19. PALEOCENE-EOCENE CALCAREOUS NANNOFOSSILS OF ONSHORE WELLS FROM THE COASTAL PLAIN OF NEW JERSEY AND MARYLAND, U.S.A.[1]

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ABSTRACT

Paleogene calcareous nannofossils from split spoon cores recovered from five wells along the Coastal Plain of New Jersey and Maryland have been analyzed in order to provide onshore information complementary to that derived from the offshore DSDP Site 605 (upper continental rise off New Jersey). Hiatuses are more numerous and of greater extent in the onshore sections, but the major ones correlate well with those noted in the offshore section. At one site at least (Leggett Well), sedimentation may well have been continuous across the Cretaceous/Tertiary boundary, as it is believed to have been at DSDP Site 605. These various correlations are discussed elsewhere in a companion paper (Olsson and Wise, this volume).

Important differences in nannofossil assemblages are noted between the onshore (shelf paleoenvironment) and offshore (slope-rise paleoenvironment) sections. *Lithostromation simplex*, not present offshore, is consistently present onshore and seems to be confined to the Eocene shelf sediments of this region. The same relationship holds for the zonal marker, *Rhabdosphaera gladius* Locker. The *Rhomboaster-Tribrachiatus* plexus is more diverse and better preserved in the onshore sections, where the lowermost Eocene Zone CP9 is well represented. Differential preservation is postulated to account for two morphotypes of *Tribrachiatus bramlettei* (Brönnimann and Stradner). Type A is represented at DSDP Site 605 by individuals with short, stubby arms, but these forms are not present in the equivalent onshore sections. There they are replaced by the Type B morphotypes, which exhibit a similar basic construction but possess much longer, more delicate arms.

INTRODUCTION

The recent advent of commercial petroleum exploration along the outer continental shelf of the eastern United States has stimulated intensive studies of the Mesozoic-Cenozoic history of this region, particularly in the area of the Baltimore Canyon Trough. In order to provide much needed drill data beyond the area of commercial exploration, DSDP Leg 93 (and subsequently DSDP Leg 95) emplaced a series of holes along the upper continental rise and slope southeast of Atlantic City, New Jersey, as part of the "New Jersey Transact." It was hoped that these DSDP holes would link outcrops and existing wells on land and along the continental shelf with those previously drilled in the deep sea to provide the first comprehensive downdip transect from the coastal plain to the abyssal plain. By correlating lithofacies and biofacies sequentially along the transect and by noting the presence of unconformities, their nature, age, correlation with seismic discontinuities, and relationships to sea-level fluctuations, it should be possible eventually to document in detail the upbuilding, outbuilding, and subsidence history of this passive margin.

If the goals outlined above are to be achieved, it will be necessary to provide data from the coastal plain equivalent in nature to that being made available from offshore. Correlations will naturally be more precise if the same microfossil groups are reported for both areas. In practice, however, some disparity exists in the available data sets, in that some microfossil groups traditionally relied on in the pelagic realm are not necessarily those which have been applied most intensively in onshore studies. For the New Jersey region, the calcareous nannofossils are a case in point. Although nannofloras of selected Campanian-Maestrichtian samples have been examined in studies by Worsley (1974), Sissingh (1977), Wind (1979), and Hattner et al. (1980), the most detailed microfossil work in New Jersey has been carried out by foraminiferal specialists, particularly by Olsson and his colleagues (Olsson, 1964, 1970; Petters, 1977a, b; Olsson and Nyong, 1984; and Nyong and Olsson, 1984). Additional correlations have been made between the dinoflagellate and planktonic foraminiferal biostratigraphies of the New Jersey Cretaceous sequences (Koch and Olsson, 1977; Aurisano, 1984). Detailed comparisons of Tertiary nannofossil data between the New Jersey onshore and offshore sections, however, are not possible until the coccoliths of the coastal plain sections are better studied.

In order to augment the available nannofossil data from New Jersey and its environs, we provide here range charts for Paleogene well samples (split spoon cores) which have previously been studied or are currently being studied by Olsson and his colleagues (see Fig. 1 for locations). The wells had been cored at designated intervals using the split spoon device, and all were rotary drilled except for the Point Pleasant well, which was bored by cable tools. The range charts provide data which are used elsewhere in these *Initial Reports*, particularly in the regional synthesis by Olsson and Wise (this volume) of Campanian-Eocene strata in the Baltimore Canyon area. Limited comments and comparisons between these on-

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Figure 1. Locations of wells used in this study.

shore nannofossil assemblages and those described from the offshore DSDP Leg 93 Site 605 (Lang and Wise, this volume; Applegate and Wise, this volume) are included herein.

METHODS, ZONATION, AND SPECIES CONSIDERED

The generally rich nannoflora found in samples examined from the coastal plain of the New Jersey greatly facilitated the preparation of samples for observation in the light microscope. Smear slides were prepared directly from raw sediment in order to examine the true abundances of coccoliths and other nannoliths.

The species abundances are described using a format similar to that outlined by Hay (1970), except that the standard smear slides were examined at ×625, rather than at ×1000 as suggested by Hay. The format used is as follows:

R = rare; 1 specimen in 101–1000 fields of view.
F = few; 1 specimen in 11–100 fields of view.
C = common; 1 specimen in 2–10 fields of view.
A = abundant; 1–10 specimens per field of view.

Downhole contaminants, which are common in some samples, are denoted by lowercase letters.

A qualitative description of the preservation of nannofossils is provided using a scheme modified from Lang and Watkins (1984). Our scheme is the following:

VG = very good; no evidence of secondary alteration via etching and/or overgrowth.
G = good; little evidence of secondary alteration via etching and/or overgrowth, identification of species not impaired.
M = moderate; significant evidence of secondary alteration via etching and/or overgrowth, identification of species not impaired.
P = poor; specimens typically heavily overgrown or severely etched, identification of some species significantly impaired.

The Cenozoic zonation of Okada and Bukry (1980) is applied in this study (Fig. 2). Taxa considered in this report are listed in the Appendix, where they are arranged alphabetically by specific epithets. Citations for these species are provided in the "Annotated index and bibliography of the calcareous nannoplankton, I–VII" (Loeblich and Tappan, 1966; 1968; 1969; 1970a, b; 1971; 1973) and from the "Bibliography and taxa of calcareous nannoplankton" (van Heck, 1979a, b; 1980a, b; 1981a, b; 1982a, b; 1983).

Mesozoic samples below the Cretaceous/Tertiary contact in each well were not examined in detail. The Mesozoic samples, therefore, are not zoned.

NANNOFOSSIL STRATIGRAPHY OF COASTAL PLAIN WELLS

Leggett Well, New Jersey (Table 1)

Figure 1 shows the location of the Leggett Well in southern New Jersey. Also known as the E.I. Dupont test well No. 2, this well was spudded at Willow Grove in Cumberland County. Split spoon samples were taken at 10-ft. intervals. This method of sampling does not provide continuous core coverage. Worsley (1974, appendix I) listed 5 Cretaceous samples from this well; he provided no information on their nannofossil content in that paper, but had earlier provided a tentative zonation for the interval from 630–750 ft. (personal communication to R. K. Olsson, 24 March 1970). The dinoflagellate and planktonic foraminiferal biostratigraphies of the Danian–Maestrichtian portion of this well were reported by Koch and Olsson (1977).

Worsley (1970, personal communication to R. K. Olsson) placed Sample 700 in the uppermost Cretaceous *Nephrolithus frequens* Zone and suggested that Sample 690 was "probably the *Cruciplacolithus tenuis* Zone." He then placed samples from 630–680 ft. in the *Discoaster multiradiatus* Zone.

Our results are quite similar to those of Worsley, including confirmation of the *N. frequens* Zone in Sample 700 (Table 1). It is quite probable that sedimentation at this site was continuous or nearly so across the Cretaceous/Tertiary boundary, as indicated by Worsley's initial results. This seems apparent despite the 10-ft. sample spacing for this well.

We did note, however, what appears to be the mixture of two assemblages in our cut of Sample 690. These consist of few *Zygodiscus sigmoides* and rare *C. tenuis* on the one hand, and abundant *Heliolithus kleinpellii* (plus common *H. riedelii*) on the other. One interpretation is that the split spoon sample taken at the bottom of interval 680–690 ft. could have sampled more than one stratum, perhaps in the configuration shown in Figure 3. Nevertheless, it is evident that the interval from CP5 to CP7 is represented by only a short interval in this well.

The Paleocene/Eocene boundary lies just below Sample 600, which contains a surprisingly diverse assemblage of *Tribrachiatus* and *Rhomboaster. Tribrachiatus contortus* and *T. bramlettei* were recorded offshore at DSDP Site 605 (Applegate and Wise, this volume), but not *Rhomboaster cuspis* and *R. bitrifida*. We did not observe in our onshore sections the stubby *T. bramlettei* seen at Site 605. Instead, a form with a similar construc-

Age	Zone		Subzone		Datum
					LAD *Chiasmolithus grandis*
middle Eocene	CP14	*Reticulofenestra umbilica*	CP14b	*Discoaster saipanensis*	FAD *Chiasmolithus solitus* LAD *Discoaster bifax*
			CP14a	*Discoaster bifax*	FAD *Discoaster bifax* FAD *Reticulofenestra umbilica*
	CP13	*Nannotetrina quadrata*	CP13c	*Coccolithus staurion*	LAD *Chiasmolithus gigas*
			CP13b	*Chiasmolithus gigas*	FAD *Chiasmolithus gigas*
			CP13a	*Discoaster strictus*	LAD *Rhabdosphaera inflata* FAD *Nannotetrina quadrata*
	CP12	*Discoaster sublodoensis*	CP12b	*Rhabdosphaera inflata*	FAD *Rhabdosphaera inflata*
early Eocene			CP12a	*Discoaster kuepperi*	FAD *Discoaster sublodoensis*
	CP11	*Discoaster lodoensis*			FAD *Coccolithus crassus*
	CP10	*Tribrachiatus orthostylus*			FAD *Discoaster lodoensis*
	CP9	*Discoaster diastypus*	CP9b	*Discoaster binodosus*	LAD *Tribrachiatus contortus*
			CP9a	*Tribrachiatus contortus*	FAD *Discoaster diastypus* FAD *Tribrachiatus contortus*
late Paleocene	CP8	*Discoaster multiradiatus*	CP8b	*Campylosphaera eodela*	FAD *Campylosphaera eodela*
			CP8a	*Chiasmolithus bidens*	FAD *Discoaster multiradiatus*
	CP7	*Discoaster nobilis*			FAD *Heliolithus riedelii* FAD *Discoaster nobilis*
	CP6	*Discoaster mohleri*			FAD *Discoaster mohleri*
	CP5	*Heliolithus kleinpellii*			FAD *Heliolithus kleinpellii*
early Paleocene	CP4	*Fasciculithus tympaniformis*			FAD *Fasciculithus tympaniformis*
	CP3	*Ellipsolithus macellus*			FAD *Ellipsolithus macellus*
	CP2	*Chiasmolithus danicus*			FAD *Chiasmolithus danicus*
	CP1	*Zygodiscus sigmoides*	CP1b	*Cruciplacolithus tenuis*	FAD *Cruciplacolithus tenuis*
			CP1a	*Cruciplacolithus primus*	LAD Cretaceous taxa

Figure 2. Zonation used in this study (from Okada and Bukry, 1980).

tion but much longer arms is present (compare Fig. 5 of this chapter, later, with Pl. 2, Figs. 8–9 of Applegate and Wise, this volume). We label this long-rayed form "*T. bramlettei* (type B)" on our range charts. We believe this is the same taxon represented at the offshore Site 605, and that the difference in morphotypes is preservational (see further discussion later under "Taxonomic Notes").

Romein (1979) indicates that the various taxa of *Rhomboaster* and *Tribrachiatus* mentioned above are confined to the uppermost Paleocene–lowermost Eocene. We have not confirmed our identifications using the electron microscope, but the long overlap of 50 ft. between the ranges of *Discoaster multiradiatus* and the species of *Rhomboaster* and *Tribrachiatus* just cited suggest extensive deposition in this region during the earliest Eocene. The basal Eocene nannofossil zone, CP9, encompasses 50 ft. of section in this well.

The base of Zone CP10 is somewhat uncertain because *D. lodoensis* occurs sporadically from Sample 540 upward. These lower occurrences may represent downhole contamination. If these are not contaminants, then Subzone CP9b (the *D. binodosus* Subzone) would be missing at this locality, and a hiatus would be suspected between 540 and 550 ft. If these are contaminants, the boundary should be placed below 490 ft, where *D. lodoensis* becomes abundant and occurs consistently.

Discoaster sublodoensis is present only in Sample 480, which indicates that most of Zone CP12 is missing, probably through a hiatus. At Site 605, this zone encompasses 86.7 m of section (Applegate and Wise, this volume).

A most interesting observation is the consistent occurrence of *Lithostromation simplex* from Sample 460 to the top of the reported section. This taxon was not present offshore (Applegate and Wise, this volume) and therefore seems to have been confined to the shelf envi-

Table 1. Distribution of calcareous nannofossils, Leggett Well, New Jersey Coastal Plain.

Age	Foraminifer zones (Olsson, pers. comm.)	Nannofossil zones	Sample interval (ft.)	Preservation	Abundance	*Blackites tenuis*	*Braarudosphaera bigelowii*	*Chiasmolithus bidens*	*C. californicus*	*C. consuetus*	*C. danicus*	*C. expansus*	*C. gigas*	*C.* sp. cf. *C. gigas*	*C. grandis*	*C. solitus*	*Chiphragmalithus calathus*	*Coccolithus formosus*	*C. pelagicus*	*Cruciplacolithus tenuis*	*Discoaster barbadiensis*	*D. binodosus*	*D. deflandrei*	*D. diastypus*	*D. distinctus*	*D. falcatus*	*D. kuepperi*	*D. lenticularis*	*D. lodoensis*	*D. mediosus*	*D. multiradiatus*
Eocene	P12?	Basal CP14 or CP13	390	PE	A	C	C			C						C		A			F										
			400	PE	A	F	C			C					F	A		C													
			410	PE	A		F			C					F	C	R?	C			R										
			420	G	VA	C	F	F		C		C				A		C	F		A		R	F		C					
	P11–P10	CP13	430	PE	A			F		F		C			C	C		C	C					F							
			440	ME	VA			C				C	F	R	F	A		C	A					F							
			450	ME	VA			C				C			C	A			C		C			C							
			460	ME	VA	R		C				C			F	C		F	C		A		C								
			470	ME	A			C				F			F	C			A		C										
	P9	CP12a	480	ME	C	F		F				F			F	F		C	C		F			F			R		A		
	P8–P7	CP11–CP10	490	ME	C			C				R			F	C			C		F			C			R		A		
		CP10–CP9b	500	PE	A			F		F						C			C		F	R									
			520	PEO	A			F		F					R				C		F	C		R					R		
			530	PEO	A			R				R			R				C			A					R			F	R
			540	MEO	A			C							R	R			C			A							F		R
	P6b	CP9a	550	MEO	C			C		F				F								C	F					F		F	A
			560	ME	A														A						C			F			F
			570	PE	A														A						C			R			F
			580	ME	C														C						C			R			F
			600	ME	C														A						C			R		F	R
Paleocene	P6a–P5	CP8	610	PE	C			C		R						C			A						F			C		R	F
			620	ME	C			C								C			A						C			F		F	F
	P4		630	P	F			R																	R						F
			640	P	R														R												
			670	MEO	C											F									F			F			C
			680	ME	C				R							C				R					C						C
	P1b	CP5/CP1	690	ME	C				r		R									R											
Cretaceous			700	G	C																										
			710	ME	A																										
			720	G	A		C																								
			730	ME	A		F																								
			740	ME	A																										
			750	ME	A																										

Note: Abundance is characterized by VA, very abundant; C, common; F, few; R, rare; B, barren, EB, essentially barren. For preservation, P, poor; M, moderate; G, good, E, etched; O, overgrown. Lowercase letters indicate material considered to be reworked.

ronment of this region, beginning around the boundary between early and middle Eocene time.

Another interesting occurrence is the rare but well documented occurrence of *Rhabdosphaera gladius* in Sample 420 (Fig. 4). This taxon, not observed at Site 605 or in most other deep-sea sections, has a short range which terminates just within (Bukry, 1978) or just at the base (Perch-Nielsen, 1985) of CP14. In the Leggett Well, it co-occurs with the first *Reticulofenestra umbilica*, which marks the base of CP14. The sequence here appears much as Bukry (1978) suggested it would, in that *Chiasmolithus gigas* (mid CP13) occurs farther down in the section in Sample 440. This sequence is not so straightforward offshore at DSDP Site 605, however, where *C. gigas* and *Reticulofenestra umbilica* overlap over some 53.1 m of section (Applegate and Wise, this volume).

Whitesville Well, New Jersey (Table 2)

The Whitesville Well was cored just east of Asbury Park, New Jersey (elevation, 20 ft.). Nannofossils are absent in the lowest Paleocene sample above the Cretaceous contact, and those in the succeeding two samples are characteristically few. Sample 238–260 contains rare *Cruciplacolithus tenuis* and *Zygodiscus sigmoides* in the absence of any chiasmoliths or fasciculiths, and is therefore assigned to Zone CP1. Sample 225–238 may belong to Zone CP3.

Heliolithus kleinpellii is abundant beginning in Sample 220–225 and is consistently present through Sample 175–180, a range of 50 ft. This is in contrast to its confinement to less than a 10-ft. interval in the Leggett Well. Rare to few *H. riedelii* in three of the lower samples are probably contaminants, but this taxon is consistently present from Sample 175–180 to 154–160, where it is common to abundant in three samples. The lowest occurrences of *D. mohleri* are probably also contaminants. For purposes of zonation, we would consider most reliable the higher, more consistent occurrences of these taxa, thereby leaving open to question the exact placement of the interval from Samples 210–205 to 180–185.

Table 1 (continued).

D. sp. cf. *D. saipanensis*	*D. sublodoensis*	*Ellipsolithus distichus*	*Fasciculithus involutus*	*Heliolithus kleinpellii*	*H. riedelii*	*Lophodolithus nascens*	*Lithostromation simplex*	*Micrantholithus attenuatus*	*M. basquensis*	*M. flos*	*Neochiastozygus chiastus*	*N. junctus*	*Neococcolithes dubius*	*Pontosphaera exilis*	*P. multipora*	*P. pulchra*	*Reticulofenestra samodurovii*	*R. umbilica*	*Rhabdosphaera creber*	*R. gladius*	*R. vitreus*	*Rhomboaster bitrifida*	*R. cuspis*	*Sphenolithus anarrhopus*	*S. editus*	*S. moriformis*	*S.* sp.	*Thoracosphaera operculata*	*Tribrachiatus bramlettei* (type B)	*T. contortus*	*T. orthostylus*	*Zygodiscus sigmoides*	*Zygrhablithus bijugatus*	*Arkhangelskiella cymbiformis*	*Eiffellithus turriseiffeli*	*Lucianorhabdus cayeuxii*	*Microrhabdulus decoratus*	*Micula decussata*	*Nephrolithus frequens*	*Prediscosphaera cretacea*	*Ragodiscus splendens*	*Reinhardtites elegans*	*Tetrapodorhabdus decorus*
							R	F	F				F		F	F			C																								
									F			F	C	F	C			F	F																								
							R	F	C			F	A	F	C		F	C	F								R																
							F		F	F		C	A	C	C		A	C	C	R													C										
							C					C	A	C	C	C	C																C										
							C					C	A	C	C	C			F																								
							C						A						C																								
							R					C	A	C	C	C			R												?		F										
F												F	A	F	F	F			F																								
C	R					R						C	C	C	C				F		F											R	C										
F												C	C	C	C	F															C												
						R						C	A	C	C	C															A												
R						R																									A												
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											C	F		F	R									C	F	R					A												
											C		F									F	F	R					F	F	C		F										
			A								F											F	C			C			R	R													
			C								F	F		F								R	C			F			F	R													
		F	C								C				F							C	C			C			R	R													
		F	C			R					C	F		F.	F							C	C			C			C	R													
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Discoaster multiradiatus is only encountered in few to rare numbers beginning in Sample 149–154 ft. Coccoliths are few in the two overlying samples where *D. multiradiatus* occurs mixed with lower and middle(?) Eocene forms such as *Chiasmolithus grandis* and *Neococcolithes dubius*. This indicates downhole contamination within the well, a fact illustrated by the presence of *C. grandis* as far down as Sample 210–215 and *D. kuepperi* in Samples 149–154 and 154–160. It is, of course, not always possible to distinguish downhole contamination as opposed to reworking upward in a sequence such as this. It is possible that the topmost two samples belong to the Eocene Zone CP9. Indeed, the youngest sample (106–127 ft) is assigned to the Eocene on the basis of planktonic foraminifers (R. K. Olsson, personal communication, 1986). We place the boundary one sample lower on the basis of rare *Tribrachiatus orthostylus*, but these specimens could be contaminants.

Glendola Well, New Jersey (Table 3)

The Glendola Well was cored at a location about 1.5 mi. northwest of the town of Glendola, New Jersey (elevation, 100 ft). The Paleocene sequence is somewhat similar to that in the Whitesville Well, but preservation is not as good.

Nannofossils are rare and poorly preserved in the first two samples above the Cretaceous contact. There is no indication among the nannofossils that the lowermost Paleocene was sampled; however, there is a long (67 ft.) sequence containing *Heliolithus kleinpellii*, which gives way to *H. riedelii* after a one-sample overlap. *Discoaster mohleri* is again sparse, making the identification of its lowest occurrences uncertain. As in the Whitesville Well, it seems to occur most consistently with *H. riedelii*. Apparently, Zones CP6 and CP7 are present in the section, which was not sampled continuously.

After a barren interval between 194 and 206 ft., *D. multiradiatus* is common and consistently present along with species of *Rhomboaster* and *Tribrachiatus*. Lower Eocene planktonic foraminifers occur in these samples (R. K. Olsson, personal communication, 1986); therefore, all are assigned somewhat arbitrarily to CP9. Without the foraminiferal data, Sample 184–186 would have been assigned to CP8, and the Paleocene–Eocene bound-

Table 2. Distribution of calcareous nannofossils, Whitesville Well, New Jersey Coastal Plain.

Age	Foraminifer zones (Olsson, pers. comm.)	Nannofossil zones	Sample no.	Preservation	Abundance	*Braarudosphaera bigelowii*	*B. discula*	*Chiasmolithus bidens*	*C. californicus*	*C. consuetus*	*C. eograndis*	*C. gigas*	*C. grandis*	*C.* sp. cf. *C. solitus*	*C.* sp.	*C. tenuis*	*Coccolithus pelagicus*	*Discoaster* sp. cf. *D. binodosus*	*D.* sp. cf. *D. distinctus*	*D. falcatus*	*D. lenticularis*	*D. mohleri*
Eocene	P6b	CP9	106–127	ME	F			R					R	R				R		F	F	
Paleocene	P6a	CP9	127–149	PE	F			R						F					R		R	
	P6a	CP8	149–154	ME	A			A		R	f			A			C			R	R	
	P4	CP6–CP7	154–160	G	A			A					f	C			C					
			160–165	G	A	R		C				r	f	C								F
			165–170	ME	C	C	R	C						C								C
			170–175	ME	A	A		C		F				A								F
			175–180	M	A	C		R						C								F
		CP5?	180–185	ME	C	F		C						C		R						
			185–190	M	A	R			F	F			r	C		F						
			190–195	M	C	F			F				f	C								r
			195–200	P	C	F								F								
			200–205	ME	A	F		C	F					A								
			205–210	ME	A	C								C								r
	P3	CP5	210–215	ME	VA	F							r	C		R						
			215–220	ME	A			F						C								
			220–225	ME	A	R								C								
		CP3?	225–238	M	F	F		R	R					F		R						
	P1b	CP1	238–260	M	F										R	R						
		Barren	260–281	Barren																		
Cretaceous			281–302	G	A																	

Note: Abundance is characterized by VA, very abundant; C, common; F, few; R, rare; B, barren, EB, essentially barren. For preservation, P, poor; M, moderate; G, good, E, etched; O, overgrown. Lowercase letters indicate material considered to be reworked.

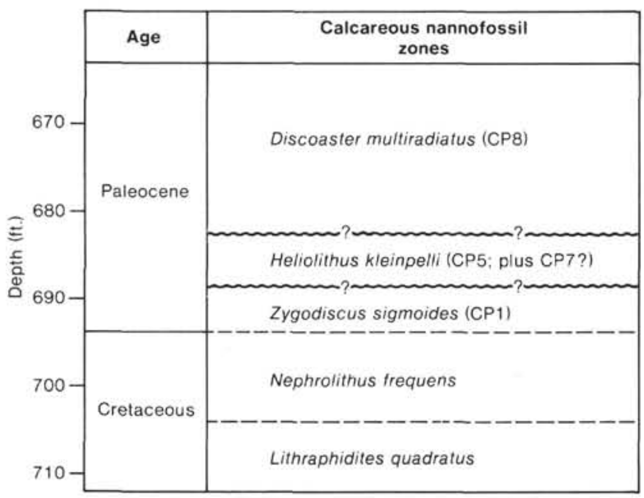

Figure 3. Interpretation of the stratigraphic sequence sampled in the Leggett Well by the split spoon cores across the interval 680–690 ft. At least two separate zones (CP1 and CP5) seem to have been sampled by the core taken at 690 ft. Sedimentation was probably continuous across the Cretaceous/Tertiary boundary, but disconformities appear to separate the CP5 zonal interval from strata above and below.

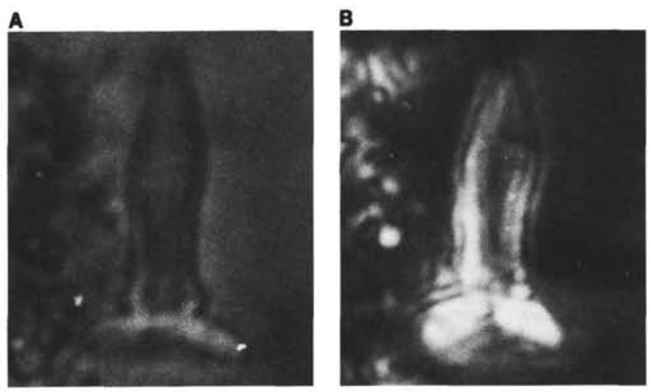

Figure 4. *Rhabdosphaera gladius* Locker, ×3400, Leggett Well, Sample 420, (A) cross-polarized light, (B) transmitted light.

ary based on nannofossils would have been drawn slightly higher, closer to the FADs in this section of *T. bramlettei* (type B) (Sample 179–180) and of *D. diastypus* (Sample 174–175), datums used by Martini (1971) and Bukry (1978), respectively, to approximate that boundary.

The FADs of *D. lodoensis* and *D. kuepperi* coincide in Sample 159–161 to mark the base of CP10. The LAD of *D. binodosus* is taken as a very rough approximation of the top of CP10 (by comparison with its occurrence at Site 605).

Table 2 (continued).

D. multiradiatus	D. kuepperi	Ellipsolithus distichus	Fasciculithus involutus	F. sp. aff. F. involutus	F. tympaniformis	Heliolithus sp. cf. H. conicus	H. kleinpellii	H. riedelii	Markalius inversus	Micrantholithus attenuatus	M. concinnus	M. entaster	M. sp. aff. M. flos	M. vesper	Neochiastozygus chiastus	N. junctus	Neococcolithes dubius	Pontosphaera exilis	Rhabdosphaera sp.	Rhomboaster bitrifida	R. cuspis	Sphenolithus moriformis	S. sp. aff. S. moriformis	Thoracosphaera operculata	Tribrachiatus bramlettei (type B)	T. orthostylus	Zygodiscus plectopons	Z. sigmoides	Z. simplex	Arkhangelskiella cymbiformis	Microrhabdulus decoratus	Micula decussata	Prediscosphaera cretacea	Ragodiscus splendens
R				F													r	R				R				R								
R				R													r					F			R	R			R					
F	r		F																			F					R							
	r		A					R							F	F		C		R	R	C					R		R					
			A		C			A		R					C	A		C			R	C												
								C		F	F			F	C	A			R			R	R											
			F			C		C		C					C	C		F				R							R					
			F			A	C	F		F					C	A											F		F					
			C		R		C							F	C													R	R					
			C				A							R	C												F	F	C					
		R					A			F					C												F	F						
			F				C			F					C	F																		
		R	F				A					F			F																			
			F				A	f				C			C												R	F	C					
		R	C				A	r		F		F	F		A														A					
			C				A			R		R			A							R						F	F					
			C				A	r		R		R			A			R				R												
									R	F		R			C													F	F					
									F						F									F				F						
																														r		a		
							R																					R		A	R	A	R	R

The absence in this well of *D. sublodoensis*, which is few to common but consistently present at Site 605, suggests a significant hiatus, which we place between Samples 124–125 and 119–120. This would account for the simultaneous disappearances upsection of *D. lodoensis* and *T. orthostylus*. We believe that most of CP11, all of CP12, and most of CP13 are missing, even taking into account the 5-ft. sampling gaps in this portion of the section.

Lithostromation simplex is again noted and is common in the topmost two samples. CP14 may be represented by Sample 114–115, which contains rare *Reticulofenestra umbilica*. It should be remembered, however, that this taxon was consistently present in the upper CP13 Zone at DSDP Site 605, where it overlapped *Chiasmolithus gigas* over a long interval. Unfortunately, neither *C. gigas* nor *Nannotetrina quadrata* are recorded in the Glendola Well, so it is difficult to delimit CP13, which we relegate to one sample.

Point Pleasant Well, New Jersey (Table 4)

The Point Pleasant Well was located in the town of Point Pleasant, New Jersey (elevation, 20 ft.). The well was bored and sampled by cable tool. As one might expect with this type of sampling, there is a significant amount of downhole contamination which complicates the interpretation of the section. For this reason, more reliance is placed on LADs than on FADs for drawing zonal boundaries.

The first sample above the Cretaceous contact is barren. The succeeding sample contains few coccoliths, and cannot be reliably dated, but may be CP1 if the rare *Chiasmolithus bidens* noted is a downhole contaminant. The next two samples contain few or rare *Fasciculithus involutus* and *Heliolithus kleinpellii*, which, if not downhole contaminants, would indicate Zone CP5. This assignment is supported by a rare specimen of *Discoasteroides bramlettei* in Sample 525. Common *H. kleinpellii* and *H. riedelii* co-occur in Sample 515, which suggests CP7. *Discoaster mohleri* is absent, so CP6 may well be missing in this section. The interval containing *H. kleinpellii* is only 20 ft. at most, far less than in the Whitesville and Glendola wells. The next 50 ft. are barren.

A diverse flora is encountered beginning with Sample 435, but much of this could be due to downhole contamination. *D. multiradiatus* is abundant in Sample 415, but is rare to few in the two samples below, where *Tribrachiatus orthostylus* is abundant. Such a reversal in dominance between these genera is unusual, but was recorded previously in Sample 550 from the Leggett Well (Table 1).

Ellipsolithus macellus occurs in unusual numbers, being abundant in Samples 435, 425, and 395. This taxon was not observed in any of the other onshore well sections, but was consistently present in Zones CP9 and CP10 at the offshore Site 605 (Applegate and Wise, this volume).

The base of CP10 could be placed around 375–285 ft., where *D. lodoensis* and *D. kuepperi* become reasonably

Table 3. Distribution of calcareous nannofossils, Glendola Well, New Jersey Coastal Plain.

Age	Foraminifer zones (Olsson, pers. comm.)	Nannofossil zones	Sample interval (ft.)	Preservation	Abundance	*Blackites tenuis*	*B.* sp. cf. *B. tenuis*	*Braarudosphaera bigelowii*	*Campylosphaera eodela*	*Chiasmolithus bidens*	*C. consuetus*	*C. danicus*	*C. expansus*	*C.* sp. cf. *gigas*	*C. grandis*	*C.* sp. aff. *C. oamaruensis*	*C. pelagicus*	*C. solitus*	*Coccolithus eopelagicus*	*Discoaster barbadiensis*	*D. binodosus*	*D.* sp. cf. *D. binodosus*	*D. diastypus*	*D. distinctus*	*D.* sp. aff. *D. falcatus*	*D.* sp. cf. *D. helianthus*	*D. kuepperi*	*D. lodoensis*	*D. mediosus*	*D. mohleri*	*D. multiradiatus*
Eocene	P12-P11	CP14?	114-115	MEO	A	C							F	R	R	R	A	A	A	R				R							
		CP13	119-120	MEO	A			R					F		F		A	A	C												
	P9-P8	CP10-CP11?	124-125	MEO	A								F				C	C	C					C				A			
			139-140	MEO	A								F		R		C	C	C			R		F				A			
		CP10	144-145	MEO	C								C				C	C			R			R			R	A			
			149-150	MEO	A		R								R		C	C			R				R		R	C			
			159-161	ME	A								R				C				R		R				R	C			
	P7	CP9	164-165	ME	A					A			F								R										R
			174-175	MEO	C					C											A		R								C
	P6b		179-180	MEO	C					C							F				F										C
			184-186	MEO	A					F	R						C				C										C
Paleocene	P6a	Barren	194-196	Barren																											
			199-201	Barren																											
			204-206	Barren																											
	P4	CP7	214-216	ME	A					A							C												R	R	
			219-221	M	F			R		R	R	R													R					R	
		CP6	225-227	P	R			R		R	R							R								R					
			230-232	M	C			R	r	F	R							C												R	
		CP6	235-237	M	C			R		C	R							C													
			245-247	M	C			R		C																					
			250-252	P	F					F																					
			255-257	P	F			R										C													
			260-262	P	F					R																					
			265-267	P	R					R																					
			275-276	P	R			R		R																					
			286-287	P	R			R		R																					
	P3		291-292	M	F			R		R																					
			296-297	P	F			R		R																					
			301-302	P	R			R		R																					
		CP4?	307-308	P	R			R										R													
Cretaceous			347-348	G	A																										

Note: Abundance is characterized by VA, very abundant; C, common; F, few; R, rare; B, barren, EB, essentially barren. For preservation, P, poor; M, moderate; G, good, E, etched; O, overgrown. Lowercase letters indicate material considered to be reworked.

consistent in their occurrence. This zone, however, could extend as far downsection as Sample 405 if the possibility of downhole contamination of the taxa is discounted. Also present are few *Chiphragmalithus calathus*, which occur at about this level in DSDP Hole 605. The CP10 boundary can only be approximated in that the presence of few to common *Reticulofenestra umbilica* in this interval indicates serious downhole contamination problems. The LAD of *T. orthostylus* is used to approximate the top of CP11. Rare occurrences of *D. sublodoensis* and *Nannotetrina quadrata* are ignored in light of the downhole contamination problem. The LADs of *D. kuepperi* and *D. lodoensis* restrict Sample 315 to CP12a or below. Section could be missing here if the hiatus noted in the Glendola Well extends to this locality. *R. umbilica* is consistently present above Sample 285; in the lower samples (275, 285) it is accompanied by common *Lithostromation simplex*.

As indicated previously, this zonation of the Point Pleasant Well cannot be considered very satisfactory in view of the considerable downhole contamination problems, which apparently resulted from the cable tool method of drilling the hole.

Maryland Well QA-BG54 (Table 5)

Samples from Well QA-BG54 (eastern shore of Maryland) were examined in order to characterize the Paleocene interval at this locality. The well is located in Queen Annes County, Maryland, just east of Unicorn (elevation approximately 60 ft.).

The well yielded an extensive sequence (33 ft.) assigned to CP1. Common *Chiasmolithus bidens* in the absence of fasciculiths assign Sample 249-250 to CP3. The overlying sample (245-247) contains few *Fasciculithus involutus* and rare *Heliolithus riedelii*, and could be assigned to Zones CP4 to CP7. Planktonic foraminiferal studies

Table 3 (continued).

D. tanii	Ellipsolithus distichus	Fasciculithus involutus	F. schaubi	Heliolithus kleinpellii	H. sp. cf. H. kleinpellii	H. riedelii	H. sp. cf. H. riedellii	Lithostromation simplex	Lophodolithus nascens	Micrantholithus concinnus	M. entaster	Neochiastozygus chiastus	N. junctus	Neococcolithes dubius	Pontosphaera exilis	P. plana	P. pulchra	Reticulofenestra samodurovii	R. umbilica	Rhabdosphaera creber	R. sp. cf. R. inflata	R. perlongus	Rhomboaster bitrifida	R. cuspis	Sphenosphaera anarrhopus	S. moriformis	S. radians	Thoracosphaera sp.	Tribrachiatus bramlettei (type B)	T. orthostylus	Zygodiscus plectopons	Z. sigmoides	Zygodiscus simplex	Zygrhablithus bijugatus	Arkhangelskiella cymbiformis	Eiffellithus turriseiffeli	Microrhabdulus decoratus	Micula decussata	Prediscosphaera cretacea	Tetrapodorhabdus decorus	Thoracosphaera operculata	Watznaueria barnesae
R								C						C	C			R	R	C	R													F								
									C						C	C			R		F															R								
																C	C			R		R												R				F								
									R						A	C		C											R			A				R								
																C	F		F			R												A				F								
																F	F								R				R					A				F								
																	R		R										R					A												
										R			F	R			F		R										R					R	R			C								
														F	R										F	F						R	R				R								
		F											F	R			F							F	F						R													
	R													C	C			F									R		C							R											
	R	A				F	F						F	C			F																C											
						R	R					R	R	R																													
	R	R				R					R		R	F															R			F	R										
		F			R	R							C			R	R												R			R											
				F	R	F							C																					R	R										
				C									R	F																					F		R										
		R						R							A																					F		R										
		F	R		C								R																															
				C											R		R																													
				F												R																						R	R										
				F											R	R																						R												
		R	R	F										R																						R	R										
				F											R	F																							R										
		R		F											R	R																															
		R		R											R																															
		R																																									
																																				A	F	F	A	C	C	F	C

suggest that CP4 is correct (R. K. Olsson, personal communication, 1986). The rare *H. riedelii* in the sample, therefore, should be considered a downhole contaminant.

TAXONOMIC NOTES

Tribrachiatus bramlettei (Brönnimann and Stradner) Proto Decima et al., 1975 (morphotype B)
(Fig. 5)

Remarks. *Tribrachiatus bramlettei* is traditionally regarded as a species of *Tribrachiatus* which consists of two superimposed triangular blocks centered symmetrically one above the other, but oriented in opposite directions. Applegate and Wise illustrate such a form from DSDP Hole 605 on the upper continental rise off New Jersey (this volume, Pl. 2, Figs. 8–9), where the taxon was few but consistently present over a 3-m interval. No such forms were observed in equivalent onshore strata analyzed in the present chapter. Instead, similarly constructed but longer-rayed individuals were present (Fig. 5). The opposed triangular units of these specimens are centered one above the other without significant offset where the rays converge; thus these specimens belong to the genus *Tribrachiatus* rather than *Rhomboaster* (*sensu* Romein, 1979).

Because the onshore and offshore specimens are stratigraphically equivalent and are of similar construction, differing only by the lengths of their rays, we consider them one and the same species. We believe the variation in ray length between the onshore versus offshore specimens is due to preservation. The section at DSDP Site 605 is more calcareous and has suffered extensive diagenesis in the way of dissolution and overgrowth of nannofossils (Applegate and Wise, this volume). Preservation is considerably better in the more siliceous sediments of the Coastal Plain, where overgrowths are far less noticeable and the chances of preserving more delicate structures are considerably enhanced (see Wise, 1977, for a discussion of factors that affect diagenesis of nannofossils).

Following the argument stated above, we distinguish two morphotypes of *Tribrachiatus bramlettei*. The stubby form represented in the offshore at DSDP Site 605 is labeled morphotype A. The long-rayed form prevalent in the New Jersey Coastal Plain sections is labeled morphotype B.

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We are indebted to Professor Richard K. Olsson (Rutgers University, New Brunswick, N.J.), who suggested the study and provided all samples used. In addition, he supplied the complementary planktonic foraminiferal data and lithologic descriptions, and suggested ways in which these data could be correlated with the nannofossil information. The range charts were constructed by the first author during a year in residence at FSU. We thank Mr. John Firth (FSU) for spotting *Nephrolithus frequens* in Leggett Sample 700, and Mr. Wuchang Wei

Table 4. Distribution of calcareous nannofossils, Point Pleasant Well, New Jersey Coastal Plain.

Age	Foraminifer zones (Olsson, pers. comm.)	Nannofossil zones	Sample interval (ft.)	Preservation	Abundance	*Blackites tenuis*	*Braarudosphaera bigelowii*	*Campylosphaera dela*	*Chiasmolithus* sp. cf. *C. altus*	*C. bidens*	*C. eograndis*	*C. expansus*	*C. grandis*	*C. solitus*	*Chiphragmalithus acanthodes*	*C. calathus*	*Coccolithus formosus*	*C. pelagicus*	*Cruciplacolithus tenuis*	*C.* sp. aff. *C. tenuis*	*Discoaster barbadiensis*	*D. binodosus*	*D. deflandrei*	*D. diastypus*	*D. distinctus*	*D. elegans*	*D. falcatus*	*D. germanicus*	*D. kuepperi*	*D. lenticularis*	*D. lodoensis*	*D. multiradiatus*	*D.* sp. aff. *D. multiradiatus*	*D. saipanensis*	*D. sublodoensis*	*Discoasteroides bramlettei*
Eocene	?	Barren	150	Barren																																
			160	Barren																																
			170	Barren																																
			180	Barren																																
			190	Barren																																
	P12–P11	CP14	200	M	F								R	R																						
			210	M	F								R	R																						
			217	M	C								F	F				F																		
			228	M	C				R				R															R								
			235	M	C																															
			245	M	A	C							R	A																						
			255	M	F												R																			
			265	M	F			R						C				F																		
			275	M	A			C				F		A																						
			285	ME	A	C						F	F	A			C	A			F		R		R											
		CP13	295	ME	A	C	R					F	R	A				A			C															
			305	ME	A	R	R					F	F	C			C	C			F															
	P9–P7	CP12a	315	G	A			C				C	C	A				A							F						C					
			325	G	A							C	F	A			F				F				F				R		C					
		CP10–CP11	335	G	A			F				C	C					C			F	R		R	R				C		A				r	
			345	M	A			C				F	F	F				C			R				R				C		F			R		
			355	G	A			C				C	C	C			F	C			R				R				C		R					
			365	G	A			F					C			F	F				F	R							R					R		
			375	M	A			F				F	F			F	F	C			R	C									R					
		CP9–CP10	385	G	A			F				F		F		R	F	C			F	R			A											
			395	M	C					F	R	R						A				A				F	F					F				
			405	G	A			C		F	R		F	R	R	R		C				C				F			R		R					
	P6b	CP9	415	M	C					R								C				F					C			F		A	R			
			425	M	C							F	F	C				C				C				F				F		R				
			435	M	A					C		F	F	F		R		C				C		R		F				F		F				
Paleocene	P6a?	Barren	445	Barren																																
			455	Barren																																
			465	Barren																																
			475	Barren																																
			485	Barren																																
			495	Barren																																
	P4	CP6/7	505	P	R													R																		
			515	M	A						C							C																		
		CP5	525	M	F					C	R																									R
	P3		535	M	F						F								R											R						
	P1b	CP1?	545	M	F					R								R		R																
		Barren	555	Barren																																
Cretaceous			565	M	F																															
			575	M	F																															
			585	M	F																															

Note: Abundance is characterized by VA, very abundant; C, common; F, few; R, rare; B, barren, EB, essentially barren. For preservation, F, poor; M, moderate; G, good, E, etched; O, overgrown. Lowercase letters indicate material considered to be reworked.

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Table 4 (continued).

Ellipsolithus distichus	E. macellus	Fasciculithus involutus	F. schaubi	Heliolithus kleinpellii	H. sp. aff. H. kleinpellii	H. riedelii	Lithostromation operosum	L. perdurum	L. simplex	Lophodolithus mochlophorus	L. nascens	L. reniformis	Nannotetrina quadrata	Neochiastozygus chiastus	N. junctus	Neococcolithes dubius	Pontosphaera distincta	P. exilis	P. plana	P. pulchra	Reticulofenestra samodurovii	R. umbilica	Rhabdosphaera perlongus	R. vitreus	Rhomboaster bitrifida	Scyphosphaera sp.	Sphenolithus anarrhopus	S. moriformis	S. primus	S. radians	Thoracosphaera operculata	T. sp.	Tribrachiatus bramlettei (type B)	T. orthostylus	Zygodiscus plectopons	Z. sigmoides	Z. simplex	Zygrhablithus bijugatus	Arkhangelskiella cymbiformis	Eiffellithus turriseiffei	Microrhabdulus decoratus	Micula decussata	Prediscosphaera cretacea	Reinhardtites elegans	R. sp.	Watznaueria barnesae
								R								R	F	F			F	F		R														R								
								R								F	F	F			F	R		F														F								
																R		F			R	C		R														R								
								R								F	C				F	C		R														F								
																	C	R		R	C	C		F														F								
																	C	F		F	R	R		C														C								
							R	R								C	F	R			F	C		C																						
																R	R				R	F		R														F								
									C			R				C	F	C	F	C	F	F		F																						
									C							C	F	C	F	C	R	R		C														F								
									F							C	C	C	F	F	R			R														C								
									F							C	C	C	C	F	F			F														F								
										R						C	C	A	C	F				F														F								
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APPENDIX

Calcareous Nannofossils Considered in This Chapter (in alphabetical order of species epithets)

Paleogene

Chiphragmalithus acanthodes Bramlette and Sullivan, 1961
Chiasmolithus altus Bukry and Percival, 1971
Sphenolithus anarrhopus Bukry and Bramlette, 1969
Discoaster barbadiensis Tan Sin Hok, 1927
Chiasmolithus bidens (Bramlette and Sullivan) Hay and Mohler, 1967
Braarudosphaera bigelowii (Gran and Braarud) Deflandre, 1947
Rhomboaster bitrifida Romein, 1979
Zygrhablithus bijugatus (Deflandre) Deflandre, 1959
Discoaster binodosus Martini, 1958
Discoasteroides bramlettei (Stradner) Bramlette and Sullivan, 1961
Tribrachiatus bramlettei (Brönnimann and Stradner) Proto Decima et al., 1975 (morphotype B)
Chiphragmalithus calathus Bramlette and Sullivan, 1961
Chiasmolithus californicus (Sullivan) Hay and Mohler, 1967
Neochiastozygus chiastus (Bramlette and Sullivan) Perch-Nielsen, 1971
Micrantholithus concinnus Bramlette and Sullivan, 1961
Heliolithus conicus Perch-Nielsen, 1971
Chiasmolithus consuetus (Bramlette and Sullivan) Hay and Mohler, 1967
Tribrachiatus contortus (Stradner) Bukry, 1972
Rhabdosphaera creber Deflandre *in* Deflandre and Fert, 1954
Rhomboaster cuspis Bramlette and Sullivan, 1961
Chiasmolithus danicus (Brotzen) Hay and Mohler *in* Hay et al., 1967
Campylosphaera dela (Bramlette and Sullivan) Hay and Mohler, 1967
Discoaster diastypus Bramlette and Sullivan, 1961
Braarudosphaera discula Bramlette and Riedel, 1954
Ellipsolithus distichus (Bramlette and Sullivan) Sullivan, 1964
Pontosphaera distincta (Bramlette and Sullivan) Roth and Thierstein, 1972
Discoaster distinctus Martini, 1958
Neococcolithes dubius (Deflandre) Black, 1967
Sphenolithus editus Perch-Nielsen, 1978
Discoaster elegans Bramlette and Sullivan, 1961
Campylosphaera eodela Bukry and Percival, 1971
Chiasmolithus eograndis Perch-Nielsen, 1971
Coccolithus eopelagicus (Bramlette and Riedel) Bramlette and Sullivan, 1961
Micrantholithus entaster Bramlette and Sullivan, 1961
Pontosphaera exilis (Bramlette and Sullivan) Romein, 1979
Chiasmolithus expansus (Bramlette and Sullivan) Gartner, 1970
Discoaster falcatus Bramlette and Sullivan, 1961
Micrantholithus flos Deflandre *in* Deflandre and Fert, 1954
Coccolithus formosus (Kamptner) Wise, 1973
Discoaster gemmifer Stradner, 1961
Discoaster germanicus Martini, 1958
Chiasmolithus gigas (Bramlette and Sullivan) Radomski, 1968
Rhabdosphaera gladius Locker, 1967
Chiasmolithus grandis (Bramlette and Riedel) Radomski, 1968
Discoaster helianthus Bramlette and Sullivan, 1961
Rhabdosphaera inflata Bramlette and Sullivan, 1961
Markalius inversus (Deflandre) Bramlette and Martini, 1964
Fasciculithus involutus Bramlette and Sullivan, 1961

Table 5. Distribution of calcareous nannofossils, Well QA-BG 54, Maryland Coastal Plain.

Age	Foraminifer zones (Olsson, pers. comm.)	Nannofossil zones	Sample interval (ft.)	Preservation	Abundance	*Braarudosphaera bigelowii*	*Chiasmolithus bidens*	*C. consuetus*	*C. solitus*	*Cruciplacolithus tenuis*	*Fasciculithus involutus*	*Heliolithus riedelii*	*Micrantholithus* sp. cf. *M. entaster*	*Neochiastozygus chiastus*	*Sphenolithus moriformis*	*Thoracosphaera operculata*	*Zygodiscus sigmoides*	*Z. simplex*	*Arkhangelskiella cymbiformis*
Paleocene	P3b	CP4	245–247	ME	C		C	F	F	R	F	r		F	R		R		
	P3a	CP3	249–250	P	F		C			R									
	P1b	CP1	260–265	P	F				f	R							R	R	
			276–277	M	C	F				F			R			C	C		r
			290–293	P	C					R				R		C	C		

Note: Abundance is characterized by V, very abundant; C, common; F, few; R, rare; B, barren, EB, essentially barren. For preservation, P, poor; M, moderate; G, good, E, etched; O, overgrown. Lowercase letters indicate material considered to be reworked,

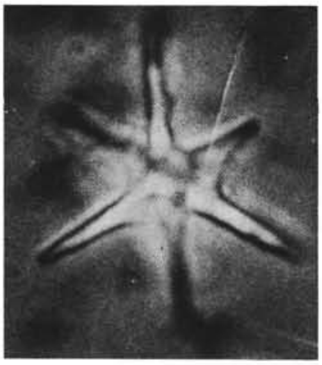

Figure 5. *Tribrachiatus bramlettei* (Brönnimann and Stradner) morphotype B, ×2240, Leggett Well, Sample 550, phase-contrast light.

Neochiastozygus junctus (Bramlette and Sullivan) Perch-Nielsen, 1971
Heliolithus kleinpellii Sullivan, 1964
Discoaster kuepperi Stradner, 1959
Discoaster lenticularis Bramlette and Sullivan, 1961
Discoaster lodoensis Bramlette and Riedel, 1954
Ellipsolithus macellus (Bramlette and Sullivan) Sullivan, 1964
Discoaster mediosus Bramlette and Sullivan, 1961
Discoaster mirus Deflandre in Deflandre and Fert, 1954
Discoaster mohleri (Stradner) Bukry and Percival, 1971
Lophodolithus mochlophorus Deflandre *in* Deflandre and Fert, 1954
Sphenolithus moriformis (Brönnimann and Stradner) Bramlette and Wilcoxon, 1967
Pontosphaera multipora (Kamptner) Roth, 1970
Discoaster multiradiatus Bramlette and Riedel, 1954
Lophodolithus nascens Bramlette and Sullivan, 1961
Discoaster nobilis Martini, 1961
Chiasmolithus oamaruensis (Deflandre) Hay, Mohler, and Wade, 1966
Thoracosphaera operculata Bramlette and Martini, 1964
Lithostromation operosum (Deflandre) Bybell, 1975
Tribrachiatus orthostylus Shamrai, 1963
Pontosphaera pectinata (Bramlette and Sullivan) Sherwood, 1974
Coccolithus pelagicus (Wallich) Schiller, 1930
Lithostromation perdurum Deflandre, 1942
Rhabdosphaera perlongus Deflandre *in* Grassé, 1952
Pontosphaera plana (Bramlette and Sullivan) Haq, 1971
Zygodiscus plectopons Bramlette and Sullivan, 1961
Sphenolithus primus Perch-Nielson, 1971
Pontosphaera pulchra (Deflandre) Romein, 1979
Nannotetrina quadrata (Bramlette and Sullivan) Bukry, 1973
Sphenolithus radians Deflandre, 1952
Heliolithus riedelii Bramlette and Sullivan, 1961
Lophodolithus reniformis Bramlette and Sullivan, 1961
Discoaster saipanensis Bramlette and Reidel, 1954
Reticulofenestra samodurovii (Hay, Mohler, and Wade) Roth, 1970
Fasciculithus schaubi Hay and Mohler, 1967
Zygodiscus sigmoides Bramlette and Sullivan, 1961
Zygodiscus simplex (Bramlette and Sullivan) Hay and Mohler, 1967
Lithostromation simplex (Klumpp) Bybell, 1975
Chiasmolithus solitus (Bramlette and Sullivan) Locker, 1968
Discoaster sublodoensis Bramlette and Sullivan, 1961
Discoaster tanii Bramlette and Riedel, 1954
Blackites tenuis (Bramlette and Sullivan) Bybell, 1975
Cruciplacolithus tenuis Hay and Mohler
Fasciculithus tympaniformis Hay and Mohler, 1967
Reticulofenestra umbilica (Levin) Martini and Ritzkowski, 1968
Micrantholithus vesper Deflandre *in* Deflandre and Fert, 1954
Rhabdosphaera vitreus Deflandre *in* Deflandre and Fert, 1954
Discoaster woodringii Bramlette and Riedel, 1954

Cretaceous Species Considered for Site 605[1]

Reinhardtites anthophorus (Deflandre) Perch-Nielsen, 1968
Watznaueria barnesae (Black) Perch-Nielsen, 1968
Lucianorhabdus cayeuxii Deflandre, 1959
Prediscosphaera cretacea (Arkhangelsky) Gartner, 1968
Arkhangelskiella cymbiformis (Arkhangelsky) Deflandre, 1952
Microrhabdulus decoratus Deflandre, 1959
Tetrapodorhabdus decorus (Deflandre and Fert) Wind and Wise, 1977
Micula decussata Vekshina, 1959
Reinhardtites elegans (Gartner) Wise, 1983
Nephrolithus frequens Gorka, 1957
Marthasterites inconspicuus Deflandre, 1959
Ragodiscus splendens (Deflandre) Verbeek, 1977
Eiffellithus turriseiffeli (Deflandre *in* Deflandre and Fert) Reinhardt, 1965

[1] Exclusive of any previously listed for the Paleogene.