26. NANNOFOSSIL BIOSTRATIGRAPHY, LEG 22, DEEP SEA DRILLING PROJECT

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INTRODUCTION

Calcareous nannofossils were recovered at every site drilled during Leg 22. Not all sites, however, yielded equally good assemblages, and, at some sites only a small fraction of the interval cored and drilled yielded calcareous sediments. In general, the most representative calcareous nannofossil successions were recovered at the shallower sites, particularly those along the crest of Ninetyeast Ridge (Sites 214, 216, and 217). Poorest recovery of calcareous nannofossils was from the deepest part of the Indian Ocean, in the Wharton Basin east of Ninetyeast Ridge (Sites 211, 212, and 213). This is not surprising as the last three sites are all well below 5000 meters, and one site (212) is situated well below 6000 meters. This same site did yield calcareous sediments over much of the interval cored, but the section is by no means representative. In fact, this site has a most unusual history of carbonate deposition in that all the calcareous sediments seem to have been transported to this site by currents, and probably none were deposited as normal pelagic sediments from the water column above. One site west of Ninetyeast Ridge (215) also was more than 5000 meters deep and only part of the section was calcareous. Finally, the site drilled on the Bengal Fan (218) yielded calcareous material throughout the interval cored, but because of the large proportion of detrital constituents, the calcareous nannofossils and other pelagic constituents were diluted to such an extent in some parts of the interval that they were only rarely encountered.

NANNOFOSSIL ZONATION

The calcareous nannofossil zonation used during Leg 22 is indicated below. With the exception of the *Discoaster asymmetricus* Zone, all of the zones listed were readily recognized in the sediments recovered in the Indian Ocean. Recognition of the *Discoaster asymmetricus* Zone depends on the identification of *Discoaster asymmetricus* and *Ceratolithus tricorniculatus* s.l. in an interval where both species may be relatively rare, and hence the zone may go undetected in a preliminary examination. Despite this fact, it has not been excluded from any scheme presented here. Data for constructing the zonal succession and the zonal names are drawn from all available sources. In choosing from among the various zonations, preference was given to zones which are readily recognized in oceanic as well as in hemipelagic sediments. Provincial species, especially those restricted to hemipelagic sediments, make poor zonal markers in oceanic deposits. Notorious among the latter are the mid-Tertiary helicopontosphaeras, pentaliths, holococcoliths, *Ericsonia subdisticha*, and some Miocene asteroliths (e.g., *Discoaster kugleri*).

The late Neogene zonation *Emiliania huxleyi* to *Discoaster quinqueramus* is essentially that proposed by Gartner, 1969 (see also Gartner, 1973, for a detailed chronology). The remaining Tertiary zones are compiled chiefly from Bramlette and Wilcoxon (1967); Hay et al. (1967); Hay and Mohler (1967); Gartner (1969; 1971); Martini and Worsley (1970); Martini (1970; 1971); Roth (1970); and Bukry (1971). Because many of these zones are used in a slightly modified sense, a brief characterization is given below for all nannofossil zones used in this volume.

Emiliania huxleyi Zone

The interval of occurrence of *Emiliania huxleyi*: This zone spans somewhat less than 200,000 years.

Gephyrocapsa Zone

The interval from the last occurrence of *Pseudoemiliania lacunosa* to the first occurrence of *Emiliania huxleyi.*

Pseudoemiliania lacunosa Zone

The interval from the last occurrence of *Discoaster brouweri* to the last occurrence of *Pseudoemiliania lacunosa.*

Discoaster brouweri Zone

The interval from the last occurrence of *Discoaster surculus* to the last occurrence of *Discoaster brouweri.* The top of this zone corresponds very closely to the Pliocene-Pleistocene boundary as commonly recognized in deep-sea sediments.

Discoaster surculus Zone

The interval from the last occurrence of *Reticulofenestra pseudoumbilica* to the last occurrence of *Discoaster surculus.*

Reticulofenestra pseudoumbilica Zone

The interval from the last occurrence of nonbirefringent ceratoliths (chiefly *Ceratolithus tricorniculatus* and *Ceratolithus primus*) to the last occurrence of *Reticulofenestra pseudoumbilica.* The top of this zone may be difficult to determine at times because *Reticulofenestra pseudoumbilica* becomes quite rare and may be represented by only small specimens.

Discoaster asymmetricus Zone

The interval from the first occurrence of *Discoaster asymmetricus* to the last occurrence of nonbirefringent ceratoliths. *Discoaster asymmetricus* as well as nonbirefringent ceratoliths may be rare in this interval in some types of pelagic sediment. Consequently, this zone may be difficult to recognize at times.

Discoaster mohleri Zone

The interval from the first occurrence of *Discoaster mohleri* to the first occurrence of *Discoaster multiradiatus.*

Heliolithus kleinpelli Zone

The interval from the first occurrence of *Heliolithus kleinpelli* to the first occurrence of *Discoaster mohleri.*

Fasciculithus tympaniformis Zone

The interval from the first occurrence of *Fasciculithus tympaniformis* to the first occurrence of *Heliolithus kleinpelli.*

Cyclococcolithina robusta Zone

The interval from the first occurrence of *Cyclococcolithina robusta* to the first occurrence of *Fasciculithus tympaniformis. Ellipsolithus macellus* and *Chiasmolithus bidens* first occur near the bottom of this zone, and the last-named species enjoys by far the most cosmopolitan distribution of the three. Unfortunately, early specimens of this species are frequently identified as *Chiasmolithus danicus* with the light microscope.

Cruciplacolithus tenuis Zone

The interval from the first occurrence of *Cruciplacolithus tenuis* to the first occurrence of *Cyclococcolithina robusta.* In oceanic calcareous oozes the Tertiary record generally does not extend below this level, so that sediments of the *Cruciplacolithus tenuis* zone are underlain by Upper Cretaceous deposits.

Ceratolithus rugosus Zone

The interval from the first occurrence of *Ceratolithus rugosus* to the first occurrence of *Discoaster asymmetricus.*

Ceratolithus tricorniculatus Zone

The interval from the last occurrence of *Discoaster quinqueramus* to the first occurrence of *Ceratolithus rugosus.* The Miocene-Pliocene boundary falls within this zone.

Discoaster quinqueramus Zone

The interval from the first occurrence of nonbirefringent ceratoliths (including but not limited to *Ceratolithus primus*) to the last occurrence of *Discoaster quinqueramus.* The base of this zone also corresponds closely to the last occurrence of *Discoaster neohamatus.*

Discoaster neohamatus Zone

The interval from the first occurrence of *Discoaster neohamatus* to the first occurrence of *Ceratolithus tricorniculatus.* For practical purposes this is a total range zone as the last occurrence of *Discoaster neohamatus* closely corresponds to the first occurrence of the genus *Ceratolithus.*

Discoaster hamatus Zone

The interval from the first occurrence of *Discoaster hamatus* to the first occurrence of *Discoaster neohamatus.*

Catinaster coalitus Zone

The interval from the first occurrence of *Catinaster coalitus* to the first occurrence of *Discoaster hamatus.*

Discoaster exilis Zone

The interval from the last occurrence of *Sphenolithus heteromorphus* to the first occurrence of *Catinaster coalitus.* This characterization is a poor one because it relies on the absence of two index species. *Cyclicargolithus floridanus* and *Cyclolithella nitescens* both occur within this zone but do not range to the very top of it. The *Discoaster kugleri* Zone of other authors corresponds to the top of this zone, but as *Discoaster kugleri* is not a cosmopolitan species the zone is not included.

Sphenolithus heteromorphus Zone

The interval from the last occurrence of *Sphenolithus belemnos* to the last occurrence of *Sphenolithus heteromorphus.* The *Helicopontosphaera ampliaperta* Zone of other authors corresponds to the lower part of this zone. It is not included here because the marker species, *Helicopontosphaera ampliaperta,* generally is not found in oceanic-type pelagic sediments.

Sphenolithus belemnos Zone

The interval of the total range of *Sphenolithus belemnos.*

Triquetrorhabdulus carinatus Zone

The interval from the first occurrence of *Triquetrohabdulus carinatus* to the first occurrence of *Sphenolithus belemnos.* The species *Triquetrorhabdulus carinatus* seemingly is highly susceptible to heavy calcification, which makes identification uncertain. Hence, identification of the zone also may be difficult.

Sphenolithus ciperoensis Zone

The interval from the first occurrence of *Sphenolithus ciperoensis* to the first occurrence of *Triquetrorhabdulus carinatus.*

Sphenolithus distentus Zone

The interval from the first occurrence of *Sphenolithus distentus* to the first occurrence of *Sphenolithus ciperoensis.*

Sphenolithus predistentus Zone

The interval from the last occurrence of *Cyclococcolithina formosa* to the first occurrence of *Sphenolithus distentus.*

Cyclococcolithina formosa Zone

The interval from the last occurrence of *Discoaster barbadiensis* to the last occurrence of *Cyclococcolithinia formosa.* The several zones designated for the lower Oligocene interval, all of which are here included in the *Cyclococcolithinia formosa* Zone, are based on provincial specie (e.g., *Helicopontosphaera reticulata, Ericsonia subdisticha, Cyclococcolithus margaritae*) and are of little or no use in open ocean pelagic sediments.

Discoaster barbadiensis Zone

The interval from the last occurrence of *Chiasmolithus grandis* to the last occurrence of *Discoaster barbadiensis.*

Chiasmolithus grandis Zone

The interval from the first occurrence of *Reticulofenestra umbilica* to the last occurrence of *Chiasmolithus grandis.* Although *Reticulofenestra umbilica* is a common, distinctive, and cosmopolitan species, the base of this zone may be difficult to determine at times on the basis of this species because it evolved gradually from similar but smaller species. The separation, therefore, becomes subjective. In oceanic sediments the first occurrence of *Bramletteius serraculoides* closely corresponds to the base of this zone, but this form is not common in hemipelagic sediments.

Nannotetrina alata Zone

The interval from the first occurrence of *Nannotetrina alata* (=*Chiphragmalithus quadratus* = *Chiphragmalithus alatus*) to the first occurrence of *Reticulofenestra umbilica.*

Discoaster sublodoensis Zone

The interval from the first occurrence of *Discoaster sublodoensis* to the first occurrence of *Nannotetrina alata.*

Discoaster lodoensis Zone

The interval from the last occurrence of *Tribrachiatus orthostylus* to the first occurrence of *Discoaster sublodoensis.*

Tribrachiabus orthostylus Zone

The interval from the last occurrence of *Discoaster diastypus* to the last occurrence of *Tribrachiatus orthostylus.*

Discoaster diastypus Zone

The interval of the total range of *Discoaster diastypus.*

Discoaster multiradiatus Zone

The interval from the first occurrence of *Discoaster multiradiatus* to the first occurrence of *Discoaster diastypus.*

Pre-Tertiary sediments recovered during Leg 22 are assignable to the uppermost four Upper Cretaceous nannofossil zones which are characterized as follows.

Nephrolithus frequens Zone

The interval from the first occurrence of *Nephrolithus frequens* to the Cretaceous-Tertiary boundary, which is marked by the disappearance of nearly all Upper Cretaceous species.

Lithraphidites quadratus Zone

The interval from the first occurrence of *Lithraphidites quadratus* to the first occurrence of *Nephrolithus frequens.*

Tetralithus nitidus trifidus Zone

The interval from the first occurrence of *Tetralithus nitidus trifidus* to the first occurrence of *Lithraphidites quadratus.*

Eiffellithus augustus Zone

The interval from the first occurrence of *Broinsonia parca* to the first occurrence of *Tetralithus nitidus trifidus.*

The nannofossil zonal succession in the Indian Ocean, and more specifically, in the equatorial region of the Ninetyeast Ridge, is very similar to the nannofossil zonal succession found by Bukry (1972) for the North Atlantic sediment recovered on DSDP Leg 12. This seems puzzling because the two areas in question, i.e., the northern North Atlantic and the Indian oceans, are separated as much from one another as is possible. Moreover, one of the areas is tropical and the other is cool temperate to subarctic. It is tempting to smugly point to this similarity of nannofossil zonal successions as proof of the universality of nannofossil biostratigraphy, but some of the similarities go beyond that. This is especially true for some Late Cretaceous and early Tertiary assemblages. The late Maastrichtian index species *Nephrolithus frequens* is best known from northern Europe. Worsley and Martini (1970) suggest that this species is a cold water form and, therefore, is absent in low latitude late Maastrichtian sediments. On Leg 22 *Nephrolithus frequens* was recovered on sites very close to the present-day equator, although a Late Cretaceous reconstruction places these same sites at much higher latitudes in the southern hemisphere. Thus, *Nephrolithus frequens*, like several modern coccolithophores, probably had a bipolar distribution.

The early Tertiary species, *Chiasmolithus danicus*, represents a similar case. This form has been reported from several localities, but only specimens from northern Europe and from the North Atlantic can be assigned to this species unequivocally. In lower Paleocene sediments of the Ninetyeast Ridge this species is common, and again the early Tertiary position of the Indian plate has to be invoked to account for the occurrence of this seemingly high latitude form. A bipolar distribution of this species also seems reasonable.

Thus, for the Late Cretaceous and early Tertiary the similarity of the zonal succession in the North Atlantic and Indian oceans is not at all unreasonable, especially if it is kept in mind that the Tethyan seaway connected the two oceans during Cretaceous and early Tertiary time.

RESULTS AND DISCUSSION

In Figures 1 through 8 are presented checklists of the calcareous nannofossils recovered at each of the sites drilled during Leg 22. These checklists have been compiled from shipboard data and from subsequent examinations. The latter were directed primarily at determining the limits of occurrence of key index species, so that the biostratigraphic framework for each site could be as accurate as possible. The checklists are by no means comprehensive, although they may be considered as representative of the nannofossils contained in a particular sample. In Figure 9 are summarized the age assignments made on the basis of calcareous nannofossils of sediments recovered during Leg 22. For additional discussion of the results, the reader is referred also to the biostratigraphy section of each site report.

Four sites (211, 212, 213, and 215) were located below the present calcium carbonate compensation depth. The calcareous sediments recovered at these sites can be interpreted to be either allochthonous in origin, i.e., they were transported to their present location by currents or turbidity flows, or, that at certain times the sites were above the calcium carbonate compensation depth. For Site 211 an allochthonous origin is suggested by possible current bedding of the sediment. On the other hand, deposition below the lysocline is suggested by the considerable solution of most nannofossils, though if the probable Late Cretaceous high latitude location of this site is taken into account, this considerable solution does not necessarily require deposition at great depth. Moreover, the low diversity of the nannofossil assemblage at this site–10 species in an interval that normally yields upward of 50 species–can be explained, at least partially, by this same high latitude location, which is postulated in most Late Cretaceous reconstructions of the Indian Ocean. Perhaps a most reasonable explanation for the calcareous nannofossils recovered at Site 211 is that they were probably deposited at less than abyssal depths in a high latitude sea and may have been redeposited by current action.

For Site 212 the calcareous sediments almost certainly have to be allochthonous. Two mechanisms for redeposition are postulated; turbidity currents probably were the major transporting agency during the last 12 million years (Cores 1 through 10). This is suggested by a general mixing of the sediment, so that the major proportion of the fossils becomes younger upward in the section, although there is a constant and significant proportion of older fossils mixed

Sample	*Arkhangelskiella* sp.	*Broinsonia parca*	*Cretarhabdus conicus*	*Cretarhabdus crenulatus*	*Micula decussata*	*Tetralithus aculeus*	*Tetralithus nitidus nitidus*	*Tetralithus nitidus trifidus*	*Tetralithus quadratus*	*Watznaueria barnesae*
211-12-2, 123 cm					X		X	X		
211-12-2, 146 cm		X			X	X	X	X	X	X
211-12-3, 25 cm		X			X	X	X	X	X	X
211-12, CC					X			X		X
211-13-1, 50 cm		X			X		X			
211-13-1, 80 cm		X			X	X	X			X
211-13-1, 100 cm					X					
211-13-1, 120 cm	X	X		X	X	X				X
211-13-1, 140 cm					X					X
211-13, CC		X	X		X		X			X
211-14-1, 58 cm		X			X	X	X		X	

Figure 1. *Checklist of calcareous nannofossils recovered at Site 211.*

in, but with a notable lack of sorting of the sediment. Prior to that time, redeposition probably was affected chiefly by bottom currents which eroded the calcareous sediments elsewhere and carried them in suspension as a nepheloid layer. The short time intervals represented by the considerable thicknesses of calcareous sediments of early middle Miocene, middle Eocene, and Late Cretaceous age: sorting of the sediments; and selective solution taken collectively suggest that all these sediments probably were deposited below the regional calcium carbonate compensation depth in a local pocket where for some peculiar reason the bottom waters were nearly saturated with calcium carbonate.

Sites 213 and 215 are treated together because their sedimentary history seems very similar even though they are on opposite sides of the Ninetyeast Ridge. The upper Miocene to Recent interval is represented by siliceous sediments; the lower Eocene to upper Miocene interval by barren zeolitic clays; and the lower Eocene to basement interval is calcareous. At each site the oldest sediment above basement is Paleocene in age. Towards the top of the calcareous interval, solution effects increase. It seems reasonable that the calcareous sediments at both of these sites were deposited above the calcium carbonate compensation depth, as there is no evidence of slumping or turbidity current deposition. Following the reasoning of Berger (1972), a likely model is that when the crust at these two sites was formed, it was at a much shallower depth in accordance with the crustal elevation-sea-floor spreading model of Menard (1969) and of Sclater, Anderson, and Bell (1971); and only after the crust had moved some distance from the spreading center, did it subside below the regional calcium carbonate compensation depth. If it is assumed that both sites originated at the average ridge crest elevation of 2700 meters and that subsidence occurred at a rate of 1000 meters during the first 10 m.y. and another 1000

Sample	Arkhangelskiella cymbiformis	Biscutum sp.	Broinsonia parca	Catinaster calyculus	Ceratolithus primus	Ceratolithus rugosus	Ceratolithus tricorniculatus	Chiasmolithus altus	Chiasmolithus expansus	Chiasmolithus grandis	Chiasmolithus oamaruensis	Chiasmolithus solitus	Chiasmolithus sp.	Coccolithus miopelagicus	Coccolithus pelagicus	Cretarhabdus conicus	Cribrosphaerella ehrenbergi	Cyclicargolithus floridanus	Cyclococcolithina formosa	Cyclococcolithina leptopora	Cyclococcolithina macintyrei	Cyclolithella nitescens	Discoaster asymmetricus	Discoaster barbadiensis	Discoaster bellus
212-1-1, top						X	X								X			X		X					
212-1, CC						X	X						X		X					X			X		
212-2-1, 25-26 cm						X	X											X							
212-2-4, 47-48 cm							X			X										X	X		X		
212-2-5, 105-106 cm						X	X			X								X							
212-2, CC						X	X																X		
212-3, CC					X		X			X										X					
212-4-1, 21-22 cm							X											X							X
212-4, CC							X			X								X							X
212-5-1, 40-41 cm							X			X								X							
212-5, CC							X			X								X							
212-6, CC					X		X											X						X	
212-7, CC				X			X			X								X		X					
212-8-1, 12-13 cm							X			X	X							X							
212-8-2, 3-4 cm																		X		X					
212-8-3, 5-6 cm																		X		X					
212-8, CC				X	X		X				X							X							
212-9-1, 97-98 cm							X											X		X			X		
212-9, CC											X							X		X					
212-10-1, 23-24 cm											X							X					X		
212-10-2, 10-11 cm																		X		X					
212-10-3, 6-7 cm																		X							
212-10-4, 10-11 cm																		X							
212-10-5, 12-13 cm																		X							
212-10-6, 10-11 cm																		X		X					
212-10, CC																		X		X					
212-11-2, 3-4 cm											X							X							
212-11, CC																		X							
212-12-2, 1-2 cm											X							X							
212-12, CC											X			X				X							
212-13-2, 1-2 cm																		X				X			
212-13, CC											X							X				X			
212-14-2, 0-1 cm																		X							
212-14, CC								X			X			X				X		X					
212-15-1, top																		X		X					
212-15-1, 33-34 cm																		X							
212-18, CC												X						X	X					X	
212-19-2, 6-8 cm										X		X							X						
212-19, CC										X		X													
212-20-1, 81-83 cm										X		X						X	X						
212-20, CC										X		X							X						
212-21-1, 0-2 cm										X		X												X	
212-21, CC										X		X							X						
212-22-2, 0-2 cm										X		X													
212-22, CC									X	X		X													
212-23-2, 0-2 cm										X		X							X						
212-23, CC										X		X												X	
212-24, CC									X			X							X						
212-25, CC									X			X							X						
212-26, CC									X	X		X							X					X	
212-27, CC												X													
212-29, CC	X	X	X													X									
212-31-6, 0-1 cm	X	X														X	X								
212-35, CC	X		X																						

Sample	Discoaster berggreni	Discoaster brouweri	Discoaster calculosus	Discoaster challengeri	Discoaster deflandrei	Discoaster exilis	Discoaster lodoensis	Discoaster neohamatus	Discoaster pentaradiatus	Discoaster quinqueramus	Discoaster saipanensis	Discoaster sublodoensis	Discoaster surculus	Discoaster tamalis	Discoaster tani	Discoaster variabilis	Discoaster variabilis decorus	Discoaster variabilis pansus	Eiffellithus turriseiffeli	Gephyrocapsa sp.	Helicopontosphaera granulata	Helicopontosphaera kamptneri	Isthmolithus recurvus	Kamptnerius magnificus	Lucianorhabdus cayeuxi
212-1-1, top		X							X				X	X		X						X			
212-1, CC		X							X				X	X		X				X		X			
212-2-1, 25-26 cm		X							X				X	X		X									
212-2-4, 47-48 cm		X								X			X	X		X									
212-2-5, 105-106 cm		X							X				X			X									
212-2, CC		X							X	X			X			X				X					
212-3, CC		X		X				X	X				X			X									
212-4-1, 21-22 cm		X						X	X				X			X									
212-4, CC		X							X				X			X									
212-5-1, 40-41 cm		X				X			X	X			X			X									
212-5, CC		X				X			X	X	X					X									
212-6, CC	X	X						X	X	X							X	X							
212-7, CC		X						X	X	X							X	X							
212-8-1, 12-13 cm		X							X	X						X									
212-8-2, 3-4 cm		X				X										X									
212-8-3, 5-6 cm		X							X	X						X									
212-8, CC		X							X							X					X				
212-9-1, 97-98 cm		X														X									
212-9, CC		X						X		X						X					X				
212-10-1, 23-24 cm									X							X									
212-10-2, 10-11 cm						X					X										X				
212-10-3, 6-7 cm						X																			
212-10-4, 10-11 cm					X	X																			
212-10-5, 12-13 cm																									
212-10-6, 10-11 cm												X													
212-10, CC																					X				
212-11-2, 3-4 cm			X			X																	X		
212-11, CC			X			X																			
212-12-2, 1-2 cm																									
212-12, CC			X			X																			
212-13-2, 1-2 cm																									
212-13, CC			X																						
212-14-2, 0-1 cm																									
212-14, CC																							X		
212-15-1, top																									
212-15-1, 33-34 cm						X																			
212-18, CC											X				X										
212-19-2, 6-8 cm																									
212-19, CC																									
212-20-1, 81-83 cm																									
212-20, CC																									
212-21-1, 0-2 cm																									
212-21, CC																									
212-22-2, 0-2 cm																									
212-22, CC																									
212-23-2, 0-2 cm																									
212-23, CC																									
212-24, CC																									
212-25, CC							X																		
212-26, CC																									
212-27, CC																									
212-29, CC																									X
212-31-6, 0-1 cm																			X					X	X
212-35, CC																			X					X	X

Sample	Microrhabdulus decoratus	Micula decussata	Nephrolithus frequens	Prediscosphaera cretacea	Pseudoemiliania lacunosa	Reticulofenestra pseudoumbilica	Reticulofenestra umbilica	Scyphosphaera amphora	Scyphosphaera sp.	Sphenolithus abies	Sphenolithus distentus	Sphenolithus heteromorphus	Sphenolithus pacificus	Sphenolithus predistentus	Tetralithus aculeus	Tetralithus nitidus nitidus	Tetralithus quadratus	Triquetrorhabdulus milowi	Triquetrorhabdulus rugosus	Watznaueria barnesae	Zygodiscus spiralis	Zygrhablithus bijugatus	Zygrhablithus bijugatus crassus
212-1-1, top					X	X	X		X	X													
212-1, CC					X	X	X		X	X													
212-2-1, 25-26 cm						X				X													
212-2-4, 47-48 cm						X	X			X													
212-2-5, 105-106 cm						X				X													
212-2, CC						X	X			X													
212-3, CC						X				X													
212-4-1, 21-22 cm						X				X													
212-4, CC						X				X													
212-5-1, 40-41 cm						X	X			X													
212-5, CC						X				X													
212-6, CC						X	X		X	X									X				
212-7, CC						X	X	X		X									X				
212-8-1, 12-13 cm										X													
212-8-2, 3-4 cm						X					X												
212-8-3, 5-6 cm						X	X			X	X												
212-8, CC						X	X			X	X								X				
212-9-1, 97-98 cm						X				X													
212-9, CC						X	X			X		X											
212-10-1, 23-24 cm						X	X			X													
212-10-2, 10-11 cm						X	X			X		X											
212-10-3, 6-7 cm							X			X		X											
212-10-4, 10-11 cm							X			X													
212-10-5, 12-13 cm							X			X		X											
212-10-6, 10-11 cm							X			X		X		X									
212-10, CC						X				X	X	X											
212-11-2, 3-4 cm										X	X	X						X					
212-11, CC						X	X			X	X	X											
212-12-2, 1-2 cm							X					X											
212-12, CC							X					X	X										
212-13-2, 1-2 cm										X		X											
212-13, CC							X					X											
212-14-2, 0-1 cm												X											
212-14, CC							X			X		X											
212-15-1, top							X			X		X											
212-15-1, 33-34 cm							X					X											
212-18, CC							X															X	
212-19-2, 6-8 cm							X																
212-19, CC							X																X
212-20-1, 81-83 cm							X																X
212-20, CC							X																X
212-21-1, 0-2 cm							X																X
212-21, CC							X																X
212-22-2, 0-2 cm							X																X
212-22, CC							X																X
212-23-2, 0-2 cm							X																X
212-23, CC							X																X
212-24, CC							X																X
212-25, CC							X																X
212-26, CC							X																X
212-27, CC							X																X
212-29, CC	X	X		X											X		X			X			
212-31-6, 0-1 cm		X	X	X												X	X			X			
212-35, CC		X	X	X																X	X		

Figure 2. *Checklist of calcareous nannofossils recovered at Site 212.*

Sample	*Cambylosphaera dela*	*Chiasmolithus bidens*	*Chiasmolithus californicus*	*Chiasmolithus consuetus*	*Chiasmolithus eograndis*	*Chiasmolithus grandis*	*Chiphragmalithus acanthodes*	*Cyclococcolithina robusta*	*Discoaster barbadiensis*	*Discoaster binodosus*	*Discoaster diastypus*	*Discoaster lenticularis*	*Discoaster lodoensis*	*Discoaster multiradiatus*	*Discoaster ornatus*	*Discoasteroides kuepperi*	*Discoasteroides megastypus*	*Ellipsolithus distichus*	*Ellipsolithus macellus*	*Fasciculithus tympaniformis*	*Heliorthus distentus*	*Sphenolithus anarrhopus*	*Sphenolithus moriformis*	*Sphenolithus radians*	*Toweius craticulus*	*Toweius eminens*	*Tribrachiatus orthostylus*	*Zygodiscus sigmoides*
213-14-5, 3-4 cm													X														X	
213-14-5, 50-51 cm									X				X			X											X	
213-14-5, 100-101 cm									X				X														X	
213-14-6, 10-11 cm									X				X														X	
213-14-6, 50-51 cm									X				X										X				X	
213-14-6, 100-101 cm									X		X		X										X	X			X	
213-14-6, 140-141 cm	X					X			X		X		X										X	X			X	
213-14, CC	X										X		X											X			X	
213-15-1, 120-121 cm	X		X				X				X		X											X			X	
213-15-3, 2-3 cm	X		X				X			X	X		X			X	X							X		X	X	
213-15-4, 25-26 cm	X		X				X				X		X			X	X		X					X		X	X	
213-15-4, 70-71 cm			X				X			X	X					X			X					X		X	X	
213-15-5, 9-10 cm	X		X		X					X	X			X		X			X			X	X	X		X	X	
213-15-6, 32-33 cm		X	X		X						X		X	X		X	X		X				X			X	X	
213-15, CC			X		X						X			X				X	X		X			X			X	
213-16-1, 89-90 cm			X	X	X									X				X		X			X		X			X
213-16-2, 4-5 cm	X		X	X	X									X	X			X		X					X	X		X
213-16-3, 25-26 cm		X	X		X									X	X					X					X			X
213-16-4, 18-19 cm	X	X		X	X									X	X				X	X					X	X		X
213-16, CC		X	X			X						X		X	X								X			X		X
213-17-1, 120 cm		X	X					X							X				X	X		X				X		

Figure 3. *Checklist of calcareous nannofossils recovered at Site 213.*

meters during the subsequent 26 m.y. (see Berger, 1972), the approximate depth of the calcium carbonate compensation level at the time when calcareous sediments ceased to accumulate at these sites can be roughly estimated. Based on paleontological data, calcareous sediments accumulated at Site 213 for about 8 m.y. after initial formation of the crust and at Site 215 for about 11 m.y. Total sediment thickness at the two sites is the same, and it can probably be assumed, therefore, that the 300-meter difference in depth at the two sites reflects original irregularities of ridge elevation when they were formed. Thus, Site 215, which accumulated calcareous sediments for about 3 m.y. longer than Site 213 started out some 300 meters shallower than the latter site. If an average of 10 m.y. for the calcareous sediment accumulation period at the two sites (a most convenient figure, indeed) is assumed, then it follows that calcareous sediments ceased to accumulate when these sites dropped to a depth of about 3700 meters. Or, putting it another way, the regional calcium carbonate compensation depth was at a depth of about 3700 meters about 40 m.y. ago.

It is noteworthy that lower latitude pelagic sediments of this same age are characterized by siliceous sediments and by chert, especially in the Atlantic Ocean, a feature lacking at Site 213 and developed weakly at Site 215. Although the above two sites are now in tropical latitudes, a more southerly latitude is implied for these sites in most reconstructions of the proto-Indian ocean.

Sites 214, 216, and 217 were all drilled along the crest of Ninetyeast Ridge. At all three of these sites presumably a complete section was penetrated, although continuous coring was done only at Site 214. A nearly complete Tertiary zonal succession can be recognized at Site 214, and of the two zones not recognized, one, the mid-Pliocene *Discoaster asymmetricus* Zone, frequently is difficult to recognize elsewhere in pelagic sections. Moreover, the missing zone falls between two cores, and it is entirely possible that the interval containing this zone was lost during coring. The second zone not recognized at Site 214 is the mid-Oligocene *Sphenolithus predistentus* Zone. In this case the missing zone falls within a core, and its absence either represents a hiatus or inadequate development of the *Sphenolithus* lineage on which is based the recognition of this zone. At Site 216, and, to a lesser extent, Site 217, this zone is developed. Most of the zones not recognized at Sites 216 and 217 correspond to uncored intervals or to intervals where recovery was poor.

At each of the above three sites shoaling can be recognized as basement is approached. It appears that at the time of formation of the crust at these sites, the crest of Ninetyeast Ridge was at or near sea level. It is of interest, therefore, that members of the family Braarudosphaeradae are sparce in the early Tertiary sediments at Site 214. At this site Paleocene and lower Eocene sediments were deposited in what is interpreted to be a lagoonal or shelf-like environment. Elsewhere, as in California (Sullivan, 1964, 1965), sediments of this age and bathymetric range contain diverse assemblages of pentaliths, and the same is true of lower, middle, and upper Eocene sediments elsewhere (Bouché, 1962; Levin and Joerger, 1967; Bramlette and Sullivan, 1961; Bybell and Gartner, 1972). It may be significant that all of the lower Tertiary nannofloras with diverse pentalith assemblages are from regions which had a subtropical to temperate climate, while all of the Ninetyeast Ridge sites, including Site 214, probably originated at relatively higher latitudes or were under the influence of high latitude oceanic conditions.

For Sites 216 and 217, no clear ecological inferences can be made from the oldest calcareous nannofossils above basement. It is unclear whether the low diversity recorded is due entirely to the scarcity of nannofossils in the samples, or whether it also is attributable to shallow water conditions or high latitude.

The nannofossils from Site 218 are precisely what might be expected in an open ocean area that receives a great deal of clastic sediment. The normal pelagic contribution is diluted by the clastic sediments being transported to the ocean floor by turbid flows and in suspension. Thus the abundance of nannofossils is related inversely to grain size and directly to carbonate content. In the case of Site 218, sufficient nannofossils were recovered to permit adequate biostratigraphic determinations.

CRETACEOUS-TERTIARY BOUNDARY

At Sites 216 and 217 on Ninetyeast Ridge the Cretaceous-Tertiary boundary was penetrated, and at Site 216 relatively undisturbed sediment was recovered across this boundary (Figure 10). The sediment above about 103 cm is uniform in texture, and color changes are gradational. Between 103 and 114 cm light buff to white chalk fragments, mottled and covered with green specks, float in a matrix of faintly and irregularly banded brownish gray chalk. Below about 107 cm the white chalk fragments lack the green specks, are irregular in size, and flattened horizontally. Below 130 cm the dark bands make up an even smaller proportion, and the white chalk fragments become more massive. Nannofossil assemblages from a selected sample in the vicinity of the Cretaceous-Tertiary boundary are as follows.

22-216-23-2; 108 cm; brownish-buff chalk

Chiasmolithus danicus, Cruciplacolithus helis, Micula sp., *Makalius reinhardti, Zygodiscus sigmoides, Cribrosphaerella* sp., *Markalius astroporus*, numerous small and some medium-sized placoliths variously assigned to the genera *Ericsonia, Biscutum, Marlkalius, Coccolithus.* Predominantly Danian assemblage with some Maastrichtian contaminants.

109 cm; dark layer in chalk

Cuiciplacolithus helis, Markalius reinhardti, Zygodiscus sigmoides, Chiasmolithus danicus, Watznaueria barnesae, many small unidentifiable placolith as at 108 cm. Predominantly Danian assemblage with some Maastrichtian contaminants.

110 cm; white chalk fragment covered with fine green layer, in brownish-buff chalk

Micula sp., *Watznaueria barnesae, Arkhangelskiella cymbiformia, Cylindralithus gallicus, Lithraphidites quadratus, Cretarhabdus* sp., *Prediscosphaera cretacea*, much unidentifiable debris. Maastrichtian assemblage.

117 cm; dark layer in brownish-buff chalk

Zygodiscus sigmoides, Chiasmolithus danicus, Micula sp., *Lithraphidites quadratus, Cruciplacolithus helis, Arkhangelskiella cymbiformis, Markalius astroporus, Markalius reinhardti, Prediscosphaera cretacea,* numerous small, unidentifiable placoliths. Predominantly Danian assemblage with some Maastrichtian contaminants.

139 cm; white chalk in mottled interval

Micula sp., *Watznaueria barnesae, Lithraphidites quadratus, Arkhangelskiella cymbiforms, Nephrolithus frequens, Cretarhabdus* sp., much unidentifiable debris. Late Maastrichtian assemblage.

The sediments above 103 cm consist largely of unidentifiable debris with predominantly Danian age nannofossils admixed with very few Maastrichtian specimens. The matrix and bands below 103 cm have a similar composition and age. The nannofossils indicate that the Danian age sediment at this site is not the oldest known Tertiary although it is early Danian (M.N. Bramlette, personal communication). The white chalk fragments below 103 cm also consist chiefly of unidentifiable debris and contain late Maastrichtian nannofossil assemblages, including *Nephrolithus frequens* and *Cylindralithus gallicus.* Thus, on the Ninetyeast Ridge, as seemingly everywhere in the marine realm, the youngest Cretaceous sediments are separated by a hiatus from the oldest Tertiary sediments.

Some novel and ingenious explanations have been offered for the widespread occurrence of this hiatus. In this particular instance the evidence seems to indicate that during the interval of nondeposition the chemistry of the ocean water in this region was such as to favor lithification of the late Maastrichtian sediments. It is obvious from the sedimentary structures in the core that the Maastrichtian sediments were relatively firm at the time when calcareous sediments again started to accumulate in early Danian time. Some solution of Maastrichtian chalk no doubt occurred during the interval represented by the hiatus, but the age of the highest Maastrichtian sediment indicates that relatively little material was lost. Indeed, most of the hiatus represents nondeposition rather than solution. According to Worsley's (1971) model of the terminal Cretaceous event the relatively short duration of noncarbonate deposition at Site 216 would require that the site be located at a relatively shallow depth. This seems to be borne out by the late Maastrichtian age of the oldest pelagic sediments above basement recovered at this site and the fact that immediately above basement the sediment indicates a lagoonal or shallow shelf environment.

Sample	Braarudosphaera bigelowi	Bramletteius serraculoides	Catinaster calyculus	Catinaster coalitus	Ceratolithus amplificus	Ceratolithus primus	Ceratolithus rugosus	Ceratolithus tricorniculatus	Chiasmolithus bidens	Chiasmolithus californicus	Chiasmolithus consuetus	Chiasmolithus gigas	Chiasmolithus grandis	Chiasmolithus solitus	Chiasmolithus titus	Chiphragmalithus acanthodes	Chiphragmalithus sp.	Coccolithus pelagicus	Cruciplacolithus tenuis	Cyclicargolithus floridanus	Cyclicargolithus marismontium	Cyclicargolithus reticulatus	Cyclococcolithina formosa
214-1-1, 8-10 cm																							
214-1-2, 0-2 cm																							
214-1-3, top																							
214-1-4, top																							
214-1-5, top																							
214-1-6, top																							
214-1, CC																							
214-2-2, top																							
214-2-3, top																							
214-2-4, top																							
214-2-5, top																							
214-2, CC																							
214-3-1, 8-9 cm																							
214-3-2, 11-12 cm																							
214-3-3, 2-3 cm																		X					
214-3-4, 2-3 cm							X											X					
214-3-5, 18-19 cm																		X					
214-3-6, 2-3 cm							X											X					
214-3, CC																							
214-4-1, top																		X					
214-4-2, 2-3 cm																		X					
214-4-3, 2-3 cm																		X					
214-4-4, 2-3 cm																		X					
214-4-5, 2-3 cm							X																
214-4-6, 2-3 cm							X											X					
214-4, CC																							
214-5-1, 2-3 cm																		X					
214-5-3, 2-3 cm																							
214-5-4, 2-3 cm							X																
214-5-5, top							X																
214-5-6, 22-23 cm																							
214-5, CC																							
214-6-1, 1-2 cm							X																
214-6-2, 2-3 cm																							
214-6-3, 2-3 cm							X																
214-6-4, 3-4 cm							X																
214-6, CC							X																
214-7-1, 5-6 cm							X																
214-7, CC							X																
214-8-2, 2-3 cm							X																
214-8-4, 12-13 cm							X																
214-8, CC							X																
214-9-1, 2-3 cm								X															
214-9-4, 12-13 cm							X	X									X						
214-9, CC							X	X															
214-10-1, 2-3 cm								X										X					
214-10-4, 12-13 cm								X										X					
214-10-5, 5-6 cm								X										X					

Sample	Cyclococcolithina gammation	Cyclococcolithina leptopora	Cyclococcolithina macintyrei	Cyclococcolithina robusta	Cyclolithella nitescens	Discoaster asymmetricus	Discoaster barbadiensis	Discoaster bellus	Discoaster binodosus	Discoaster brouweri	Discoaster calculosus	Discoaster challengeri	Discoaster exilis	Discoaster hamatus	Discoaster lodoensis	Discoaster mirus	Discoaster multiradiatus	Discoaster neohamatus	Discoaster neorectus	Discoaster pentaradiatus	Discoaster quinqueramus	Discoaster saipanensis	Discoaster spp.
214-1-1, 8-10 cm																							
214-1-2, 0-2 cm																							
214-1-3, top																							
214-1-4, top																							
214-1-5, top																							
214-1-6, top																							
214-1, CC																							
214-2-2, top																							
214-2-3, top																							
214-2-4, top																							
214-2-5, top																							
214-2, CC																							
214-3-1, 8-9 cm			X																				
214-3-2, 11-12 cm			X																				
214-3-3, 2-3 cm										X													
214-3-4, 2-3 cm			X							X													
214-3-5, 18-19 cm			X							X													
214-3-6, 2-3 cm										X													
214-3, CC										X													
214-4-1, top		X	X							X													
214-4-2, 2-3 cm		X	X			X				X										X			
214-4-3, 2-3 cm						X				X										X			
214-4-4, 2-3 cm		X	X							X										X			
214-4-5, 2-3 cm		X	X			X				X										X			
214-4-6, 2-3 cm		X	X			X				X										X			
214-4, CC						X				X										X			
214-5-1, 2-3 cm			X			X				X										X			
214-5-3, 2-3 cm		X				X				X										X			
214-5-4, 2-3 cm		X				X				X		X								X			
214-5-5, top		X				X				X										X			
214-5-6, 22-23 cm						X				X										X			
214-5, CC						X				X		X								X			
214-6-1, 1-2 cm						X				X		X								X			
214-6-2, 2-3 cm		X				X				X										X			
214-6-3, 2-3 cm		X				X				X										X			
214-6-4, 3-4 cm		X				X				X										X			
214-6, CC						X				X										X			
214-7-1, 5-6 cm		X				X				X										X			
214-7, CC						X				X										X			
214-8-2, 2-3 cm		X				X				X										X			
214-8-4, 12-13 cm						X				X										X			
214-8, CC						X				X										X			
214-9-1, 2-3 cm		X								X										X			
214-9-4, 12-13 cm		X								X										X			
214-9, CC										X													
214-10-1, 2-3 cm		X								X		X								X			
214-10-4, 12-13 cm		X								X										X			
214-10-5, 5-6 cm		X								X										X			

Sample	Discoaster sublodoensis	Discoaster surculus	Discoaster tamalis	Discoaster tani	Discoaster variabilis	Discoaster variabilis decorus	Discoaster variabilis pansus	Discoasteroides kuepperi	Emiliania huxleyi	Fasciculithus tympaniformis	Gephyrocapsa oceanica	Gephyrocapsa sp.	Hayella situliformis	Helicopontosphaera heezeni	Heliolithus kleinpelli	Heliorthus concinnus	Heliorthus fallax	Leptodiscus larvalis	Lophodolithus nascens	Nannotetrina alata	Oolithotus antillarum	Peritrachelina sp.	Pseudoemiliania lacunosa
214-1-1, 8-10 cm									X		X												
214-1-2, 0-2 cm									cf		X												
214-1-3, top											X												
214-1-4, top											X												
214-1-5, top											X												
214-1-6, top																							X
214-1, CC											X												X
214-2-2, top											X												X
214-2-3, top											X												X
214-2-4, top											X												X
214-2-5, top											X												X
214-2, CC											X												X
214-3-1, 8-9 cm												X											X
214-3-2, 11-12 cm												X											X
214-3-3, 2-3 cm																							X
214-3-4, 2-3 cm																							X
214-3-5, 18-19 cm																							X
214-3-6, 2-3 cm																							X
214-3, CC																							X
214-4-1, top																							X
214-4-2, 2-3 cm		X																					X
214-4-3, 2-3 cm		X																					X
214-4-4, 2-3 cm		X	X																				X
214-4-5, 2-3 cm		X	X																				X
214-4-6, 2-3 cm		X	X																				X
214-4, CC		X																					X
214-5-1, 2-3 cm		X	X																				X
214-5-3, 2-3 cm		X	X																				X
214-5-4, 2-3 cm		X																					X
214-5-5, top		X	X																				X
214-5-6, 22-23 cm		X			X																		X
214-5, CC		X	X																				X
214-6-1, 1-2 cm		X	X			\	X																X
214-6-2, 2-3 cm		X	X			X																	X
214-6-3, 2-3 cm		X				X	X																X
214-6-4, 3-4 cm		X				X															X		X
214-6, CC		X																					
214-7-1, 5-6 cm		X			X																		
214-7, CC		X			X																		
214-8-2, 2-3 cm		X				X																	
214-8-4, 12-13 cm		X				X																	
214-8, CC		X																					
214-9-1, 2-3 cm		X				X																	
214-9-4, 12-13 cm		X				X																	
214-9, CC		X				X																	
214-10-1, 2-3 cm		X				X																	
214-10-4, 12-13 cm		X				X	X																
214-10-5, 5-6 cm		X				X																	

Sample	Reticulofenestra pseudoumbilica	Reticulofenestra samodurovi	Reticulofenestra scissura	Reticulofenestra umbilica	Sphenolithus abies	Sphenolithus belemnos	Sphenolithus ciperoensis	Sphenolithus distentus	Sphenolithus furcatolithoides	Sphenolithus heteromorphus	Sphenolithus predistentus	Sphenolithus pseudoradians	Sphenolithus radians	Thoracosphaera oblonga	Toweius bisulcus	Toweius eminens	Toweius sp.	Toweius spp.	Triquetrorhabdulus carinatus	Triquetrorhabdulus rugosus	Zygodiscus sigmoides	Zygrhablithus bijugatus	Zygrhablithus bijugatus crassus
214-1-1, 8-10 cm																							
214-1-2, 0-2 cm																							
214-1-3, top																							
214-1-4, top																							
214-1-5, top																							
214-1-6, top																							
214-1, CC																							
214-2-2, top																							
214-2-3, top																							
214-2-4, top																							
214-2-5, top																							
214-2, CC																							
214-3-1, 8-9 cm																							
214-3-2, 11-12 cm																							
214-3-3, 2-3 cm																							
214-3-4, 2-3 cm																							
214-3-5, 18-19 cm																							
214-3-6, 2-3 cm																							
214-3, CC																							
214-4-1, top																							
214-4-2, 2-3 cm																							
214-4-3, 2-3 cm																							
214-4-4, 2-3 cm																							
214-4-5, 2-3 cm																							
214-4-6, 2-3 cm																							
214-4, CC																							
214-5-1, 2-3 cm																							
214-5-3, 2-3 cm																							
214-5-4, 2-3 cm																							
214-5-5, top																							
214-5-6, 22-23 cm																							
214-5, CC																							
214-6-1, 1-2 cm																							
214-6-2, 2-3 cm																							
214-6-3, 2-3 cm					X																		
214-6-4, 3-4 cm	X				X																		
214-6, CC	X				X																		
214-7-1, 5-6 cm	X				X																		
214-7, CC	X				X																		
214-8-2, 2-3 cm	X				X																		
214-8-4, 12-13 cm	X				X																		
214-8, CC	X				X																		
214-9-1, 2-3 cm	X				X																		
214-9-4, 12-13 cm	X				X																		
214-9, CC	X				X																		
214-10-1, 2-3 cm	X				X																		
214-10-4, 12-13 cm	X				X																		
214-10-5, 5-6 cm	X				X																		

Figure 4. *Checklist of calcareous nannofossils recovered at Site 214.*

Sample	Braarudosphaera bigelowi	Bramletteius serraculoides	Catinaster calyculus	Catinaster coalitus	Ceratolithus amplificus	Ceratolithus primus	Ceratolithus rugosus	Ceratolithus tricorniculatus	Chiasmolithus bidens	Chiasmolithus californicus	Chiasmolithus consuetus	Chiasmolithus gigas	Chiasmolithus grandis	Chiasmolithus solitus	Chiasmolithus titus	Chiphragmalithus acanthodes	Chiphragmalithus sp.	Coccolithus pelagicus	Cruciplacolithus tenuis	Cyclicargolithus floridanus	Cyclicargolithus marismontium	Cyclicargolithus reticulatus	Cyclococcolithina formosa
214-10-6, 19-20 cm								X															
214-10, CC						X		X										X					
214-11-1, 12-13 cm								X															
214-11, CC								X															
214-12-1, 56-57 cm					cf			X										X					
214-12, CC								X															
214-13-2, 2-3 cm								X															
214-13-3, 2-3 cm								X															
214-13-5, 7-8 cm																							
214-13, CC																		X					
214-14-1, 2-3 cm																		X					
214-14-3, 11-12 cm																		X					
214-14-5, 11-12 cm																		X					
214-14, CC																		/					
214-15-2, 2-3 cm																		/					
214-15, CC																		X					
214-16-1, 2-3 cm																		X					
214-16, CC																		X					
214-17-1, 5-6 cm																		X					
214-17-2, 4-5 cm			X															X					
214-17-3, 2-3 cm			X																				
214-17-5, 2-3 cm			X																				
214-17-6, 2-3 cm			X																				
214-17, CC				X														X					
214-18-1, 47-48 cm				X														X					
214-18-2, 5-6 cm				X														X					
214-18, CC				X														X					
214-19-1, 91-92 cm																		X		X			
214-19, CC																				X			
214-20-1, 3-4 cm																		X		X			
214-20, CC																		X		X			
214-21-1, top																		X		X			
214-21, CC																		X		X			
214-22-1, 2-3 cm																		X		X			
214-22-2, 2-3 cm																				X			
214-22-3, 95-96 cm																				X			
214-22, CC																				X			
214-23-2, 3-4 cm																				X			
214-23-3, 2-3 cm																							
214-23-4, 3-4 cm																							
214-23-5, 27-28 cm																							
214-23, CC																				X			
214-24-1, top																		X		X			
214-24-2, 2-3 cm																		X		X			
214-24-4, top																		X		X			
214-24, CC																				X			
214-25-2, top																		X		X			
214-25, CC																				X			

Sample	Cyclococcolithina gammation	Cyclococcolithina leptopora	Cyclococcolithina macintyrei	Cyclococcolithina robusta	Cyclolithella nitescens	Discoaster asymmetricus	Discoaster barbadiensis	Discoaster bellus	Discoaster binodosus	Discoaster brouweri	Discoaster calculosus	Discoaster challengeri	Discoaster exilis	Discoaster hamatus	Discoaster lodoensis	Discoaster mirus	Discoaster multiradiatus	Discoaster neohamatus	Discoaster neorectus	Discoaster pentaradiatus	Discoaster quinqueramus	Discoaster saipanensis	Discoaster spp.
214-10-6, 19-20 cm		X						X		X										X			
214-10, CC								X		X													
214-11-1, 12-13 cm		X						X		X										X			
214-11, CC								X		X										X			
214-12-1, 56-57 cm								X												X	X		
214-12, CC								X		X										X			
214-13-2, 2-3 cm		X						X		X													
214-13-3, 2-3 cm		X						X											X				
214-13-5, 7-8 cm		X						X										X	X		X		
214-13, CC		X						X		X								X					
214-14-1, 2-3 cm		X						X										X	X				
214-14-3, 11-12 cm		/						X										X	X		X		
214-14-5, 11-12 cm		X						X										X	X				
214-14, CC		X						X										X	X				
214-15-2, 2-3 cm		X						X										X	X				
214-15, CC		X						X										X	X	X			
214-16-1, 2-3 cm		X																X	X				
214-16, CC		X																X	X				
214-17-1, 5-6 cm																		X					
214-17-2, 4-5 cm														X				X					
214-17-3, 2-3 cm														X				X					
214-17-5, 2-3 cm		X												X									
214-17-6, 2-3 cm														X									
214-17, CC														X									
214-18-1, 47-48 cm		X											X	X				X					
214-18-2, 5-6 cm		X																					
214-18, CC													cf										
214-19-1, 91-92 cm		X			X								X										X
214-19, CC		X			X																		X
214-20-1, 3-4 cm		X			X								X										
214-20, CC		X			X								X										X
214-21-1, top					X								X										
214-21, CC																							
214-22-1, 2-3 cm											cf												
214-22-2, 2-3 cm					X																		
214-22-3, 95-96 cm					X						X												
214-22, CC					X						X												
214-23-2, 3-4 cm					X						X												
214-23-3, 2-3 cm																							
214-23-4, 3-4 cm																							
214-23-5, 27-28 cm																							
214-23, CC																							
214-24-1, top					X						X												
214-24-2, 2-3 cm					X																		
214-24-4, top					X						X												
214-24, CC					X																		
214-25-2, top																							
214-25, CC					X																		

Sample	Discoaster sublodoensis	Discoaster surculus	Discoaster tamalis	Discoaster tani	Discoaster variabilis	Discoaster variabilis decorus	Discoaster variabilis pansus	Discoasteroides kuepperi	Emiliania huxleyi	Fasciculithus tympaniformis	Gephyrocapsa oceanica	Gephyrocapsa sp.	Hayella situliformis	Helicopontosphaera heezeni	Heliolithus kleinpelli	Heliorthus concinnus	Heliorthus fallax	Leptodiscus larvalis	Lophodolithus nascens	Nannotetrina alata	Oolithotus antillarum	Peritrachelina sp.	Pseudoemiliania lacunosa
214-10-6, 19-20 cm		X				X																	
214-10, CC		X				X																	
214-11-1, 12-13 cm		X				X	X																
214-11, CC		X				X	X																
214-12-1, 56-57 cm		X					X																
214-12, CC		X																					
214-13-2, 2-3 cm		X																					
214-13-3, 2-3 cm		X					X																
214-13-5, 7-8 cm		X				X																	
214-13, CC		X					X																
214-14-1, 2-3 cm		X				X																	
214-14-3, 11-12 cm		X																					
214-14-5, 11-12 cm		X				X	X																
214-14, CC		X				X																	
214-15-2, 2-3 cm						X																	
214-15, CC						X																	
214-16-1, 2-3 cm							X																
214-16, CC						X																	
214-17-1, 5-6 cm						X																	
214-17-2, 4-5 cm						X																	
214-17-3, 2-3 cm							X																
214-17-5, 2-3 cm						X	X																
214-17-6, 2-3 cm																							
214-17, CC						X																	
214-18-1, 47-48 cm																							
214-18-2, 5-6 cm																							
214-18, CC																							
214-19-1, 91-92 cm																							
214-19, CC																							
214-20-1, 3-4 cm																							
214-20, CC																							
214-21-1, top																							
214-21, CC																							
214-22-1, 2-3 cm																							
214-22-2, 2-3 cm																							
214-22-3, 95-96 cm																							
214-22, CC																							
214-23-2, 3-4 cm																							
214-23-3, 2-3 cm																							
214-23-4, 3-4 cm																							
214-23-5, 27-28 cm																							
214-23, CC																							
214-24-1, top																							
214-24-2, 2-3 cm																							
214-24-4, top																							
214-24, CC																							
214-25-2, top																							
214-25, CC																							

Sample	Reticulofenestra pseudoumbilica	Reticulofenestra samodurovi	Reticulofenestra scissura	Reticulofenestra umbilica	Sphenolithus abies	Sphenolithus belemnos	Sphenolithus ciperoensis	Sphenolithus distentus	Sphenolithus furcatolithoides	Sphenolithus heteromorphus	Sphenolithus predistentus	Sphenolithus pseudoradians	Sphenolithus radians	Thoracosphaera oblonga	Toweius bisulcus	Toweius eminens	Toweius sp.	Toweius spp.	Triquetrorhabdulus carinatus	Triquetrorhabdulus rugosus	Zygodiscus sigmoides	Zygrhablithus bijugatus	Zygrhablithus bijugatus crassus
214-10-6, 19-20 cm	X				X																		
214-10, CC																							
214-11-1, 12-13 cm	X				X																		
214-11, CC	X				X																		
214-12-1, 56-57 cm	X				X																		
214-12, CC	X				X																		
214-13-2, 2-3 cm	X				X																		
214-13-3, 2-3 cm	X				X																		
214-13-5, 7-8 cm																				X			
214-13, CC																				X			
214-14-1, 2-3 cm					X																		
214-14-3, 11-12 cm					X																		
214-14-5, 11-12 cm					X															X			
214-14, CC					X															X			
214-15-2, 2-3 cm													X							X			
214-15, CC													X							X			
214-16-1, 2-3 cm					X															X			
214-16, CC	X				X																		
214-17-1, 5-6 cm	X				X															X			
214-17-2, 4-5 cm	X				X																		
214-17-3, 2-3 cm	X				X																		
214-17-5, 2-3 cm	X				X															X			
214-17-6, 2-3 cm																							
214-17, CC	X				X															X			
214-18-1, 47-48 cm	X				X															X			
214-18-2, 5-6 cm	X				X															X			
214-18, CC	X				X															X			
214-19-1, 91-92 cm	X				X															X			
214-19, CC	X				X															X			
214-20-1, 3-4 cm				X	X																		
214-20, CC					X																		
214-21-1, top										X													
214-21, CC										X													
214-22-1, 2-3 cm										X													
214-22-2, 2-3 cm						X																	
214-22-3, 95-96 cm						X																	
214-22, CC						X																	
214-23-2, 3-4 cm						X																	
214-23-3, 2-3 cm																			cf				
214-23-4, 3-4 cm																			cf				
214-23-5, 27-28 cm																			X				
214-23, CC						X													X				
214-24-1, top					X	X													X				
214-24-2, 2-3 cm					X		X																X
214-24-4, top					X		X																X
214-24, CC							X																X
214-25-2, top							X																X
214-25, CC			X				X	X															X

Figure 4. *(Continued)*.

Sample	Braarudosphaera bigelowi	Bramletteius serraculoides	Catinaster calyculus	Catinaster coalitus	Ceratolithus amplificus	Ceratolithus primus	Ceratolithus rugosus	Ceratolithus tricorniculatus	Chiasmolithus bidens	Chiasmolithus californicus	Chiasmolithus consuetus	Chiasmolithus gigas	Chiasmolithus grandis	Chiasmolithus solitus	Chiasmolithus titus	Chiphragmalithus acanthodes	Chiphragmalithus sp.	Coccolithus pelagicus	Cruciplacolithus tenuis	Cyclicargolithus floridanus	Cyclicargolithus marismontium	Cyclicargolithus reticulatus	Cyclococcolithina formosa	Cyclococcolithina gammation	Cyclococcolithina leptopora	Cyclococcolithina macintyrei	Cyclococcolithina robusta	Cyclolithella nitescens	Discoaster asymmetricus	Discoaster barbadiensis	Discoaster bellus	Discoaster binodosus	Discoaster brouweri	Discoaster calculosus	Discoaster challengeri	Discoaster exilis	Discoaster hamatus	Discoaster lodoensis	Discoaster mirus	Discoaster multiradiatus	Discoaster neohamatus	Discoaster neorectus	Discoaster pentaradiatus	Discoaster quinqueramus	Discoaster saipanensis	Discoaster spp.
214-26-2, top																				X								X																		
214-26-3, top																																														
214-26-5, top																																														
214-26-6, top																				X								X																		
214-26, CC																				X								X																		
214-27-1, top		X																					X																							
214-27-5, top		X																					X																							
214-27-6, top		X																					X																							
214-27, CC		X																				X	X							X															X	
214-28-2, top		X																					X							X															X	
214-28-5, 4-5 cm		X																					X							X															X	
214-28, CC		X																				X	X							X															X	
214-29-2, top		X											X										X					X		X															X	
214-29, CC		X											X		X								X							X															X	
214-30-1, 2-3 cm		X											X										X							X		X														
214-30, CC		X											X										X							X		X														
214-31-1, 2-3 cm		X											X		X								X							X		X														
214-31-4, 25-26 cm		X											X	X									X									X														
214-31, CC													X	X									X	X						X									X							
214-32-1, top											X	X	X								X		X							X																
214-32-4, 1-2 cm											X	X	X	X							X		X							X																
214-32, CC											X	X	X								X		X							X																
214-33-1, 1-2 cm	X												X	X			X				X		X							X																
214-33, CC	X												X	X		X					X		X	X						X																
214-34-1, 2-3 cm	X												X										X							X								X								
214-34-4, 2-3 cm	X												X										X	X						X								X								
214-34-5, 4-5 cm	X									X			X										X	X						X								X								
214-34, CC													X										X	X														X								
214-35-1, 44-45 cm	X												X																									X		X						
214-35-3, 15-16 cm	X									X			X										X	X						X								X								
214-35-4, 5-6 cm										X	X		X										X	X														X								
214-35-4, 148-149 cm																																														
214-35, CC										X	X		X						X																											
214-36-2, 9-10 cm									X														X	X						cf																
214-36-4, top									X																																					
214-37-1, 5-6 cm									X																		X																			
214-37, CC									X																																					
214-38-2, 8-9 cm									X																																					
214-38-3, top									X																																					
214-38-4, top									X																																					
214-38, CC									X																																					
214-39-2, top									X																																					
214-39-3, 12-13 cm									X																																					
214-39, CC																																														
214-40-2, top									X																																					
214-40, CC									X																																					
214-41-3, 19-20 cm									X																																					
214-41, CC									X																																					

Sample	Discoaster sublodoensis	Discoaster surculus	Discoaster tamalis	Discoaster tani	Discoaster variabilis	Discoaster variabilis decorus	Discoaster variabilis pansus	Discoasteroides kuepperi	Emiliania huxleyi	Fasciculithus tympaniformis	Gephyrocapsa oceanica	Gephyrocapsa sp.	Hayella situliformis	Helicopontosphaera heezeni	Heliolithus kleinpelli	Heliorthus concinnus	Heliorthus fallax	Leptodiscus larvalis	Lophodolithus nascens	Nannotetrina alata	Oolithotus antillarum	Peritrachelina sp.	Pseudoemiliania lacunosa	Reticulofenestra pseudoumbilica	Reticulofenestra samodurovi	Reticulofenestra scissura	Reticulofenestra umbilica	Sphenolithus abies	Sphenolithus belemnos	Sphenolithus ciperoensis	Sphenolithus distentus	Sphenolithus furcatolithoides	Sphenolithus heteromorphus	Sphenolithus predistentus	Sphenolithus pseudoradians	Sphenolithus radians	Thoracosphaera oblonga	Toweius bisulcus	Toweius eminens	Toweius sp.	Toweius spp.	Triquetrorhabdulus carinatus	Triquetrorhabdulus rugosus	Zygodiscus sigmoides	Zygrhablithus bijugatus	Zygrhablithus bijugatus crassus
214-26-2, top				X																						X					X			X	X											X
214-26-3, top																																														
214-26-5, top																																														
214-26-6, top				X																						X					X			X	X											X
214-26, CC				X																						X	X				X			X	X											X
214-27-1, top				X									X									X				X	X																			X
214-27-5, top				X									X									X				X	X								X											X
214-27-6, top				X									X													X	X								X											X
214-27, CC				X									X													X	X								X		X									X
214-28-2, top				X									X													X	X										X									X
214-28-5, 4-5 cm				X									X													X	X								X											X
214-28, CC				X									X													X	X								X		X									X
214-29-2, top				X									X													X	X								X											X
214-29, CC				X										X				X								X	X																			X
214-30-1, 2-3 cm																											X					X					X									X
214-30, CC																											X					X				X	X									X
214-31-1, 2-3 cm																		X									X					X														X
214-31-4, 25-26 cm																				X					X		X					X				X										X
214-31, CC																				X					X							X				X										X
214-32-1, top																				X					X							X				X										X
214-32-4, 1-2 cm																				X					X							X														X
214-32, CC																				X					X							X				X										X
214-33-1, 1-2 cm	X																																													X
214-33, CC	X																																			X										X
214-34-1, 2-3 cm																																				X										X
214-34-4, 2-3 cm																																				X										X
214-34-5, 4-5 cm								X																																						X
214-34, CC																																				X										X
214-35-1, 44-45 cm																			X																											
214-35-3, 15-16 cm																			X																	X				X						X
214-35-4, 5-6 cm																																						X		X						X
214-35-4, 148-149 cm																																														
214-35, CC																	X																			X		X								X
214-36-2, 9-10 cm																																							X	X					X	
214-36-4, top										X					X																							X	X					X		
214-37-1, 5-6 cm										X					X																							X	X					X		
214-37, CC																X																						X								
214-38-2, 8-9 cm																																								X						
214-38-3, top																																								X						
214-38-4, top																																								X						
214-38, CC																																														
214-39-2, top																																						X								
214-39-3, 12-13 cm																																						X								
214-39, CC																																						X								
214-40-2, top																X																						X								
214-40, CC																																						X								
214-41-3, 19-20 cm																																									X					
214-41, CC																																									X					

Figure 4. *(Continued).*

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Sample	*Chiasmolithus bidens*	*Chiasmolithus californicus*	*Chiasmolithus consuetus*	*Chiasmolithus eograndis*	*Chiasmolithus grandis*	*Cruciplacolithus tenuis*	*Cyclococcolithina robusta*	*Discoaster oraneus*	*Discoaster diastypus*	*Discoaster lenticularis*	*Disocaster lodoensis*	*Discoaster mohleri*	*Discoaster multiradiatus*	*Discoaster ornatus*	*Discoasteroides kuepperi*	*Discoasteroides megastypus*	*Ellipsolithus distichus*	*Ellipsolithus macellus*	*Fasciculithus mitreus*	*Fasciculithus tympaniformis*	*Heliolithus kleinpelli*	*Heliolithus riedeli*	*Heliolithus concinnus*	*Heliolithus distentus*	*Lophodolithus nascens*	*Markalius astroporus*	*Sphenolithus anarrhopus*	*Sphenolithus radians*	*Toweius bisulcus*	*Toweius craticulus*	*Toweius eminens*	*Toweius* sp.	*Tribrachiatus orthostylus*	*Zygodiscus sigmoides*	*Zygrhablithus bijugatus*
215-9-3, 130-131 cm											X		X		X													X					X		
215, CC					X						X				X													X					X		
215-10-1, 104-105 cm	X		X		X				X				X	X	X			X										X		X			X		
215-10-2, 30-33 cm	X		X	X	X			X	X				X			X												X					X		
215-10-3, 42-43 cm	X		X	X					X	X			X			X				X												X			
215-10-3, 105-106 cm				X					X																										
215-10, CC	X		X	X						X			X	X		X	X	X		X				X	X					X		X		X	
215-11-1, 30-31 cm	X		X	X					X			cf	X			X	X	X		X					X					X				X	X
215-11-2, 4-5 cm				X					X																										
215-11-2, 80-81 cm				X					X																										
215-11-3, 2-3 cm				X																															
215-11-3, 89-90 cm	X									X		X	X			X	X			X										X	X			X	
215-11, CC	X		X							X		X	X			X				X										X	X			X	
215-12-1, 19-20 cm	X		X							X		X	X						X	X											X				
215-12, CC	X		X							X			X				X		X	X									X		X				
215-13-2, 4-5 cm	X	X					X			X		X	X				X	X	X	X									X		X			X	
215-13-2, 97-98 cm	X	X					X					X						X		X	X						X		X		X				
215-13-3, 90-91 cm	X	X					X					X						X	X	X									X		X				
215-13, CC	X	X				X	X					X						X		X							X		X		X			X	
215-14-1, 12-13 cm	X		X				X					X								X		X					X			X	X			X	
215-14-4, 2-3 cm	X					X						X								X										X	X			X	
215-14-4, 91-92 cm	X											X								X		X									X			X	
215-14-5, 2-3 cm	X					X						X								X	X										X			X	
215-14-5, 90-91 cm	X											X								X	X	X								X	X			X	
215-14, CC	X		X				X					X								X	X										X			X	
215-15-1, 112-113 cm	X		X																	X	X									X	X			X	
215-15-4, 20-21 cm	X																			X	X										X			X	
215-15, CC	X	X	X																	X	X									X	X			X	
215-16-1, 99-100 cm	X	X				X														X		X								X	X			X	
215-16-4, 2-3 cm	X					X	X													X		X								X	X			X	
215-16-4, 90-91 cm	X					X	X													X	X	X								X	X			X	
215-16, CC	X					X	X													X		X	X							X				X	
215-17-1, 90 cm	X					X	X													X	X					X			X					X	
215-17-1, 106 cm	X					X	X													X									X					X	
215-17-1, 110 cm	X	X				X	X													X									X					X	
215-17, CC	X																			X									X					X	

Figure 5. *Checklist of calcareous nannofossils recovered at Site 215.*

Sample	Ahmullerella octaradiata	Arkhangelskiella cymbiformis	Bramletteius serraculoides	Ceratolithus cristatus	Ceratolithus rugosus	Ceratolithus tricorniculatus	Chiasmolithus bidens	Chiasmolithus californicus	Chiasmolithus consuetus	Chiasmolithus danicus	Chiasmolithus grandis	Coccolithus pelagicus	Cretarhabdus conicus	Cretarhabdus crenulatus	Cribrosphaerella ehrenbergi	Cribrosphaerella sp.	Cruciplacolithus tenuis	Cyclicargolithus floridanus	Cyclicargolithus reticulatus	Cyclococcolithina formosa	Cyclococcolithina leptopora	Cyclococcolithina robusta	Cyclolithella nitescens	Cylindralithus gallicus
216-1-1, 2-3 cm																					X			
216-1-2, top																								
216-1-3, 4-5 cm				X																				
216-1-4, 3-4 cm																								
216-1-6, 3-4 cm				X																				
216-1, CC																					X			
216-2-1, 4-5 cm					X																			
216-2-4, top					X																X			
216-2-5, 21-22 cm																								
216-2, CC					X																X			
216-3-1, 91-92 cm						X																		
216-3, CC						X						X									X			
216-4-1, 2-3 cm																					X			
216-4-2, 4-5 cm												X									X			
216-4-3, 2-3 cm																					X			
216-4, CC												X									X			
216-5-1, 104-105 cm																		X					X	
216-5-2, 1-2 cm																		X					X	
216-5-3, 2-3 cm																		X					X	
216-5-4, top																		X					X	
216-5, CC																		X			X		X	
216-6-1, 2-3 cm												X						X						
216-6-3, 2-3 cm												X						X					X	
216-6, CC												X						X					X	
216-7-1, 31-32 cm												X						X					X	
216-7, CC												X						X					X	
216-8-1, 91-92 cm												X						X					X	
216-8, CC												X						X						
216-9-1, 13-14 cm																		X					X	
216-9, CC																		X						
216-10, CC												X						X					X	
216-11, CC												X						X						
216-12-1, 74-75 cm																		X						
216-12, CC																		X						
216-13-1, 108-109 cm																		X						
216-13, CC																		X					X	
216-14-1, 97-98 cm																		X						
216-14, CC																		X						
216-15-1, 80-81 cm			X																					

Sample	Dictiococcites abisectus	Discoaster asymmetricus	Discoaster barbadiensis	Discoaster bellus	Discoaster binodosus	Discoaster brouweri	Discoaster calculosus	Discoaster deflandrei	Discoaster druggi	Discoaster exilis	Discoaster hamatus	Discoaster lenticularis	Discoaster lodoensis	Discoaster mohleri	Discoaster multiradiatus	Discoaster neohamatus	Discoaster pentaradiatus	Discoaster quinqueramus	Discoaster saipanensis	Discoaster surculus	Discoaster tani	Discoaster variabilis decorus	Discoaster variabilis pansus	Eiffellithus augustus
216-1-1, 2-3 cm																								
216-1-2, top																								
216-1-3, 4-5 cm																								
216-1-4, 3-4 cm																								
216-1-6, 3-4 cm																								
216-1, CC																								
216-2-1, 4-5 cm		X				X											X					X		
216-2-4, top						X																		
216-2-5, 21-22 cm																								
216-2, CC		X				X											X			X		X		
216-3-1, 91-92 cm				X		X												X		X				
216-3, CC				X		X												X						
216-4-1, 2-3 cm											X					X						X	X	
216-4-2, 4-5 cm										X												X	X	
216-4-3, 2-3 cm										X												X		
216-4, CC										X														
216-5-1, 104-105 cm																								
216-5-2, 1-2 cm																								
216-5-3, 2-3 cm																								
216-5-4, top							X																	
216-5, CC							X																	
216-6-1, 2-3 cm																								
216-6-3, 2-3 cm																								
216-6, CC							X	X																
216-7-1, 31-32 cm																								
216-7, CC									X															
216-8-1, 91-92 cm							X																	
216-8, CC								X																
216-9-1, 13-14 cm																								
216-9, CC																								
216-10, CC	X																							
216-11, CC	X																							
216-12-1, 74-75 cm	X																							
216-12, CC	X																							
216-13-1, 108-109 cm																					X			
216-13, CC																					X			
216-14-1, 97-98 cm																					X			
216-14, CC																					X			
216-15-1, 80-81 cm																					X			

Figure 6. *Checklist of calcareous nannofossils recovered at Site 216.*

Sample	Eiffellithus turriseiffeli	Ellipsolithus macellus	Emiliania huxleyi	Fasciculithus anarrhopus	Fasciculithus mitreus	Fasciculithus tympaniformis	Gephyrocapsa oceanica	Gephyrocapsa spp.	Hayella situliformis	Helicopontosphaera compacta	Heliolithus kleinpelli	Heliolithus sp.	Kamptnerius magnificus	Leptodiscus larvalis	Lithraphidites quadratus	Markalius astroporus	Microrhabdulus decoratus	Micula decussata	Nephrolithus frequens	Nephrolithus sp.	Orthorhabdus serratus	Prediscosphaera cretacea	Prediscosphaera spinosa	Pseudoemiliania lacunosa	Reticulofenestra hillae	Reticulofenestra pseudoumbilica	Reticulofenestra scissura	Reticulofenestra umbilica	Sphenolithus abies	Sphenolithus belemnos	Sphenolithus capricornutus	Sphenolithus ciperoensis	Sphenolithus distentus	Sphenolithus heteromorphus	Sphenolithus moriformis	Sphenolithus obtusus	Sphenolithus predistentus	Sphenolithus pseudoradians	Sphenolithus radians	Tetralithus murus	Toweius bisulcus	Toweius eminens	Toweius sp.	Watznaueria barnesae	Zygodiscus sigmoides	Zygrhablithus bijugatus	Zygrhablithus bijugatus crassus
216-1-1, 2-3 cm			X				X																																								
216-1-2, top			X				X																																								
216-1-3, 4-5 cm			cf				X																																								
216-1-4, 3-4 cm							X	X																																							
216-1-6, 3-4 cm							X	X																																							
216-1, CC								X																X																							
216-2-1, 4-5 cm																								X					X																		
216-2-4, top																								cf					X																		
216-2-5, 21-22 cm																								cf		X			X																		
216-2, CC																										X			X																		
216-3-1, 91-92 cm																										X			X																		
216-3, CC																										X			X																		
216-4-1, 2-3 cm																										X																					
216-4-2, 4-5 cm																										X			X																		
216-4-3, 2-3 cm																										X			X																		
216-4, CC																										X																					
216-5-1, 104-105 cm																																		X	X												
216-5-2, 1-2 cm																													X	X					X												
216-5-3, 2-3 cm																														X					X												
216-5-4, top																																			X												
216-5, CC																					X														X												
216-6-1, 2-3 cm																													X						X												
216-6-3, 2-3 cm																													X						X												
216-6, CC																													X					?	X												
216-7-1, 31-32 cm																													X		X																
216-7, CC																													X																		
216-8-1, 91-92 cm																											X		X						X												
216-8, CC																													X		X			?	X												
216-9-1, 13-14 cm																													X			X															
216-9, CC																											X					X															
216-10, CC																											X		X			X															
216-11, CC																											X					X	X														
216-12-1, 74-75 cm																											X					X															
216-12, CC																											X					X	X														
216-13-1, 108-109 cm																											X										X		X								
216-13, CC																											X						X				X		X								
216-14-1, 97-98 cm																											X						X		X		X										X
216-14, CC																											X						X		X		X										X
216-15-1, 80-81 cm																											X		X								X									X	

Figure 6. *(Continued).*

Sample	*Ahmuellerella octaradiata*	*Arkhangelskiella cymbiformis*	*Bramletteius serraculoides*	*Ceratolithus cristatus*	*Ceratolithus rugosus*	*Ceratolithus tricorniculatus*	*Chiasmolithus bidens*	*Chiasmolithus californicus*	*Chiasmolithus consuetus*	*Chiasmolithus danicus*	*Chiasmolithus grandis*	*Coccolithus pelagicus*	*Cretarhabdus conicus*	*Cretarhabdus crenulatus*	*Cribrosphaerella ehrenbergi*	*Cribrosphaerella* sp.	*Cruciplacolithus tenuis*	*Cyclicargolithus floridanus*	*Cyclicargolithus reticulatus*	*Cyclococcolithina formosa*	*Cyclococcolithina leptopora*	*Cyclococcolithina robusta*	*Cyclolithella nitescens*	*Cylindralithus gallicus*
216-15-2, top			X																	X				
216-15-3, top			X																	X				
216-15, CC			X																X	X				
216-16-1, 7-8 cm			X																X					
216-16, CC			X																X	X				
216-17-1, 23-24 cm			X																X	X				
216-17-2, 1-2 cm			X								X													
216-17, CC			X								X													
216-18-1, 97-98 cm			X																	X				
216-18, CC																								
216-19, CC																								
216-20-1, 83-84 cm																	X							
216-20-3, 4-5 cm								X														X		
216-20, CC							X	X														X		
216-21, CC									X															
216-22-1, 82-84 cm							X																	
216-22, CC							X		X								X							
216-23-1, top										X							X							
216-23-2, 1-2 cm																	X							
216-23-2, 20-21 cm										cf							X							
216-23-2, 40-41 cm										cf							X							
216-23-2, 60-61 cm									X	cf							X							
216-23-2, 80-81 cm										cf							X							
216-23-2, 100-101 cm										cf														
216-23-2, 120-121 cm		X								cf														X
216-23-2, 139-140 cm		X														X								
216-23-3, 1-2 cm	X	X											X											X
216-23, CC		X											X		X									
216-24, CC		X													X									
216-25, CC		X													X									
216-26, CC	X	X												X										
216-27, CC		X																						
216-28, CC		X																						
216-30, CC		X																						
216-31, CC		X																				X		
216-32, CC		X																						
216-33, CC		X																						
216-34, CC														X										
216-35, CC																								

Sample	*Dictiococcites abisectus*	*Discoaster asymmetricus*	*Discoaster barbadiensis*	*Discoaster bellus*	*Discoaster binodosus*	*Discoaster brouweri*	*Discoaster calculosus*	*Discoaster deflandrei*	*Discoaster druggi*	*Discoaster exilis*	*Discoaster hamatus*	*Discoaster lenticularis*	*Discoaster lodoensis*	*Discoaster mohleri*	*Discoaster multiradiatus*	*Discoaster neohamatus*	*Discoaster pentaradiatus*	*Discoaster quinqueramus*	*Discoaster saipanensis*	*Discoaster surculus*	*Discoaster tani*	*Discoaster variabilis decorus*	*Discoaster variabilis pansus*	*Eiffellithus augustus*
216-15-2, top																								
216-15-3, top																			cf		X			
216-15, CC																			X		X			
216-16-1, 7-8 cm			X																X		X			
216-16, CC			X																X		X			
216-17-1, 23-24 cm			X		X																X			
216-17-2, 1-2 cm			X																					
216-17, CC			X																					
216-18-1, 97-98 cm			cf																					
216-18, CC			cf										?											
216-19, CC															X									
216-20-1, 83-84 cm															X									
216-20-3, 4-5 cm												X		X	X									
216-20, CC														X										
216-21, CC														X										
216-22-1, 82-84 cm																								
216-22, CC																								
216-23-1, top																								
216-23-2, 1-2 cm																								
216-23-2, 20-21 cm																								
216-23-2, 40-41 cm																								
216-23-2, 60-61 cm																								
216-23-2, 80-81 cm																								
216-23-2, 100-101 cm																								
216-23-2, 120-121 cm																								
216-23-2, 139-140 cm																								
216-23-3, 1-2 cm																								
216-23, CC																								
216-24, CC																								
216-25, CC																								
216-26, CC																								
216-27, CC																								
216-28, CC																								
216-30, CC																								
216-31, CC																								
216-32, CC																								
216-33, CC																								
216-34, CC																								
216-35, CC																								cf

Figure 6. *(Continued).*

Sample	*Eiffellithus turriseiffeli*	*Ellipsolithus macellus*	*Emiliania huxleyi*	*Fasciculithus anarrhopus*	*Fasciculithus mitreus*	*Fasciculithus tympaniformis*	*Gephyrocapsa oceanica*	*Gephyrocapsa* spp.	*Hayella situliformis*	*Helicopontosphaera compacta*	*Heliolithus kleinpelli*	*Heliolithus* sp.	*Kamptnerius magnificus*	*Leptodiscus larvalis*	*Lithraphidites quadratus*	*Markalius astroporus*	*Microrhabdulus decoratus*	*Micula decussata*	*Nephrolithus frequens*	*Nephrolithus* sp.	*Orthorhabdus serratus*	*Prediscosphaera cretacea*	*Prediscosphaera spinosa*	*Pseudoemiliania lacunosa*	*Reticulofenestra hillae*	*Reticulofenestra pseudoumbilica*	*Reticulofenestra scissura*	*Reticulofenestra umbilica*	*Sphenolithus abies*	*Sphenolithus belemnos*	*Sphenolithus capricornutus*	*Sphenolithus ciperoensis*	*Sphenolithus distentus*	*Sphenolithus heteromorphus*	*Sphenolithus moriformis*	*Sphenolithus obtusus*	*Sphenolithus predistentus*	*Sphenolithus pseudoradians*	*Sphenolithus radians*	*Tetralithus murus*	*Toweius bisulcus*	*Toweius eminens*	*Toweius* sp.	*Watznaueria barnesae*	*Zygodiscus sigmoides*	*Zygrhablithus bijugatus*	*Zygrhablithus bijugatus crassus*
216-15-2, top																											X																				
216-15-3, top									X																		X		X										X								
216-15, CC														X											X		X	X							X				X							X	
216-16-1, 7-8 cm																											X											X									
216-16, CC																											X									X		X									
216-17-1, 23-24 cm																											X																			X	
216-17-2, 1-2 cm																											X	X																		X	
216-17, CC																											X																			X	
216-18-1, 97-98 cm										X																	X	X							X	X											
216-18, CC										X																																					
216-19, CC						X																																									X
216-20-1, 83-84 cm					X	X																																									
216-20-3, 4-5 cm					X	X					X					X																															X
216-20, CC				cff		X																																				X					
216-21, CC		X				X																																							X		
216-22-1, 82-84 cm						X						X																																	X		
216-22, CC					X	X																																			X				X		
216-23-1, top																X																													X		
216-23-2, 1-2 cm																X																															
216-23-2, 20-21 cm																																													X		
216-23-2, 40-41 cm																X																													X		
216-23-2, 60-61 cm																X																													X		
216-23-2, 80-81 cm																																													X		
216-23-2, 100-101 cm																X		X																													
216-23-2, 120-121 cm																X	X	X	X																									X			
216-23-2, 139-140 cm	X														X		X	X	X			X	X																					X			
216-23-3, 1-2 cm	X												X				X	X	X																									X			
216-23, CC															X			X	X																									X			
216-24, CC	X												X				X	X	X				X																	X				X			
216-25, CC	X					X							X					X	X																							X	X	X			
216-26, CC	X												X					X	X																												
216-27, CC													X					X	X																												
216-28, CC	X												X					X	X																												
216-30, CC													X					X	X				X																								
216-31, CC	X												X					X	X																								X				
216-32, CC	X												X					X	X																												
216-33, CC	X												X					X	X																												
216-34, CC																		X																													
216-35, CC																				X																											

Figure 6. *(Continued).*

Sample	Ahmuellerella octoradiata	Arkhangelskiella cymbiformis	Arkhangelskiella sp.	Biantholithus sparsus	Biscutum sp.	Bramletteius serraculoides	Broinsonia parca	Ceratolithus cristatus	Ceratolithus rugosus	Ceratolithus tricorniculatus	Chiasmolithus bidens	Chiasmolithus californicus	Chiasmolithus danicus	Chiasmolithus grandis	Chiastozygus cuneatus	Coccolithus pelagicus	Cretarhabdus conicus	Cretarhabdus crenulatus	Cretarhabdus decorus	Cribrosphaerella ehrenbergi	Cruciplacolithus staurion	Cruciplacolithus tenuis	Cyclicargolithus floridanus	Cyclicargolithus marismontium	Cyclicargolithus reticulatus	Cyclococcolithina leptopora	Cyclococcolithina robusta	Cyclolithella nitescens	Cyclococcolithina formosa	Cylindralithus gallicus	Cylindralithus sp.	Cylindralithus serratus	Dictiococcites abisectus	Discoaster asymmetricus	Discoaster barbadiensis	Discoaster bellus	Discoaster brouweri	Discoaster calculosus	Discoaster exilis	Discoaster loeblichi	Discoaster moorei	Discoaster multiradiatus	Discoaster neohamatus	Discoaster pentaradiatus	Discoaster quinqueramus	Discoaster saipanensis	Discoaster surculus	Discoaster tani	Discoaster variabilis decorus	Discoaster variabilis pansus	Discoasteroides megastypus	Discolithina japonica	Eiffellithus turriseiffeli	Ellipsolithus distichus	Ellipsolithus macellus	Emiliania huxleyi	Fasciculithus billi
217-1-1, 2-3 cm								X																X																												X				X	
217-1-2, 5-6 cm																																																									
217-1-4, top								X																X																																
217-1-5, top								X																X																																
217-1-6, top								X																X																																
217-1, CC																																																									
217-2-1, 112-113 cm								cf																X											X							X					X								
217-2-3, 2-3 cm									X																	X							X			X							X					X								
217-2, CC								cf	X																	X							X			X							X			X											
217-3-1, 18-19 cm																	X									X											X							X		X		X	X							
217-3, CC									X	X						X									X											X							X	X		X			X							
217-4-1, 106-107 cm																																				X	X						X														
217-4-2, 7-8 cm																																					X						X	X	X												
217-4-5, 2-3 cm																																				X	X			X			X	X			X		X								
217-4-6, 10-11 cm																										X												X	X						X	X					X								
217-4, CC																																					X						X	X					X								
217-5-1, 118-119 cm																	X									X		X											X											X							
217-5, CC																	X								X					X												X		X								X								
217-6-1, 2-3 cm																									X					X												X																				
217-6-3, 1-2 cm																									X					X																															
217-6-4, top																									X			X		X																															
217-6-5, 26-27 cm																									X					X																															
217-6-6, 7-8 cm																									X			X		X																															
217-6, CC																									X			X		X																															
217-7-1, 121-122 cm																									X										X																											
217-7, CC																									X																																	
217-8-1, 4-5 cm																									X					X																															
217-8-2, 0-1 cm																																																									
217-8-4, top																																																X									
217-8, CC																									X					X																															
217-9-1, 1-2 cm						X																X																								X									
217-9-2, top						X																																																			
217-9-4, top						X																X																								X									
217-9-5, 1-2 cm																																																									
217-9-6, top						X																																						X		X									
217-9, CC						X																	X				X						X														X											
217-10-1, 110-111 cm														X							cf			X					X						X																X						
217-10, CC														X												X					X						X																							
217-12-1, 131-132 cm												X																														X															
217-12, CC											X	X															X																														
217-13, CC											X	X										X					X																														
217-14-1, 1-2 cm												X										X																																	X	X		
217-14, CC																						X																																	X			X
217-15-1, 121-122 cm													cf									X																																			X		
217-15, CC													cf									X																																				
217-16-1, 0-1 cm													X																																											
217-16-5, 20-21 cm													X									X																																			
217-16-6, 39-40 cm													X																																							X				
217-16, CC		X		X	X														X		X								X																						X				
217-17, CC		X			X																X										X																						X				
217-18, CC		X															X			X										X																						X				
217-19, CC	X	X																			X										X																						X				
217-20, CC	X	X															X	X		X										X																						X				
217-21, CC		X			X													X	X		X											X																					X				
217-22, CC		X															X	X												X																						X				
217-23, CC		X																			X										X		X																									
217-24, CC		X					X								X		X	X												X		X																					X				
217-25, CC		X					X														X	X											X																				X				
217-26, CC		X					X																									X																								X				
217-27, CC		X					X																																														X				
217-28-6, top							X																																														X				
217-29, CC			X				X														X																																X				
217-30, CC																																																									
217-31, CC			X				X																																														X				
217-32-2, base		X																																																				X				
217-33-3, base		X					X																																																	
217-34-1, base		X																																																				X				
217-36, CC		X					X																																														X				

Figure 7. *Checklist of calcareous nannofossils recovered at Site 217.*

Sample	Fasciculithus mitreus	Fasciculithus tympaniformis	Gephyrocapsa oceanica	Havella situliformis	Helicopontosphaera bramlettei	Helicopontosphaera compacta	Helicopontosphaera heezeni	Helicopontosphaera kamptneri	Helicopontosphaera recta	Helicopontosphaera wallichi	Heliorthus concinnus	Kamptnerius magnificus	Kamptnerius sp.	Lithraphidites carniolensis	Lithraphidites quadratus	Lucianorhabdus cayeuxi	Markalius astroporus	Microrhabdulus decoratus	Micula decussata	Mannoterrina alata	Orthorhabdus serratus	Prediscosphaera cretacea	Prediscosphaera spinosa	Pseudoemiliania lacunosa	Reticulofenestra pseudoumbilica	Reticulofenestra scissura	Reticulofenestra umbilica	Rhabdolithina regularis	Rhabdolithina splendens	Rhabdosphaera claviger	Sphenolithus abies	Sphenolithus anarrhopus	Sphenolithus belemnos	Sphenolithus ciperoensis	Sphenolithus distentus	Sphenolithus furcatolithoides	Sphenolithus heteromorphus	Sphenolithus moriformis	Sphenolithus predistentus	Sphenolithus pseudoradians	Sphenolithus radians	Sphenolithus spiniger	Tetralithus aculeus	Tetralithus murus	Tetralithus nitidus nitidus	Tetralithus nitidus trifidus	Toweius bisulcus	Toweius eminens	Triquetrorhabdulus carinatus	Triquetrorhabdulus rugosus	Umbilicosphaera mirabilis	Watznaueria barnesae	Zygodiscus elegans	Zygodiscus sigmoides	Zygodiscus spiralis	Zygodiscus splendens	Zygrhablithus bijugatus
217-1-1, 2-3 cm			X					X		X																																									X						
217-1-2, 5-6 cm			X																																																						
217-1-4, top			X					X		X														X																											X						
217-1-5, top			X					X																X						X																											
217-1-6, top			X					X																																											X						
217-1, CC			X																					X																											X						
217-2-1, 112-113 cm																								X	X						X																										
217-2-3, 2-3 cm								X		X																					X																										
217-2, CC								X																	X					X	X																										
217-3-1, 18-19 cm																									X						X																										
217-3, CC																									X						X																										
217-4-1, 106-107 cm																															X																										
217-4-2, 7-8 cm																															X																										
217-4-5, 2-3 cm																															X																										
217-4-6, 10-11 cm																															X																										
217-4, CC																									X						X																										
217-5-1, 118-119 cm																					X				X						X																										
217-5, CC																					X				X						X																			X							
217-6-1, 2-3 cm																															X							X																			
217-6-3, 1-2 cm																															X																										
217-6-4, top																															X							X																			
217-6-5, 26-27 cm																															X						X																				
217-6-6, 7-8 cm																															X						X																				
217-6, CC									X																						X		X																X								
217-7-1, 121-122 cm																															X			X															X								
217-7, CC																																		X				X																			
217-8-1, 4-5 cm																																		X	X			X																			
217-8-2, 0-1 cm																																			X																						
217-8-4, top																																			X					X																	
217-8, CC						cf																													X			X	X	X																	X
217-9-1, 1-2 cm					X	X																				X									?			X	X																		X
217-9-2, top																										X	X								X																						
217-9-4, top				X			X																			X	X											X	?																		
217-9-5, 1-2 cm																																																									
217-9-6, top						X																				X	X																														
217-9, CC						X																				X	X											X																			
217-10-1, 110-111 cm																																				X					X	X															
217-10, CC																				cf																X						X															
217-12-1, 131-132 cm	X	X																																														X									
217-12, CC		X																														X																cf									
217-13, CC	X	X																																													X										
217-14-1, 1-2 cm		X																																													X							X			
217-14, CC		X																																													X							X			
217-15-1, 121-122 cm											X																																											X			
217-15, CC											X																																											X			
217-16-1, 0-1 cm																																																						X			
217-16-5, 20-21 cm																	X																																					X			
217-16-6, 39-40 cm																	X		X																																			X			
217-16, CC																	X	X	X			X																														X		X			
217-17, CC															X			X	X			X																														X			X		
217-18, CC														X	X				X			X																					X									X					
217-19, CC													X		X			X	X			X																					X									X					
217-20, CC													X					X	X																								X	X								X					
217-21, CC													X						X			X	X					X	X														X									X					
217-22, CC													X					X	X			X						X															X									X					
217-23, CC													X						X			X																					X									X	X				
217-24, CC												X	X					X	X			X						X															X									X	X				
217-25, CC																		X	X			X																					X									X	X				
217-26, CC													X					X	X			X																							X	X						X					
217-27, CC													X						X			X																							X	X						X				X	
217-28-6, top													X						X			X																							X	X						X	X				
217-29, CC													X						X			X																							X								X				
217-30, CC																			X			X																														X					
217-31, CC																		X	X																																	X					
217-32-2, base																			X			X																														X					
217-33-3, base													X									X																																			
217-34-1, base												X							X																																	X					
217-36, CC												X				X			X			X																														X	X				

Figure 7. *(Continued).*

Sample	*Catinaster coalitus*	*Ceratolithus cristatus*	*Coccolithus pelagicus*	*Cyclococcolithina leptopora*	*Discoaster brouweri*	*Discoaster hamatus*	*Discoaster neohamatus*	*Discoaster pentaradiatus*	*Discoaster quinqueramus*	*Discoaster surculus*	*Discoaster variabilis decorus*	*Discoaster variabilis pansus*	*Emiliania huxleyi*	*Gephyrocapsa aperta*	*Gephyrocapsa oceanica*	*Gephyrocapsa* sp.	*Helicopontosphaera kamptneri*	*Helicopontosphaera wallichi*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*Rhabdosphaera claviger*	*Sphenolithus abies*	*Triquetrorhabdulus rugosus*	*Umbilicosphaera mirabilis*
218-1-1, 25		X		X									X		X		X	X			X			X
218-1, CC				X									X		X			X						X
218-2, CC															X									
218-3, CC															X									
218-4, CC				X											X									
218-5, CC		X		X											X		X		X					
218-6, CC				X											X		X		X					
218-7, CC																X								
218-8, CC														X					X					
218-9, CC																								
218-10, CC																						X		
218-11, CC				X	X			X		X							X	X		X		X		
218-12, CC								X	X											X		X		
218-13, CC				X	X			X	X	X									X			X		
218-14, CC			X	X	X				X	X		X						X		X		X		
218-15, CC									X													X		
218-16, CC							X	X	X	X	X	X					X			X		X	X	
218-18, CC					X			X		X							X					X		
218-19, CC					X				X											X		X		
218-21, CC					X			X												X		X		
218-23, CC				X	X		X	X		X	X									X		X		
218-24, CC					X			X												X		X		
218-25, CC					X	X														X		X		
218-26, CC	X																			X				
218-27, CC									cff															

Figure 8. *Checklist of calcareous nannofossils recovered at Site 218.*

Age	m.y.	Nannofossil Zone	211	212	213	214	215	216	216A	217	217A	218
Pleistocene		*Emiliania huxleyi* Zone				1-1 to 1-2		1-1 to 1-3		1-1		1-1 to 1, CC
Pliocene		*Gephyrocapsa oceanica* Zone				1-3 to 1-5		1-4 to 1-6		1-2 to 1-3		2-1 to 4, CC
	5	*Pseudoemiliania lacunosa* Zone				1-6 to 3-2		1 CC		1-4 to 1, CC		5-CC to 8, CC
		Discoaster brouweri Zone				3-3 to 4-1						
	10	*Discoaster surculus* Zone				4-2 to 6-3		2-1 to 2-4				
		Reticulofenestra pseudoumbilica Zone		1-1		6-4 to 8, CC		2-5 to 2, CC				
Miocene		*Discoaster asymmetricus* Zone								2-1 to 2, CC		11, CC
	15	*Ceratolithus rugosus* Zone		to		9-1 to 9, CC						
		Ceratolithus tricorniculatus Zone				10-1 to 10-5						
		Discoaster quinqueramus Zone				10-6 to 13-3		3-1 to 3, CC		3-1 to 3, CC		12-CC to 15, CC
	20	*Discoaster neohamatus* Zone		10-1		13-5 to 17-1			1-CC to 2, CC	4-1 to 4, CC		16-CC to 23, CC
		Discoaster hamatus Zone				17-2 to 17-6		4-1		5-1		25, CC
	25	*Catinaster coalitus* Zone				17-CC to 18, CC			3, CC	to		26, CC
		Discoaster exilis Zone				19-1 to 20, CC		4-2 to 4, CC	4, CC	6-4		
		Sphenolithus heteromorphus Zone		10-2 to 15-1		21-1 to 22-1		5-1	5, CC	6-5 to 6-6		
	30	*Sphenolithus belemnos* Zone				22-2 to 23-2		5-2 to	6, CC	6, CC		
Oligocene		*Triquetrorhabdulus carinatus* Zone				23-2 to 24-1		8, CC				
		Sphenolithus ciperoensis Zone				24-1 to 25, CC		9-1 to 10, CC		7-1 to 8-1		
	35	*Sphenolithus distentus* Zone				26-1 to 26-6		11-1 to 14, CC		8-2 to 9-1		
		Sphenolithus predistentus Zone						15-1		9-2 to		
	40	*Cyclococcolithina formosa* Zone				26-CC to 27-6		15-2 to 15-3		9-5		
		Discoaster barbadiensis Zone				27-CC to 28, CC		15-CC to 17-1		9-6		
		Chiasmolithus grandis Zone		18-2 to 27, CC		29-2 to 31-4		17-2 to 18-1		0-1 to 10, CC		
Eocene	45	*Nannotetrina alata* Zone				31-5 to 32, CC						
		Discoaster sublodoensis Zone				33-1 to 33, CC						
		Discoaster lodoensis Zone				34-1 to 35-4						
	50	*Tribrachiatus orthostylus* Zone			14-5 to 14-6	35, CC	9-3 to 9, CC					
		Discoaster diastypus Zone			14-6 to 15, CC	to	10-1 to 11-2					
		Discoaster multiradiatus Zone			16-1 to 16, CC	36-2	11-3 to 13-2	19-CC to 20-3		12-1		
	55	*Discoaster mohleri* Zone			17-1		13-3 to 14-4	20-CC to 21, CC				
		Heliolithus kleinpelli Zone				36-4	14-5 to 17-1	22-1				
Paleocene	60	*Fasciculithus tympaniformis* Zone				37-1	17-1 to 17, CC	to		12-CC to 14, CC		
		Cyclococcolithina robusta Zone				37-CC to 41, CC		23-2		15-1		
	65	*Cruciplacolithus helis* Zone								15-CC to 16-6		
U. Cretaceous Maastrichtian		*Nephrolithus frequens* Zone		29-CC to 35, CC				23-3 to 35, CC		16, CC to		
		Lithraphidites quadratus Zone								24, CC		
	72	*Tetralithus nitidustrifidus* Zone	12-2 to 12, CC							25-1 to 28-6		
U. Cretaceous Campanian		*Eiffellithus augustus* Zone	13-1 to 14-2							29-1 to 36	13-1 to 14, CC	

Figure 9. *Summary correlation chart based on calcareous nannofossils of sites drilled on Leg 22, DSDP.*

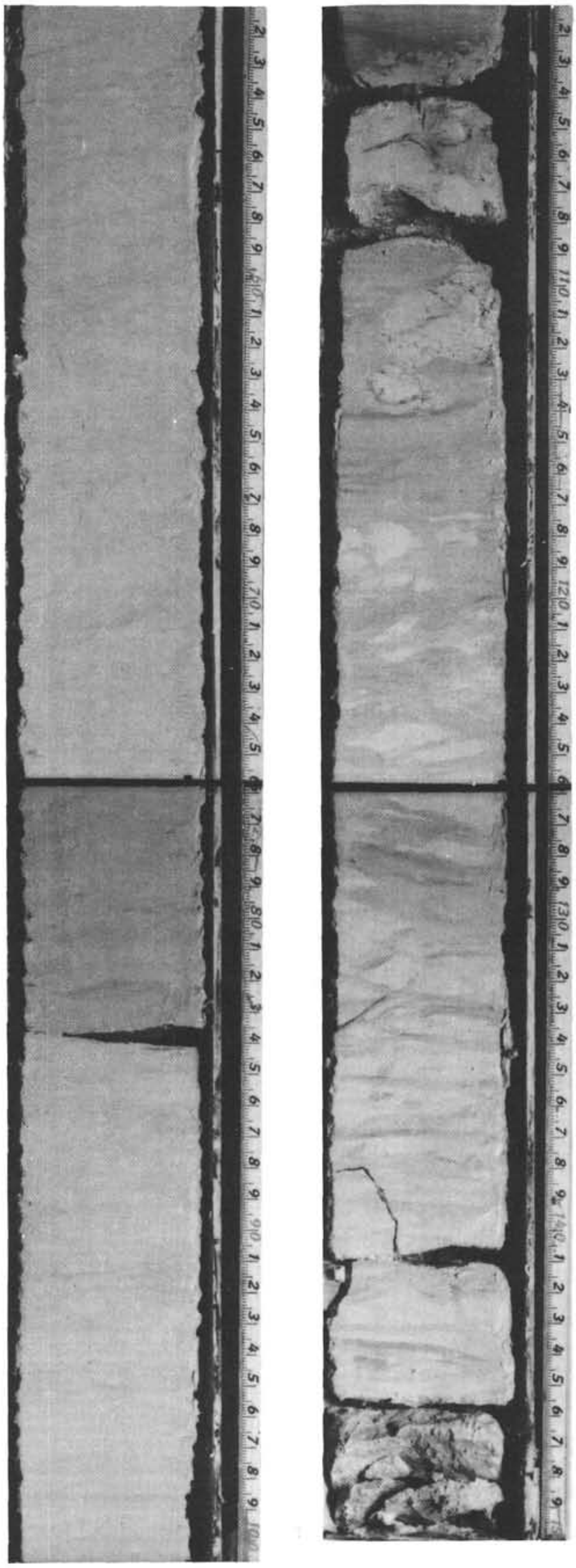

Figure 10. *Core photograph across Cretaceous-Tertiary Boundary at Site 216, Sample 32-2, 61-150 cm.*

APPENDIX I

Nannofossil species identified in sediment recovered during Leg 22 (listed in Alphabetical order).

Ahmullerella octoradiata
Arkhangelskiella cymbiformis

Biantholithus sparsus
Biscutum sp.
Braarudosphaera bigelowi
Bramletteius serraculoides
Broinsonia parca

Cambylosphaera dela
Catinaster calyculus
Catinaster coalitus
Ceratolithus amplificus
Ceratolithus cristatus
Ceratolithus primus
Ceratolithus rugosus
Ceratolithus tricorniculatus
Chiasmolithus altus
Chiasmolithus bidens
Chiasmolithus californicus
Chiasmolithus consuetus
Chiasmolithus danicus
Chiasmolithus eograndis
Chiasmolithus expansus
Chiasmolithus gigas
Chiasmolithus grandis
Chiasmolithus oamaruensis
Chiasmolithus solitus
Chiasmolithus titus
Chiastozygus cuneatus
Chiphragmalithus acanthodes
Coccolithus miopelagicus
Coccolithus pelagicus
Cretarhabdus conicus
Cretarhabdus crenulatus
Cretarhabdus decorus
Cribrosphaerella ehrenbergi
Cruciplacolithus staurion
Cruciplacolithus tenuis
Cyclicargolithus floridanus
Cyclicargolithus marismontium
Cyclicargolithus reticulatus
Cyclococcolithina formosa
Cyclococcolithina gammation
Cyclococcolithina leptopora
Cyclococcolithina macintyrei
Cyclococcolithina robusta
Cyclolithella nitescens
Cylindralithus gallicus
Cylindralithus serratus

Dictiococcites abisectus
Discoaster araneus
Discoaster asymmetricus
Discoaster barbadiensis
Discoaster bellus
Discoaster berggreni
Discoaster binodosus
Discoaster brouweri
Discoaster calculosus
Discoaster challengeri
Discoaster deflandrei
Discoaster diastypus
Discoaster druggi
Discoaster exilis
Discoaster hamatus
Discoaster lenticularis
Discoaster lodoensis
Discoaster loeblichi
Discoaster mirus
Discoaster mohleri
Discoaster moorei
Discoaster multiradiatus
Discoaster neohamatus
Discoaster neorectus
Discoaster ornatus
Discoaster pentaradiatus
Discoaster quinqueramus
Discoaster saipanensis
Discoaster sublodoensis
Discoaster surculus
Discoaster tamalis
Discoaster tani
Discoaster variabilis decorus
Discoaster variabilis pansus
Discoasteroides kuepperi
Discoasteroides megastypus
Discolithina japonica

Eiffellithus augustus
Eiffellithus turriseiffeli
Ellipsolithus distichus
Ellipsolithus macellus
Emiliania huxleyi

Fasciculithus billi
Fasciculithus mitreus
Fasciculithus tympaniformis

Gephyrocapsa aperta
Gephyrocapsa caribbeanica
Gephyrocapsa oceanica

Hayella situliformis
Helicopontosphaera bramlettei
Helicopontosphaera compacta
Helicopontosphaera granulata
Helicopontosphaera heezeni
Helicopontosphaera kamptneri
Helicopontosphaera recta
Helicopontosphaera wallichi
Heliolithus kleinpelli
Heliolithus riedeli
Heliorthus concinnus
Heliorthus distentus
Heliorthus fallax

Isthmolithus recurvus

Kamptnerius magnificus

Leptodiscus larvalis
Lithraphidites carniolensis
Lithraphidites quadratus
Lophodolithus nescens
Lucianorhabdus cayeuxi

Markalius astroporus
Microhabdulus decoratus
Micula decussata

Nannotetrina alata
Nephrolithus frequens

Oolithotus antillarum
Orthorhabdus serratus

Peritrachelina sp.
Prediscosphaera cretacea
Prediscosphaera spinosa
Pseudoemiliania lacunosa

Reticulofenestra hillae
Reticulofenestra pseudoumbilica
Reticulofenestra samodurovi
Reticulofenestra scissura
Reticulofenestra umbilica
Rhabdolithina regularis
Rhabdolithina splendens
Rhabdosphaera claviger

Scyphosphaera amphora
Sphenolithus abies

Sphenolithus anarrhopus
Sphenolithus belemnos
Sphenolithus capricornutus
Sphenolithus ciperoensis
Sphenolithus distentus
Sphenolithus furcatolithoides
Sphenolithus heteromorphus
Sphenolithus moriformis
Sphenolithus obtusus
Sphenolithus pacificus
Sphenolithus predistentus
Sphenolithus pseudoradians
Sphenolithus radians
Sphenolithus spiniger

Tetralithus aculeus
Tetralithus murus
Tetralithus nitidus nitidus
Tetralithus nitidus trifidus
Tetralithus quadratus
Thoracosphaera oblonga
Toweis bisulcus
Toweius craticulus
Toweius eminens
Tribrachiatus orthostylus
Triquetrorhabdulus carinatus
Triquetrorhabdulus milowi
Triquetrorhabdulus rugosus

Umbilicosphaera mirabilis

Watznaueria barnesae

Zygodiscus elegans
Zygodiscus sigmoides
Zygodiscus spiralis
Zygrhablithus bijugatus
Zygrhablithus bijugatus crassus