*Helicosphaera bramlettei*	*Helicosphaera compacta*	*Helicosphaera reticulata*	*Isthmolithus recurvus*	*Lanternithus minutus*	*Pedinocyclus larvalis*	*Pemma papillatum*	*Pontosphaera multipora*	*Pyrocyclus hermosus*	*Reticulofenestra hillae*	*Reticulofenestra* spp. (small)	*Reticulofenestra umbilicus*	*Sphenolithus moriformis*	*Sphenolithus predistentus*	*Sphenolithus radians*	*Thoracosphaera* spp.	*Transversopontis pulcheroides*	*Zygrhablithus bijugatus*
			149-899B																																							
late Eocene	NP19/20	CP15b	14R-1, 35–36	350.95	A	M	.	.	.	.	R	.	R	F	C	.	C	F	.	R	.	R	R	R	.	.	.	R	.	.	.	.	.	F	.	F	F	.	.	R	.	F
			14R-2, 16–17	352.26	A	M	F	F	.	.	F	.	C	F	A	.	A	C	.	R	.	R	R	R	R	F	F	R	.	.	.	.	F	F	C	F	C	R	R	R	R	F
			14R-2, 55–56	352.65	A	M	.	.	.	.	F	.	R	F	A	.	A	C	.	R	R	R	R	R	.	R	R	R	.	.	.	.	R	C	C	F	R	.	.	R	.	R
			14R-2, 67–68	352.77	A	M	R	.	.	.	R	.	C	F	A	.	A	C	R	R	.	R	R	R	.	F	F	R	.	.	.	.	R	C	F	F	C	R	.	R	.	R
			14R-3, 6-7	353.66	A	M	R	R	F	.	R	.	F	F	A	R	A	C	.	R	R	R	R	R	.	F	R	R	.	.	R	.	R	C	F	F	C	.	.	R	.	R
			14R-3, 94–95	354.54	A	M	R	R	F	R	F	R	F	F	A	R	A	C	R	R	R	R	F	R	R	F	F	F	F	R	.	R	R	C	F	F	C	.	.	F	.	C
			14R-4, 23–24	355.33	A	M	R	.	F	R	R	.	F	F	A	R	A	C	R	F	R	F	F	F	.	F	.	F	.	.	.	.	.	C	F	C	C	.	.	F	.	F
			14R-4, 105–106	356.15	A	M	R	R	F	.	R	.	F	F	A	.	C	C	.	R	R	R	F	R	.	F	.	F	F	R	F	.	.	C	F	F	C	.	.	F	.	F
			14R-5, 120–121	357.80	A	M	R	.	R	.	R	.	F	F	C	.	C	C	.	C	R	F	F	F	.	F	.	R	R	.	.	.	R	C	F	C	C	.	.	F	.	F

Note: V = very abundant; A = abundant; C = common; F = few; R = rare; G = good; M = moderate; P = poor

Table 6. Distribution of calcareous nannofossils, Hole 900A.

Age	Nannofossil zone: Martini (1971)	Nannofossil zone: Okada and Bukry (1980)	Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	*Blackites spinosus*	*Blackites tenuis*	*Braarudosphaera bigelowii*	*Bramletteius serraculoides*	*Calcidiscus protoannulus*	*Chiasmolithus grandis*	*Chiasmolithus oamaruensis*	*Chiasmolithus titus*	*Clausicoccus fenestratus*	*Coccolithus eopelagicus*	*Coccolithus pelagicus*	*Corannulus germaricus*	*Coronocyclus nitiscens*	*Cribrocentrum reticulatum*	*Cruciplacolithus cruciformis*	*Cyclicargolithus floridanus*	*Cyclicargolithus formosus*
			149-900A																				
late Eocene	NP19/20	CP15b	53R-1, 113–114	490.03	A	M	F	R	R	R	F	.	R	R	F	R	A	R	R	.	F	A	C
			53R-1, 141–142	490.31	A	M	F	R	R	R	F	.	R	.	F	F	A	.	R	.	F	A	C
			53R-2, 45–46	490.85	A	M	F	R	R	F	F	.	R	R	F	F	A	R	.	.	F	A	C
			53R-2, 84–85	491.24	C	M	F	R	R	R	R	.	R	.	F	F	A	.	R	.	F	A	C
			53R-3, 10–11	492.00	A	M	F	.	R	R	F	.	R	.	F	F	A	R	.	.	F	A	C
			53R-3, 95-96	492.85	A	M	F	F	R	R	F	.	R	R	F	F	A	R	R	.	F	A	C
			53R-4, 19–20	493.59	A	M	F	F	R	R	F	.	R	R	F	F	A	.	.	.	F	A	C
			53R-4, 91–92	494.31	A	M	F	F	R	F	F	.	R	.	F	F	A	R	.	.	F	A	C
			53R-5, 48–49	495.38	A	M	F	F	R	F	F	.	.	R	F	F	A	R	.	.	F	C	C
			53R-5, 113–114	496.03	A	M	F	F	.	R	F	.	R	.	F	F	A	R	R	.	F	A	C
			53R-6, 63–64	497.03	A	M	F	F	R	F	F	.	R	.	F	F	A	.	R	.	F	A	C
			53R-6, 86–87	497.26	A	M	F	F	R	F	C	.	R	.	F	F	A	.	R	.	F	A	C
			54R-1, 37–38	498.97	A	M	F	F	R	F	F	.	R	R	F	F	A	.	R	.	F	A	C
			54R-1, 75–76	499.25	A	M	F	F	R	F	F	.	F	.	F	F	A	.	F	R	F	C	C
			54R-2, 35–36	500.45	A	M	F	F	R	F	F	.	F	.	F	F	A	R	R	F	F	C	C
			54R-2, 108–109	501.18	A	M	F	F	R	F	C	.	F	.	F	F	A	R	F	F	F	C	C
			54R-3, 35–36	501.95	A	M	F	F	.	F	F	.	F	R	F	F	A	.	F	F	F	C	C
			54R-3, 119–120	502.79	A	M	F	F	.	F	C	.	F	R	F	F	A	.	F	F	F	C	C
			54R-4, 78–79	503.88	A	M	F	F	R	F	C	.	F	R	F	F	A	.	F	F	F	C	C
			55R-CC	518.00	F	M	F	F	.	F	C	.	R	.	F	F	C	.	R	F	F	F	F
	NP18	CP15a	56R-1, 37–38	518.37	A	M	R	R	R	F	C	.	.	.	F	F	A	R	R	C	F	F	F
			56R-1, 144–145	519.44	A	M	F	R	R	F	C	F	F	.	F	F	A	.	F	C	F	F	C
			56R-2, 31–32	519.81	C	M	R	.	.	.	F	.	.	.	R	.	C	.	.	F	.	F	F
			56R-3, 2–3	521.02	C	M	R	.	.	R	F	F	R	R	R	F	A	R	F	C	R	F	C
			56R-4, 129–130	523.79	A	M	F	R	.	.	C	R	.	.	R	F	A	R	.	C	.	C	F
			56R-5, 26–27	524.26	A	M	R	R	.	R	C	R	.	.	R	F	A	R	.	C	R	C	F
			56R-5, 56–57	524.56	A	M	F	.	.	.	C	F	R	.	R	F	A	F	R	C	.	C	C
			56R-5, 152–153	525.52	A	M	R	R	R	R	C	F	R	R	R	F	A	F	.	C	R	C	C
			57R-1, 22–23	527.82	C	M	F	R	.	R	C	R	.	.	F	F	A	.	.	C	R	C	F
			57R-1, 95–96	528.55	C	M	F	.	.	F	F	R	R	.	R	F	C	.	.	C	F	C	F
			57R-1, 125–126	528.85	C	M	R	R	.	R	F	R	.	.	R	F	A	.	.	F	R	C	C
			57R-2, 20–21	528.80	A	M	F	R	.	.	F	.	.	R	R	F	C	.	.	C	.	F	C
			57R-2, 55–56	529.65	A	M	F	R	.	.	F	R	.	.	.	F	C	.	.	C	.	C	C
			57R-2, 86–87	529.96	A	M	F	R	.	.	R	R	R	F	R	F	A	R	.	F	.	C	C
			57R-2, 101–102	530.11	A	M	F	.	.	.	C	R	.	R	R	F	A	R	.	F	.	C	C
			57R-3, 8–9	530.68	C	M	R	R	.	R	F	R	R	R	R	F	A	F	.	C	R	C	C
			57R-3, 40–41	531.00	A	M	R	R	R	F	F	R	R	R	R	F	A	F	.	F	F	C	C
			57R-3, 71–72	531.31	C	M	R	R	.	R	F	R	R	R	R	R	C	R	.	F	R	C	F
			57R-4, 31–32	532.41	A	M	R	R	.	R	F	R	R	R	R	F	A	R	.	C	F	C	C

Note: V = very abundant; A = abundant; C = common; F = few; R = rare; G = good; M = moderate; P = poor.

Table 6 (continued).

Dictyococcites bisectus	*Dictyococcites retiformis*	*Discoaster barbadiensis*	*Discoaster binodosus*	*Discoaster saipanensis*	*Discoaster tani nodifer*	*Discoaster tani tani*	*Helicosphaera bramlettei*	*Helicosphaera compacta*	*Helicosphaera reticulata*	*Helicosphaera wilcoxonii*	*Isthmolithus recurvus*	*Lanternithus minutus*	*Micrantholithus* spp.	*Neococcolithes dubius*	*Pedinocyclus larvalis*	*Pemma angulatum*	*Pemma basquensis*	*Pemma papillatum*	*Pentaster* sp.	*Pontosphaera multipora*	*Pyrocyclus hermosus*	*Reticulofenestra hillae*	*Reticulofenestra* spp. (small)	*Reticulofenestra umbilicus*	*Rhabdosphaera rudis*	*Scapholithus fossilis*	*Sphenolithus moriformis*	*Sphenolithus obtusus*	*Sphenolithus predistentus*	*Sphenolithus radians*	*Thoracosphaera* spp.	*Transversopontis obliquipons*	*Transversopontis pulcheroides*	*Transversopontis sigmoidalis*	*Zygrhablithus bijugatus*
C	R	R	.	R	.	R	F	F	R	R	F	C	.	.	R	.	.	R	.	F	F	C	C	F	R	R	C	.	R	R	F	.	R	R	C
C	R	R	.	R	R	.	F	F	.	R	F	C	R	.	R	.	.	R	.	F	R	F	C	F	.	.	C	.	R	.	F	.	R	R	C
C	F	R	.	R	R	R	F	F	R	R	F	C	R	.	R	.	.	R	.	R	F	F	C	F	.	.	C	.	.	.	F	.	R	.	C
C	.	R	.	R	R	R	F	F	.	R	F	C	.	.	R	.	.	R	.	F	F	F	C	F	.	.	C	.	R	.	F	.	R	R	C
C	R	R	.	R	R	R	F	F	R	R	F	C	.	.	R	.	.	R	.	F	F	F	C	F	.	.	C	.	.	R	F	.	F	R	C
C	F	R	.	R	R	.	F	F	R	R	F	C	.	.	F	.	.	R	.	F	R	F	C	F	.	.	C	.	R	.	F	.	R	R	C
C	R	R	.	R	R	R	R	F	R	R	F	C	R	.	R	.	.	R	.	F	R	F	C	F	.	R	C	.	R	.	F	.	R	R	C
C	R	R	R	R	R	R	F	F	R		F	C	.	.	R	.	.	.	.	F	F	F	C	F	.	.	C	.	.	.	F	.	R	R	C
C	F	R	.	R	R	R	F	F	R	R	F	F	.	.	R	.	.	R	.	F	R	F	C	R	.	.	C	.	R	.	F	.	.	R	C
C	R	F	.	F	F	.	R	F	R	R	F	C	R	.	R	.	.	.	.	F	R	C	C	F	R	.	C	.	.	R	F	.	R	R	F
C	R	F	.	F	R	R	R	F	R	F	F	C	.	.	R	.	.	R	.	F	R	C	C	F	.	.	C	.	.	.	F	.	R	R	F
C	R	F	.	F	F	R	F	F	.	F	F	C	.	.	F	.	.	R	.	F	.	F	C	F	.	.	C	.	R	.	F	.	R	.	C
C	F	F	.	F	R	R	F	F	F	.	F	C	.	.	R	.	.	.	.	F	R	F	C	F	.	.	C	.	.	.	F	.	R	.	C
C	R	F	R	F	R	F	F	F	R	R	F	R	.	.	R	.	.	.	.	F	R	C	C	F	.	.	C	.	.	.	F	.	F	R	F
C	R	C	.	F	.	.	F	F	R	.	F	R	.	.	.	.	.	.	.	R	.	F	C	F	.	.	C	.	.	.	F	.	R	R	F
C	F	C	.	F	R	R	F	F	R	R	F	F	.	.	R	.	.	.	.	R	R	C	C	F	.	.	C	.	.	.	F	.	R	R	F
C	.	C	.	F	.	.	R	F	R	F	F	R	.	.	R	.	.	.	.	F	.	F	C	F	.	.	C	.	.	.	F	.	R	R	F
F	R	F	.	F	R	R	F	F	R	F	F	F	.	.	R	.	.	.	.	R	F	F	C	F	.	.	C	.	.	.	F	.	R	R	F
F	R	F	R	F	R	R	R	F	.	.	F	F	.	.	R	.	.	.	R	R	.	F	C	F	.	.	F	.	.	.	F	.	R	R	F
F	R	F	.	F	R	R	R	R	R	.	R	R	.	.	R	.	.	.	.	R	R	R	F	R	.	.	F	.	.	.	F	.	R	.	F
F	F	F	R	R	R	R	R	R	R	.	.	F	.	.	.	R	.	R	.	R	.	R	C	R	.	.	F	.	.	.	F	.	R	.	F
C	F	C	.	C	R	R	F	R	R	.	.	F	.	F	R	.	.	.	.	R	.	F	C	F	.	.	C	.	.	.	F	.	R	.	F
F	R	R	R	R	.	.	.	.	.	.	.	F	.	.	.	.	.	R	.	.	R	R	F	R	.	.	C	.	.	.	F	.	.	.	F
C	R	C	R	F	F	F	R	F	R	.	.	F	R	F	.	.	.	R	R	R	R	F	C	F	.	.	C	.	.	.	F	.	.	.	C
C	R	F	.	F	F	F	F	F	.	.	.	C	.	F	.	F	R	F	.	F	.	R	C	F	.	.	C	.	.	.	F	.	R	.	C
C	R	F	.	R	R	R	F	F	.	.	.	F	.	F	.	R	.	R	.	F	R	R	C	F	.	.	F	.	.	.	F	.	.	.	C
C	F	C	R	F	R	R	R	F	.	.	.	F	.	R	R	R	R	F	.	F	.	F	C	F	.	.	C	.	.	.	F		.	.	C
C	R	C	.	C	F	F	F	F	.	.	.	F	F	F	R	R	R	F	.	F	.	F	C	F	.	.	C	.	.	.	F	R	R	.	C
C	R	F	.	F	.	.	.	F	R	.	.	F	.	.	.	.	.	.	.	.	R	R	C	F	.	.	C	.	.	.	F	.	.	.	C
F	R	F	R	F	R	R	R	R	.	.	.	F	.	R	.	.	.	R	.	.	.	F	C	F	.	.	F	.	.	.	F	.	.	.	F
F	R	F	R	F	R	R	.	R	R	.	.	R	.	.	.	.	.	.	.	.	.	R	F	R	.	.	F	.	.	.	F	.	.	.	F
C	.	F	R	F	R	R	R	.	.	.	.	R	.	.	.	.	.	.	.	R	.	R	C	R	.	.	F	.	.	.	F	.	.	.	C
C	R	C	.	C	R	R	.	.	.		.	R	.R	R	.	.	.	R	.	.	R	R	C	R	.	.	F	.	.	.	F	R	.	.	F
C	R	C	.	C	R	R	R	F	.		.	F	.	.	.	R	.	.	.	.	R	F	C	F	.	.	F	.	.	.	F	.	.	.	C
C	R	C	R	C	F	F	R	F	.	.	.	F	.	R	.	.	.	.	.	R	.	F	F	F	.	.	C	F	.	.	F	.	.	.	C
F	.	F	R	F	R	R	.	R	R	.	.	F	.	.	.	.	.	.	.	.	R	R	C	R	.	.	F	F	.	.	F	.	.	.	C
C	R	C	R	C	F	F	R	R	.	.	.	F	.	R	.	.	.	.	.	R	.	F	C	F	.	.	F	F	.	.	F	R	.	.	C
C	R	F	R	F	R	R	R	R	.	.	.	F	.	R	.	.	.	.	.	.	R	R	F	R	.	.	F	F	.	.	F	.	.	.	F
C	R	C	R.	C	F	F	.	F	R	.	.	F	.	R	.	.	.	.	.	R	.	F	A	F	R	.	C	C	.	.	F	.	R	.	C

Table 7. Distribution of calcareous nannofossils, Hole 900A.

Age	Nannofossil zone: Martini (1980)	Nannofossil zone: Okada and Bukry (1980)	Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	*Blackites spinosus*	*Blackites tenuis*	*Braarudosphaera bigelowii*	*Bramletteius serraculoides*	*Calcidiscus protoannulus*	*Campylosphaera dela*	*Campylosphaera eodela*	*Chiasmolithus consuetus*	*Chiasmolithus expansus*	*Chiasmolithus gigas*	*Chiasmolithus grandis*	*Chiasmolithus nitidus*	*Chiasmolithus solitus*	*Chiasmolithus titus*	*Clausicoccus fenestratus*	*Clausicoccus* sp.	*Coccolithus eopelagicus*	*Coccolithus pelagicus*	*Coronannulus germanicus*	*Coronocyclus nitiscens*	*Cribrocentrum reticulatum*	*Cruciplacolithus cruciformis*	*Cyclicargolithus floridanus*	*Cyclicargolithus formosus*	*Dictyococcites bisectus*	*Dictyococcites retiformis*	*Discoaster barbadiensis*
			149-900A																														
middle Eocene	NP17	CP14b	57R-5, 34–35	533.94	A	M	R	R	F	F	C	.	.	.	.	.	.	F	.	F	R	R	.	A	.	.	C	F	C	C	C	R	C
			58R-1, 12–13	537.31	A	M	R	R	.	F	F	F	.	.	.	.	R	R	.	R	F	R	F	A	.	.	C	F	C	C	C	R	C
			58R-1, 106–107	538.26	A	M	.	.	.	F	C	F	.	.	.	.	R	R	.	R	F	R	F	C	.	.	C	F	C	C	C	R	F
			58R-2, 33–34	539.03	C	M	.	R	.	R	F	F	.	.	.	.	R	.	.	.	F	R	F	C	.	.	C	.	C	C	F	R	C
			58R-3, 48–49	540.68	A	M	R	R	R	R	F	R	.	.	.	.	.	R	.	R	R	R	F	C	.	.	C	.	C	C	F	R	F
			58R-3, 90–91	541.10	A	M	.	.	.	R	F	R	.	.	.	.	R	R	.	R	F	R	F	C	R	.	F	.	C	F	F	R	C
			59R-1, 119–120	548.09	A	P	.	R	.	R	F	R	.	.	.	.	R	R	.	R	R	R	F	C	.	.	F	.	C	C	F	.	F
	NP16	CP14a	59R-2, 26–27	548.66	A	M	.	R	R	R	F	F	.	.	.	.	F	F	R	F	F	R	F	C	.	R	C	.	C	C	F	R	C
			59R-3, 122–123	551.12	A	M	.	.	R	R	F	F	.	.	.	.	R	F	R	F	F	R	F	C	.	R	F	R	C	C	F	.	F
			59R-4, 25–26	551.65	A	M	.	R	R	R	R	F	.	.	.	.	.	F	R	F	F	R	F	C	.	.	F	.	C	C	C	R	F
			59R-5, 59–60	553.49	A	M	R	.	R	R	F	F	.	.	.	.	.	F	R	F	F	R	F	C	.	.	F	R	C	C	C	R	F
			59R-6, 133–134	555.73	A	M	R	R	.	F	R	F	.	.	.	.	R	R	R	R	R	R	F	C	.	R	F	.	C	C	C	.	F
			60R-1, 91–92	557.51	A	M	R	R	R	R	F	F	.	.	.	.	R	R	R	R	R	R	F	A	.	.	C	.	A	C	F	R	F
			60R-2, 41–42	558.51	A	M	R	R	.	R	F	F	.	.	.	.	R	F	R	F	R	R	F	A	.	.	F	.	C	C	F	R	F
			60R-3, 118–119	560.78	A	P	R	R	R	R	F	F	.	.	.	.	R	F	R	F	R	R	F	C	.	.	F	.	C	F	F	R	C
			60R-4, 113–114	562.23	A	P	R	R	.	.	F	F	.	.	R	.	R	F	R	F	F	F	F	C	R	.	F	.	F	F	.	.	F
			60R-5, 64–65	563.24	A	P	R	.	R	R	F	F	.	.	R	.	R	R	R	R	F	R	F	C	R	.	F	.	F	C	.	R	F
			60R-6, 64–65	564.74	C	P	R	R	R	.	F	F	.	.	.	.	R	R	R	R	F	F	F	C	.	.	F	.	F	C	.	R	F
			61R-1, 58–59	566.78	A	P	R	.	R	R	F	F	.	R	.	.	R	R	R	R	F	F	F	C	R	.	F	R	C	C	.	R	F
			61R-2, 106–107	568.76	A	M	R	R	.	.	F	C	.	.	.	.	R	R	R	R	C	F	F	C	F	R	F	.	C	C	.	R	F
			61R-3, 76–77	569.96	A	P	R	R	R	.	F	F	.	.	.	.	R	R	F	R	F	F	F	C	R	.	F	.	C	F	.	R	F
			61R-4, 62–63	571.32	A	P	R	R	F	.	F	F	.	.	R	.	R	R	R	R	R	F	F	C	.	.	F	.	C	F	.	R	C
			62R-1, 90–91	576.80	A	P	R	R	R	.	F	F	.	.	R	.	R	R	R	R	R	F	F	C	.	.	F	.	C	F	.	R	C
			62R-2, 2–3	577.42	A	P	R	.	F	.	F	F	.	R	.	.	R	R	R	R	R	F	F	C	R	.	F	.	F	C	.	R	F
			62R-3, 31–32	579.21	A	M	R	.	.	.	F	F	.	.	R	.	R	R	R	R	R	F	F	A	.	.	F	.	F	C	.	.	C
			63R-1, 124–125	586.84	A	P	.	.	R	.	F	F	.	.	.	.	.	R	R	R	F	F	R	C	R	.	F	.	F	C	.	.	F
			63R-2, 66–67	587.76	A	M	R	R	F	.	F	F	.	.	.	.	.	R	R	R	F	R	.	C	.	.	F	.	F	F	.	.	F
			63R-CC	595.10	C	M	R	R	R	.	F	R	.	.	.	.	R	R	R	R	R	R	.	C	.	.	.	.	F	F	.	.	F
	NP15	CP13	64R-1, 142–143	596.52	C	M	R	.	R	.	R	R	.	.	R	.	R	R	R	R	.	R	R	C	.	.	.	R	F	F	.	.	F
			64R-2, 100–101	597.60	C	M	R	.	.	.	R	F	.	.	.	.	.	.	R	.	.	R	R	C	.	.	.	.	F	F	.	.	F
			65R-2, 48–49	606.58	C	P	R	.	R	R	R	F	.	.	.	.	R	R	R	R	R	R	R	C	.	.	.	.	F	F	.	.	F
			65R-3, 33–34	607.93	C	P	.	.	.	.	R	R	.	.	.	.	.	.	R	.	.	.	.	C	.	.	.	.	R	F	.	.	F
			66R-1, 94–95	615.04	A	P	.	.	.	.	R	F	.	.	R	.	.	R	R	R	.	R	R	A	.	.	.	.	F	F	.	.	F
			66R-2, 40–41	616.00	A	M	.	.	R	R	R	F	.	.	.	.	.	R	R	R	R	R	F	A	.	.	.	.	F	F	.	.	F
			66R-CC	623.80	A	M	.	.	.	.	R	F	.	.	R	.	F	.	F	R	R	R	F	C	.	.	.	.	F	F	.	.	F
			67R-1, 36–37	624.16	C	P	.	.	.	.	R	F	.	.	.	R	F	.	F	R	R	R	F	C	.	.	.	.	F	F	.	.	C
			67R-1, 107–108	624.87	A	P	R	.	.	.	F	F	R	.	.	R	.	R	F	R	F	R	F	C	.	.	.	.	F	F	.	R	F
			67R-2, 43–44	625.73	C	P	.	.	.	.	F	F	.	.	R	R	R	R	F	R	R	R	F	C	.	.	.	.	F	F	.	.	F
			67R-2, 111–112	626.41	C	P	.	.	.	.	R	R	.	.	.	R	.	.	R	.	R	.	.	F	.	.	.	.	R	R	.	.	.
			67R-3, 8–9	626.88	C	M	R	.	.	.	R	F	.	.	.	R	R	R	F	.	R	R	R	F	.	.	.	.	R	F	.	.	F
			67R-CC	633.40	C	P	.	.	.	.	R	R	.	.	R	R	.	.	R	.	R	R	R	F	.	.	.	.	R	F	.	.	F
			68R-1, 83–84	634.23	A	M	R	.	R	R	F	F	R	.	F	R	R	R	F	R	F	R	R	C	.	.	.	.	F	F	.	.	C
			68R-2, 129–130	636.19	A	M	.	.	F	.	R	R	.	.	F	F	R	.	R	.	R	R	R	C	.	.	.	.	R	F	.	.	F
			68R-3, 41–42	636.81	A	M	R	.	R	.	R	F	.	.	R	R	F	R	R	R	F	R	F	C	.	.	.	.	R	F	.	.	C
			69R-1, 44–45	643.54	A	M	F	.	F	.	R	F	.	R	R	F	F	F	F	.	F	F	F	A	.	.	.	.	.	F	.	.	C
			69R-1, 129–130	644.39	A	M	R	.	R	R	R	F	.	R	R	F	F	F	F	R	F	F	F	C	.	.	.	.	.	F	.	.	C
			69R-2, 107–108	645.67	A	P	.	.	.	.	R	F	.	.	R	R	R	F	F	R	R	R	R	C	.	.	.	.	.	F	.	.	F
			70R-1, 11–12	652.81	A	M	R	.	C	.	R	F	.	.	.	.	R	F	F	R	R	R	R	C	.	.	.	.	.	F	.	.	C
	NP14	CP12	70R-2, 48–49	654.68	A	P	.	.	C	.	R	F	.	.	R	.	F	F	F	R	R	R	F	A	.	.	.	.	.	F	.	.	C
			71R-1, 93–94	663.33	A	P	.	.	F	.	R	F	.	.	.	.	F	F	F	.	R	R	F	A	.	.	.	R	.	F	.	.	C
			71R-2, 17–18	664.07	A	P	.	.	F	.	R	F	.	.	.	.	R	F	F	R	R	R	F	C	.	.	.	.	.	F	.	.	C
			71R-3, 11–12	665.51	A	M	.	.	.	.	R	F	.	.	.	.	R	F	R	.	R	R	R	C	.	.	.	.	.	F	.	.	C
			72R-1, 39–40	672.49	A	P	.	.	.	.	R	F	.	.	.	.	F	F	F	.	R	R	R	C	.	.	.	.	.	F	.	.	C
			72R-1, 78–79	672.88	A	M	.	.	.	.	.	F	.	.	.	.	R	F	F	.	R	R	R	C	.	.	.	.	.	F	.	.	F
			72R-3, 3–4	673.63	A	M	.	.	.	.	.	F	.	.	.	.	R	F	R	R	R	R	R	C	.	.	.	.	.	F	.	.	C
			72R-2, 114–115	674.74	A	P	.	.	.	.	.	F	.	.	.	.	R	F	F	.	R	R	F	C	.	.	.	.	.	F	.	.	C
			73R-1, 21–22	681.91	A	M	.	.	.	.	.	F	.	.	.	.	F	F	F	.	R	R	F	A	.	.	.	.	.	F	.	.	C
			73R-2, 106–107	684.26	A	M	.	.	.	.	R	F	.	.	.	.	F	F	F	R	R	R	F	C	.	.	.	.	.	F	.	.	C
			74R-1, 38–39	691.78	C	P	.	.	.	.	.	F	.	.	.	.	F	F	F	.	R	R	F	C	.	.	.	.	.	F	.	.	C
			74R-2, 46–47	693.36	A	M	.	.	.	.	R	F	.	.	.	.	F	F	F	R	R	R	F	C	.	.	.	.	.	F	.	.	C
early Eocene	NP12/13	CP11–CP10	75R-1, 56–57	701.66	A	M	.	.	.	.	.	F	.	.	.	.	F	F	F	.	R	R	F	C	.	.	.	R	.	F	.	.	C
			75R-1, 77–78	701.87	A	P	.	.	.	.	R	F	.	.	.	.	F	R	R	R	F	R	R	C	.	.	.	.	.	F	.	.	C
			75R-2, 29–30	702.59	C	P	.	.	.	.	R	F	.	.	.	.	F	R	R	R	R	R	.	C	.	.	.	.	.	F	.	.	C
			76R-1, 34–35	710.74	C	P	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	C	.	.	.	.	.	F	.	.	F
			76R-2, 105–106	712.95	C	P	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	F	.	.	.	.	.	F	.	.	R
	NP11–NP10	CP9	77R-2, 120–121	722.70	C	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	F	.	.	.
			77R-3, 3–4	723.03	C	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.

Note: V = very abundant; A = abundant; C = common; F = few; R = rare; G = good; M = moderate; P = poor.

Table 7 (continued).

Discoaster bifax	*Discoaster binodosus*	*Discoaster lodoensis*	*Discoaster multiradiatus*	*Discoaster saipanensis*	*Discoaster sublodoensis*	*Discoaster tani nodifer*	*Discoaster tani tani*	*Ericsonia robusta*	*Girgisia gammation*	*Helicosphaera bramlettei*	*Helicosphaera compacta*	*Helicosphaera reticulata*	*Helicosphaera salebrosa*	*Helicosphaera seminulum*	*Lanternithus minutus*	*Markalius inversus*	*Micrantholithus* spp.	*Nannotetrina alata*	*Nannotetrina cristata*	*Nannotetrina fulgens*	*Neococcolithes dubius*	*Pedinocyclus larvalis*	*Pemma altus*	*Pemma angulatum*	*Pemma papillatum*	*Pentaster* sp.	*Pontosphaera multipora*	*Pseudotriquetrorhabdulus inversus*	*Pyrocyclus hermosus*	*Reticulofenestra dictyoda*	*Reticulofenestra hillae*	*Reticulofenestra* spp. (small)	*Reticulofenestra umbilicus*	*Rhabdosphaera gladius*	*Rhabdosphaera inflata*	*Rhabdosphaera rudis*	*Sphenolithus editus*	*Sphenolithus furcatolithoides*	*Sphenolithus moriformis*	*Sphenolithus obtusus*	*Sphenolithus radians*	*Thoracosphaera* spp.	*Transversopontis duovavus*	*Transversopontis pulcheroides*	*Tribrachiatus bramlettei*	*Tribrachiatus contortus*	*Tribrachiatus orthostylus*	*Zygrhablithus bijugatus*
.	.	.	.	F	.	F	F	R	.	R	F	F	.	.	C	.	.	.	.	.	.	.	.	R	F	R	.	.	.	C	R	A	R	.	.	.	.	.	C	F	F	F	.	.	.	.	.	C
.	R	.	.	F	.	R	R	.	.	R	F	F	.	.	F	.	.	.	.	.	.	.	.	.	E	.	R	.	.	C	F	A	F	.	.	.	.	.	C	C	F	F	.	R	.	.	.	A
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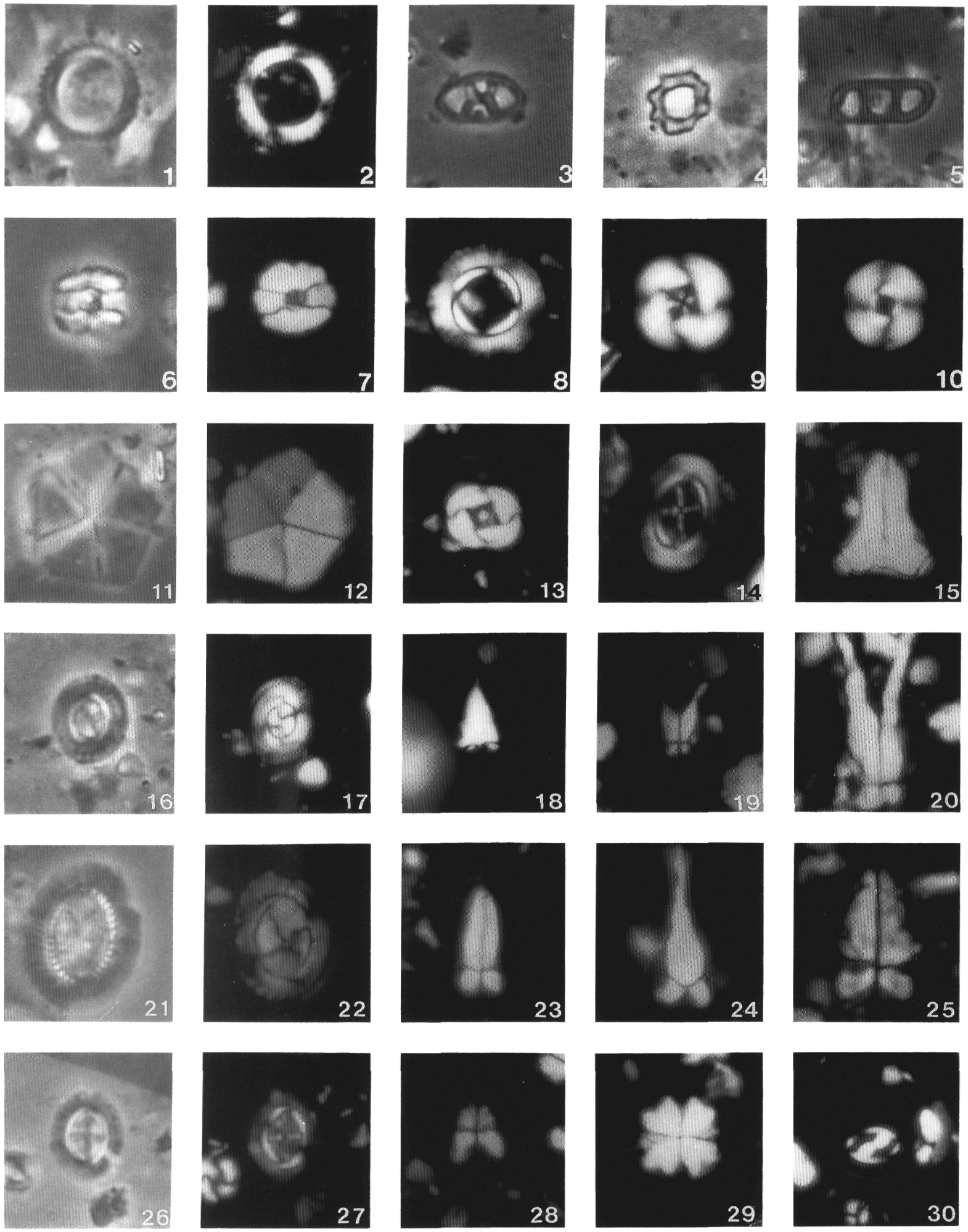

Plate 1. **1, 2.** *Coronocyclus nitiscens,* Sample 149-900A-54R-3, 35-36 cm (1, ph; 2, pol). **3.** *Neococcolithus dubius,* Sample 149-900A-56R-4, 129-130 cm, ph. **4.** *Corannulm germaricus,* Sample 149-900A-56R-5, 152-153 cm, ph. **5.** *Isthmolithus recurvus,* Sample 149-900A-53R-3, 95-96 cm, ph. **6, 7.** *Lanternithus minutus,* Sample 149-900A-53R-1, 141-142 cm (6, ph; 7, pol). **8.** *Calcidiscus protoannulus,* Sample 149-900A-53R-1, 141-142 cm, pol. **9.** *Cribrocentrum reticulatum,* Sample 149-900A-56R-5, 26-27 cm, pol. **10.** *Cyclicargolithus floridanus,* Sample 149-900A-53R-1, 141-142 cm, ph. **11, 12.** *Braarudosphaera bigelowii,* Sample 149-900A-53R-1, 141-142 cm (11, ph; 12, pol). **13.** *Pyrocyclus hermosus,* Sample 149-900A-53R-2, 45-46 cm, pol. **14.** *Campylosphaera dela,* Sample 149-900A-61R-2, 106-107 cm, pol. **15.** *Zygrhablithus bijugatus,* Sample 149-900A-53R-1, 141-142 cm, pol. **16, 17.** *Clausicoccus fenestratus,* Sample 149-900A-53R-1, 141-142 cm (16, ph; 17, pol). **18.** *Sphenolithus predistentus,* Sample 149-900A-53R-1, 141-142 cm, pol. **19, 20.** *Sphenolithus furcatolithoides* Sample 149-900A-62R-2, 2-3 cm, pol. **21, 22.** *Clausicoccus* sp., Sample 149-900A-62R-2, 2-3 cm (21, ph; 22, pol). **23,24.** *Sphenolithus obtusus,* Sample 149-900A-58R-1, 12-13 cm, pol. **25.** *Sphenolithus pseudoradians,* Sample 149-897C-55R-3, 75-76 cm, pol. **26, 27**. *Cruciplacolithus cruciformis,* Sample 149-900A-53R-1, 141-142 cm (26, ph; 27, pol). **28.** *Sphenolithus editus,* Sample 149-900A-59R-4, 25-26 cm. **29.** *Sphenolithus moriformis,* Sample 149-900A-53R-1, 141-142 cm, pol. **30.** *Transversopontis sigmoidalis,* Sample 149-900A-53R-3, 10-11 cm, pol. Light micrograph abbreviations: pol = polarized light, ph = phase contrast light. Magnification = ×2000.

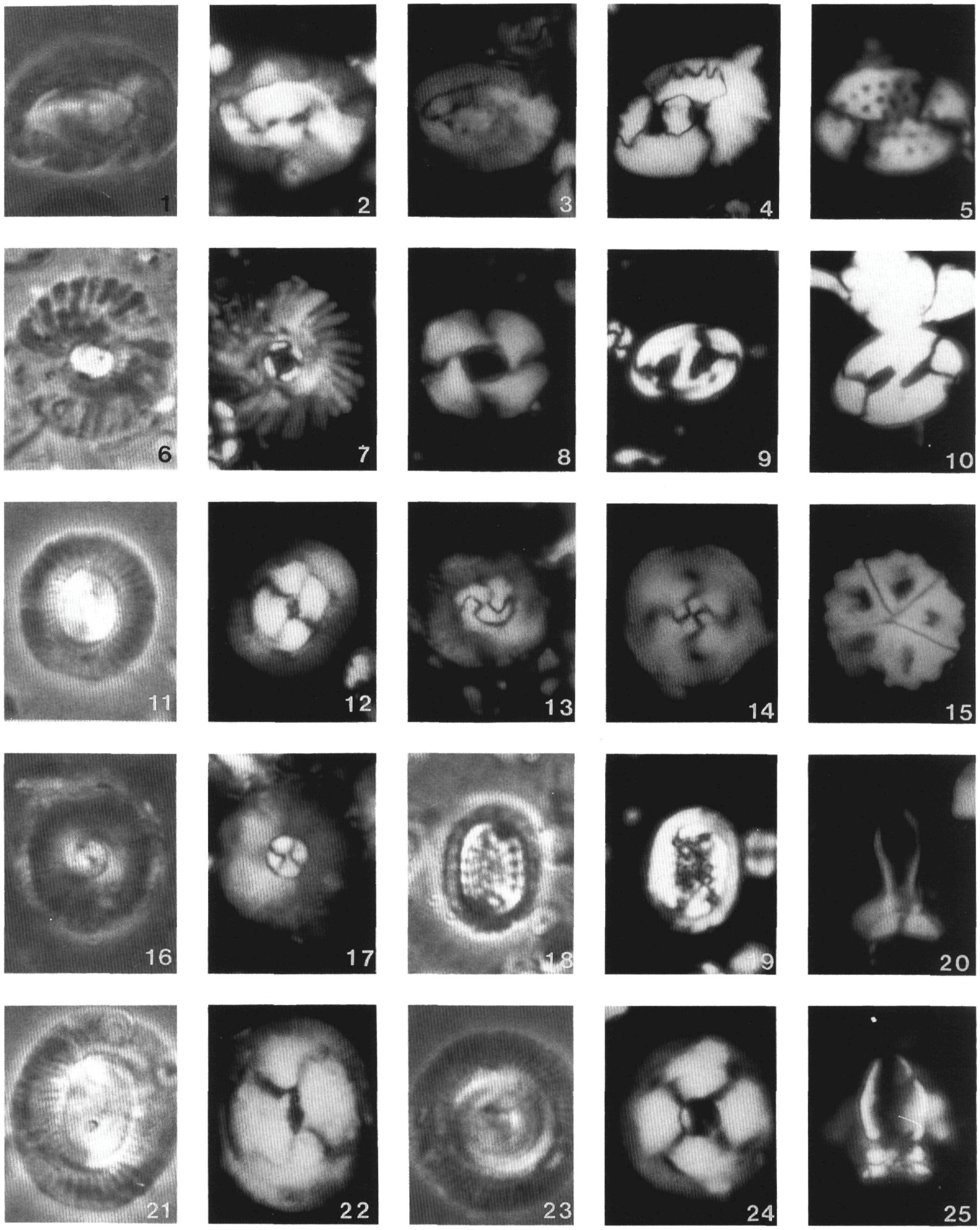

Plate 2. **1, 2.** *Helicosphaera compacta,* Sample 149-900A-58R-1, 12-13 cm (1, ph; 2, pol). **3.** *Helicosphaera reticulata,* Sample 149-900A-54R-1, 37-38 cm, pol. **4.** *Helicosphaera wilcoxonii,* Sample 149-900A-54R-3, 35-36 cm, pol. **5.** *Pontosphaera multipora,* Sample 149-900A-53R-1, 141-142 cm, pol. **6, 7.** *Pedinocyclus larvalis,* Sample 149-900A-53R-1, 141-142 cm (6, ph; 7, pol). **8.** *Reticulofenestra dictyoda,* Sample 149-900A-58R-1, 12-13 cm, pol. **9.** *Transversopontis pulcheroides,* Sample 149-900A-53R-1, 141-142 cm, pol. **10.** *Transversopontis obliquipons,* Sample 149-900A-57R-3, 8-9 cm, pol. **11, 12.** *Coccolithus pelagicus,* Sample 149-900A-53R-1, 141-142 cm (11, ph; 12, pol). **13, 14.** *Girgisia gammation,* Sample 149-900A-75R-1, 77-78 cm, pol. **15.** *Pemma basquensis,* Sample 149-897C-54R-1, 19-20 cm, pol. **16, 17.** *Markalius inversus,* Sample 149-900A-63R-1, 124-125 (16, ph; 17, pol). **18, 19.** *Cribrocentrum* sp., Sample 149-900A-60R-5, 64-65 cm, pol. **20.** *Rhabdosphaera gladius,* Sample 149-900A-65R-2, 48-49 cm, pol. **21, 22.** *Coccolithus eopelagicus,* Sample 149-900A-53R-1, 141-142 cm (21, ph; 22, pol). **23, 24.** *Coccolithus formosus,* Sample 149-900A-53R-l, 141-142 cm (23, ph; 24, pol). **25.** *Rhabdosphaera rudis,* Sample 149-900A-59R-5, 59-60 cm, pol. Light micrograph abbreviations: pol = polarized light, ph = phase contrast light. Magnification = ×2000.

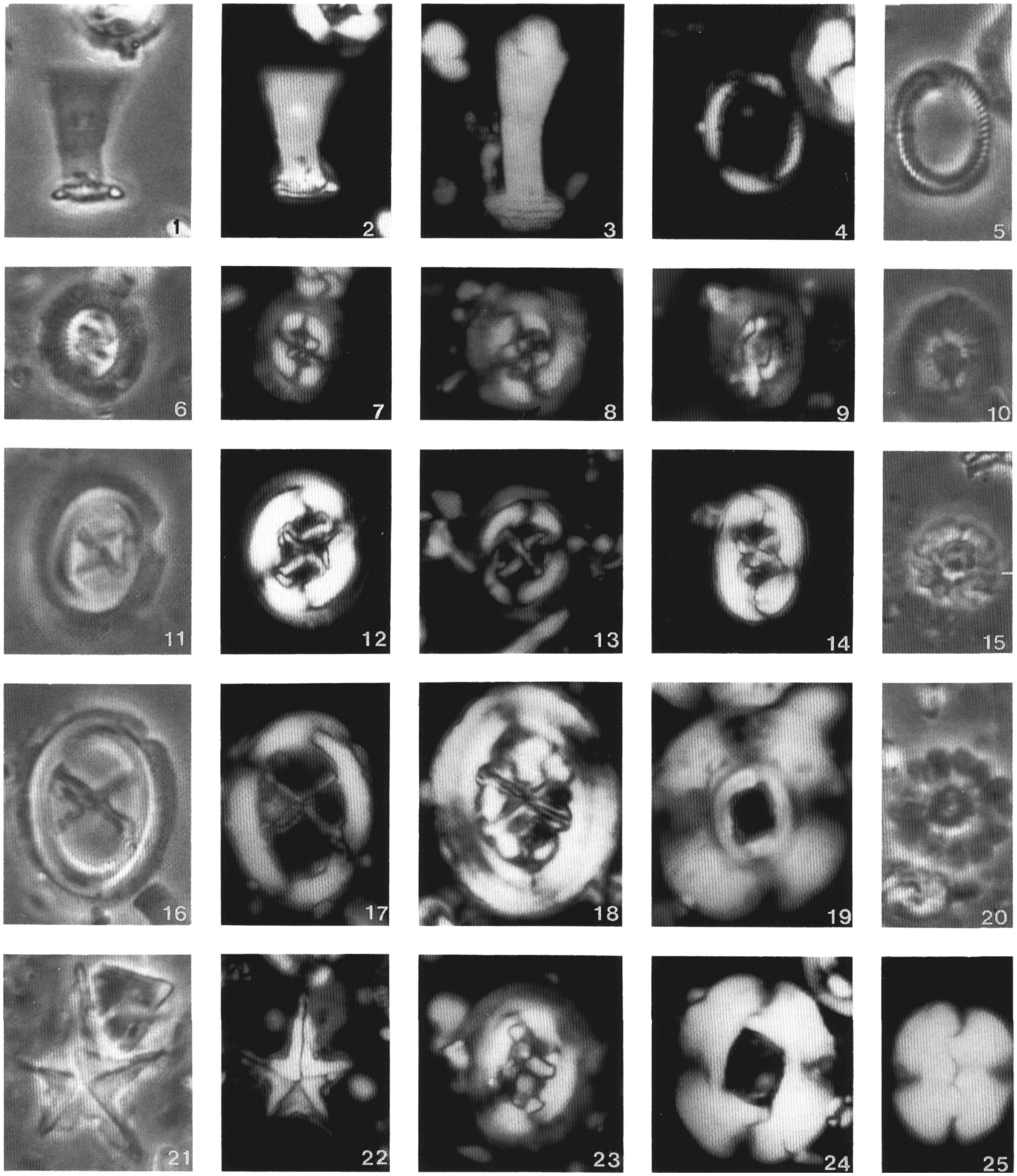

Plate 3. **1-3.** *Bramletteius serraculoides,* Sample 149-900A-58R-1, 12-13 cm (1, ph; 2-3, pol). **4, 5.** *Lophodolithus* sp., Sample 149-900A-63R-2, 66-67 cm, pol. **6-8.** *Chiasmolithus titus,* Sample 149-900A-59R-4, 25-26 cm (6, ph; 7-8, pol). **9, 10.** *Dictyococcites retiformis,* Sample 149-900A-53R-2, 45-46 cm (9, pol; 10, ph). **11, 12.** *Chiasmolithus solitus,* Sample 149-900A-70R-1, 11-12 cm (11, ph; 12, pol). **13.** *Chiasmolithus consuetus,* Sample 149-900A-69R-1, 44-45 cm, pol. **14.** *Neochiastozygus distentus,* Sample 149-900A-77R-2, 120-121 cm, pol. **15, 20.** *Discoaster bifax,* Sample 149-900A-66R-2, 40-41 cm, ph. **16-18.** *Chiasmolithus oamaruensis,* Sample 149-900A-54R-3, 35-36 cm (16, ph; 17-18, pol). **19.** *Reticulofenestra hillae,* Sample 149-900A-53R-1, 113-114 cm, pol. **21, 22.** *Pentaster* sp., Sample 149-900A-59R-6, 133-134 cm (21, ph; 22, pol). **23.** *Cruciplacolithus tenuis,* Sample 149-900A-77R-2, 120-121 cm, pol. **24.** *Reticulofenestra umbilicus,* Sample 149-900A-62R-3, 31-32 cm, pol. **25.** *Dictyococcites bisectus,* Sample 149-900A-53R-1, 141-142 cm, pol. Light micrograph abbreviations: pol = polarized light, ph = phase contrast light. Magnification = ×2000.

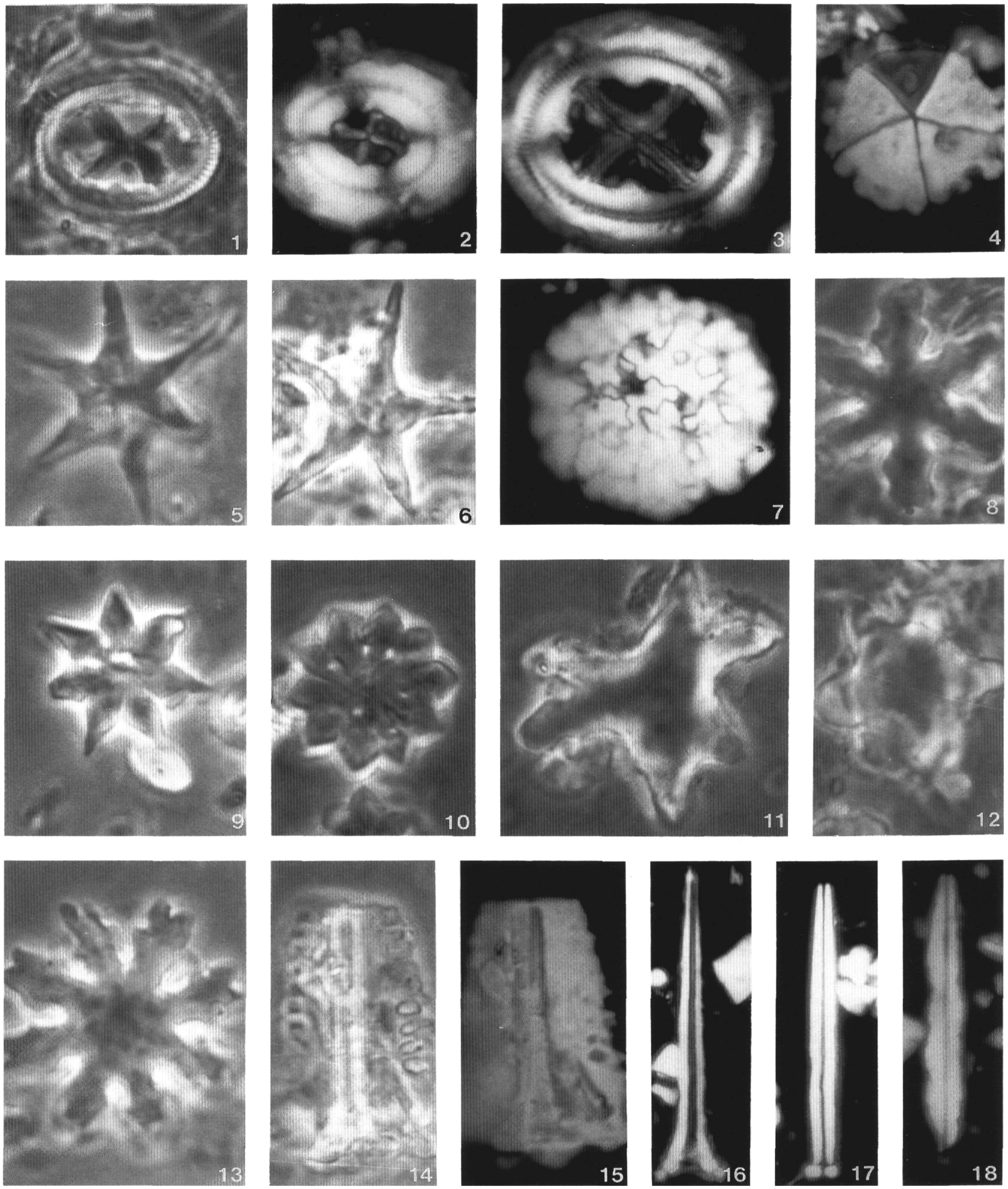

Plate 4. **1.** *Chiasmolithus expensus,* Sample 149-900A-68R-1, 83-84 cm, ph. **2.** *Cruciplacolithus staurion,* Sample 149-900A-73R-2, 106-107 cm, pol. **3.** *Chiasmolithus grandis,* Sample 149-900A-69R-1, 44-45 cm, pol. **4.** *Pemma papillatum,* Sample 149-900A-62R-1, 90-91 cm, pol. **5.** *Discoaster sublodoensis,* (sample 149-900A-73R-1, 21-22 cm, ph. **6.** *Discoaster lodoensis,* Sample 149-900A-75R-2, 29-30 cm, ph. **7.** *Thoracosphaera* spp., Sample 149-900A-53R-1, 1141-142 cm, pol. **8.** *Discoaster tani nodifer,* Sample 149-900A-61R-3, 76-77 cm, ph. **9.** *Discoaster saipanensis,* Sample 149-900A-54R-4, 78-79 cm, ph. **10.** (*Discoaster barbadiensis,* Sample 149-900A-54R-3, 35-36 cm, ph. **11.** *Tribrachiatus contortus,* Sample 149-900A-77R-2, 120-121 cm, ph. **12.** *Tribrachiatus bramlettei,* Sample 149-900A-77R-3, 3-4 cm, ph. **13.** *Discoaster binodosus,* Sample 149-900A-60R-1, 91-92 cm, ph. **14, 15.** *Micrantholithus altus,* Sample 149-897C-54R-4, 1-2 cm (14, ph; 15, pol). **16.** *Blackites spinosus,* Sample 149-900A-53R-1, 141-142 cm, pol. **17.** *Blackites tenuis,* Sample 149-900A-54R-4, 178-79 cm, pol. **18.** *Pseudotriquetrorhabdulus inversus,* Sample 149-900A-71R-1, 93-94 cm, pol. Light micrograph abbreviations: pol = polarized light, ph = phase contrast light. Magnification = ×2000.

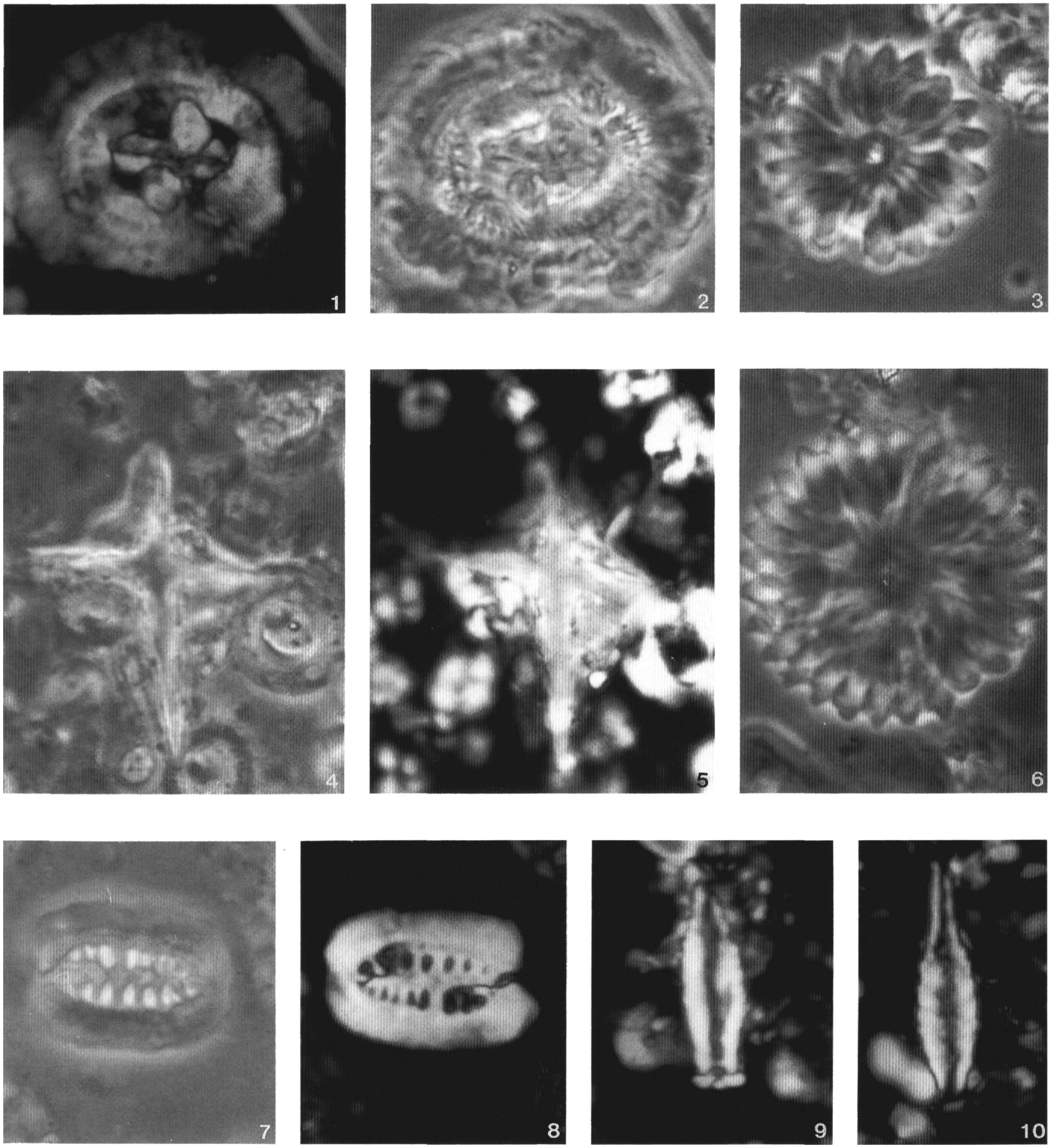

Plate 5. **1, 2.** *Chiasmolithus gigas,* Sample 149-900A-69R-1, 44-45 cm (1, pol; 2, ph). **3, 6.** *Discoaster multiradiatus,* Sample 149-900A-77R-3, 3-4 cm, ph. **4, 5.** *Nannotetrina fulgens,* Sample 149-900A-70R-1, 11-12 cm (4, ph; 5, pol). **7, 8.** *Ellipsolithus distichus,* Sample 149-900A-75R-1, 56-57 cm (7, ph; 8, pol). **9, 10.** *Rhabdosphaera inflata,* Sample 149-900A-71R-2, 17-18 cm, pol. Light micrograph abbreviations: pol = polarized light, ph = phase contrast light. Magnification = ×2000