

42. LEG 23 BIOSTRATIGRAPHIC SYNTHESIS: LOWER EOCENE TO PLEISTOCENE OF THE ARABIAN SEA *

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By integrating the sediment cores recovered at Sites 219 and 220, a fairly complete Tertiary sequence can be obtained, and a correlation between the sites can be made despite occasional drilling and recovery gaps. Foraminifera and calcareous nannofossils are common and well preserved throughout the sequence; Radiolaria are found in numbers in Upper Oligocene through Lower Eocene sediments. More detailed studies of the fossil groups may be found in other chapters within this volume.

This compilation of paleontological events from Arabian Sea sediments is preliminary and should be refined and expanded as additional core material becomes available. Similar compilations for other parts of the Indian Ocean would provide the basis for the construction and correlation of regional biostratigraphic zonation systems. A synthesis of this type has already been made for the western tropical Pacific (Brönnimann et al., 1971).

In Table 1, paleontological events for the calcareous nannofossils (highest species occurrences), foraminifera (highest and lowest species occurrences), and Radiolaria (highest and lowest species occurrences and evolutionary transitions) have been tabulated chronologically. The top of the range of a taxon is indicated by T, the bottom by B and an evolutionary transition by an arrow.

The interval within which these events occurred, expressed in terms first of cores and sections and then of subbottom depth (in meters), is given in the body of the

Table. It should be noted that a drilled interval often produces artificial bunching of events.

Table 2 shows the relationship between zonations based on calcareous nannofossils, foraminifera, and Radiolaria, as observed at Sites 219 and 220. The thickness allocated to each zone is proportional to the thicknesses at the two sites. Dashed lines in the foraminiferal column indicate unconformities, and hatched areas represent drilled intervals. Boundaries between epochs are based on calcareous nannofossil data; this convention has been used in the site summary chapters unless overwhelming evidence from another fossil group has dictated the boundary position. There are discrepancies in the placement of the Pliocene-Miocene boundary and the Late-Middle Miocene boundary in Site 219 (see the biostratigraphic summary for Site 219). The correlations between Sites 219 and 220 differ slightly for each fossil group, producing offsets in the Eocene portion of Table 2.

REFERENCE

- Brönnimann, P. et al., 1971. Biostratigraphic synthesis: Late Oligocene and Neogene of the Western tropical Pacific. *In* Winterer, E. L., Riedel, W. R., et al., Initial Reports of the Deep Sea Drilling Project, Volume VII: Washington (U. S. Government Printing Office), p. 1723-1745.

*"Documentation for radiolarian events in this chapter will appear in an article by Catherine Nigrini to be published in Volume 24 of the Initial Report series."

TABLE 1
Sequence of Paleontological Events Recognized in the Arabian Sea
(Events are from youngest downward—see text for details)

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)
T <i>Gephyrocapsa oceanica</i>	Within 219-1-1 (0-2)	B <i>Globigerinella adamsi</i>	219-1-1 219-1-2 (0-2)		
		T <i>Streptochilus tokelauae</i>	219-1-1 219-1-2 (0-2)		
		T <i>Turborotalia (Turborotalia) pseudopima</i>	219-1-1 219-1-2 (0-2)		
		T <i>Globorotalia (Globorotalia) tumida flexuosa</i>	219-1-2 219-1-3 (2-3)		
		T <i>Globigerina digitata</i>	219-1-3 219-1-4 (3-5)		
T <i>Pseudoemiliania lacunosa</i>	219-1-4 219-1, CC (5-6)	T <i>Globorotalia (Globorotalia) unguata</i>	219-1-4 219-1, CC (5-6)		
		T <i>Globorotalia (Truncorotalia) truncatulinoides</i>	219-1-4 219-1, CC (5-6)		
		B <i>Turborotalita pumilio</i>	219-2-2 219-2-3 (8-9)		
		T <i>Globorotalia (Globorotalia) tumida</i> subsp. 1	219-2-4 219-2-5 (11-12)		
T <i>Scyphosphaera campanula</i>	219-2-3 219-2, CC (9-13)	T <i>Globoquadrina pseudofoliata</i>	219-2-5 219-2, CC (12-13)		
		T <i>Sphaeroidinella dehiscens immatura</i>	219-2-5 219-2, CC (12-13)		
		B <i>Globorotalia (Hirsutella) theyeri</i>	219-2, CC 219-3-1 (13-15)		
		T <i>Turborotalia (Turborotalia) humerosa trochoidea</i>	219-3-3 219-3-4 (18-20)		
		B <i>Pulleniatina obliquiloculata finalis</i>	219-3-4 219-3, CC (20-21)		
		T <i>Globorotalia (Truncorotalia) tosaensis</i>	219-3-4 219-3, CC (20-21)		
		T <i>Turborotalia (Turborotalia) humerosa humerosa</i>	219-3-4 219-3, CC (20-21)		
		T <i>Globigerinoides obliquus extremus</i>	219-3, CC 219-4-1 (21-24)		
		T <i>Globigerinoides quadrilobatus fistulosus</i>	219-4-2 219-4-3 (26-27)		

Radiolarian preservation inadequate

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)
T <i>Discoaster brouweri</i>	219-4-4 219-4-5 (29-30)	B <i>Globigerina digitata</i>	219-4-4 219-4-5 (29-30)		
		B <i>Globorotalia (Truncorotalia) truncatulinoides</i>	219-4-4 219-4-5 (29-30)		
		T <i>Globigerinoides obliquus obliquus</i>	219-4-4 219-4-5 (29-30)		
		T <i>Turborotalia (Turborotalia) acostaensis acostaensis</i>	219-4-4 219-4-5 (29-30)		
T <i>Discoaster pentaradiatus</i>	219-4-5 219-4, CC (30-32)	B " <i>Globigerina</i> " <i>rubescens tenella</i>	219-4-5 219-4-6 (30-32)		
		T " <i>Globigerina</i> " <i>rubescens decoraperta</i>	219-4-5 219-4-6 (30-32)		
		T <i>Globigerinoides bollii</i>	219-4-5 219-4-6 (30-32)		
		T <i>Globorotalia (Globorotalia) limbata</i>	219-4-5 219-4-6 (30-32)		
		T <i>Orbulina suturalis</i>	219-4-5 219-4-6 (30-32)		
		T <i>Pulleniatina obliquiloculata praecursor</i>	219-4-5 219-4-6 (30-32)		
		B <i>Globigerina calida</i>	219-4-6 219-4, CC (32-32)		
T <i>Discoaster surculus</i>	219-4, CC 219-5-3 (32-36)	T <i>Turborotalia (Turborotalia) vincentae</i>	219-4, CC 219-5-1 (32-33)		
		T <i>Globorotalia (Globorotalia) multicamerata</i>	219-5-1 219-5-2 (33-35)		
		T <i>Sphaeroidinellopsis sphaeroides</i>	219-5-1 219-5-2 (33-35)		
		B <i>Globorotalia (Truncorotalia) tosaensis</i>	219-5-2 219-5-3 (35-36)		
		T <i>Globorotalia (Globorotalia) merotumida</i>	219-5-2 219-5-3 (35-36)		
		B <i>Turborotalita pumilio</i>	219-5-3 219-5, CC (36-37)		
		T <i>Globoquadrina altispira altispira</i>	219-5-3 219-5, CC (36-37)		
		T <i>Turborotalia (Turborotalia) nigrinae</i>	219-5-3 219-5, CC (36-37)		

Radiolarian preservation inadequate

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site Core, Section, Subbottom, Depth (m)
T <i>Sphenolithus abies</i>	219-5, CC 219-6-2 (37-44)	B <i>Turborotalia (Turborotalia) pseudopima</i>	219-5, CC 219-6-1 (37-42)		
		T <i>Globoquadrina larmeyi obesa</i>	219-5, CC 219-6-1 (37-42)		
		B <i>Globigerinoides quadrilobatus fistulosus</i>	219-6-1 219-6-2 (42-44)		
		B <i>Globoquadrina pseudofoliata</i>	219-6-1 219-6-2 (42-44)		
		B <i>Pulleniatina obliquiloculata obliquiloculata</i>	219-6-1 219-6-2 (42-44)		
		B <i>Sphaeroidinella dehiscens dehiscens</i>	219-6-2 219-6-2 (42-44)		
		T <i>Globorotaloides variabilis</i>	219-6-1 219-6-2 (42-44)		
		T <i>Sphaeroidinellopsis subdehiscens</i>	219-6-1 219-6-2 (42-44)		
T <i>Reticulofenestra pseudoumbilica</i>	219-6-2 219-6-3 (44-45)	B " <i>Globigerina</i> " <i>rubescens rubescens</i>	219-6-2 219-6-3 (44-45)	Radiolarian preservation inadequate	
		B <i>Globoquadrina conglomerata</i>	219-6-2 219-6-3 (44-45)		
		B <i>Globorotalia (Truncorotalia) crassaformis</i> s.l.	219-6-2 219-6-3 (44-45)		
		B <i>Sphaeroidinella dehiscens immatura</i>	219-6-2 219-6-3 (44-45)		
		B <i>Turborotalia (Neogloboquadrina) dutertrei</i>	219-6-2 219-6-3 (44-45)		
		T <i>Globigerinoides conglobatus canimarensis</i>	219-6-2 219-6-3 (44-45)		
		T <i>Globorotalia (Hirsutella) margaritae</i>	219-6-2 219-6-3 (44-45)		
		T <i>Globorotalia (Hirsutella) hirsuta praehirsuta</i>	219-6-2 219-6-3 (44-45)		
		T <i>Pulleniatina primalis</i>	219-6-2 219-6-3 (44-45)		
		T <i>Sphaeroidinellopsis seminulina</i>	219-6-2 219-6-3 (44-45)		
		T <i>Globoquadrina dehiscens dehiscens</i>	219-6-3 219-6-4 (45-47)		

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval: Site, Core, Section Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)
		T <i>Sphaeroidinellopsis paenedehiscens</i>	219-6-3 219-6-4 (45-47)		
		T <i>Turborotalia (Turborotalia) humerosa praepulleniatina</i>	219-6-3 219-6-4 (45-47)		
		B <i>Globorotalia (Globorotalia) tumida</i> subsp. 1	219-6-4 219-6-5 (47-48)		
		B <i>Turborotalia (Turborotalia) humerosa trochoidea</i>	219-6-4 219-6-5 (47-48)		
		B <i>Globigerinoides ruber</i>	219-6-5 219-6-6 (48-50)		
		T " <i>Globigerina</i> " <i>nepenthes</i>	219-6-5 219-6-6 (48-50)		
T <i>Ceratolithus tricorniculatus</i>	219-6-6 219-6, CC (50-51)	T <i>Globigerinella siphonifera involuta</i>	219-6-6 219-6, CC (50-51)	Radiolarian preservation inadequate	
		T <i>Globorotalia (Globorotalia) tumida plesiotumida</i>	219-6-6 219-6, CC (50-51)		
		B <i>Pulleniatina obliquiloculata praecursor</i>	219-6, CC 219-7-1 (51-51)		
		B <i>Sphaeroidinellopsis sphaeroides</i>	219-6, CC 219-7-1 (51-51)		
		B <i>Streptochilus tokelauae</i>	219-7-1 219-7-2 (51-53)		
		T <i>Globigerina angustiumblicata</i>	219-7-1 219-7-2 (51-53)		
		B <i>Globorotalia (Globorotalia) ungulata</i>	219-7-2 219-7-3 (53-54)		
		B <i>Turborotalia (Turborotalia) nigrinia</i>	219-7-2 219-7-3 (53-54)		
		B <i>Turborotalita humilis</i>	219-7-3 219-7-4 (54-56)		
		T <i>Streptochilus globigerum</i>	219-7-3 219-7-4 (54-56)		
		B <i>Globorotalia (Globorotalia) multicamerata</i>	219-7-4 219-7-5 (56-57)		
		B <i>Tenuitella anfracta</i>	219-7-4 219-7-5 (56-57)		
		B <i>Globorotalia (Hirsutella) hirsuta praehirsuta</i>	219-7-5 219-7-6 (57-59)		

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)
		B <i>Globigerinita glutinata parkerae</i>	219-7-6 219-7, CC (59-59)		
		B <i>Globorotalia (Hirsutella) margaritae</i>	219-7-6 219-7, CC (59-59)		
		B <i>Globigerinoides conglobatus conglobatus</i>	219-8-2 219-8-3 (62-63)		
		B <i>Globorotalia (Globorotalia) tumida flexuosa</i>	219-8-2 219-8-3 (62-63)		
		T <i>Turborotalia (Turborotalia) acostaensis tegillata</i>	219-8-2 219-8-3 (62-63)		
		T <i>Candeina nitida praenitida</i>	219-8-3 219-8-4 (63-65)		
		T <i>Pulleniatina praespectabilis</i>	219-8-4 219-8-5 (63-65)		
T <i>Discoaster quinqueramus</i>	219-8-5 219-8-6 (63-65)	B <i>Globorotalia (Globorotalia) tumida tumida</i>	219-8-5 219-8-6 (63-65)	Radiolarian preservation inadequate	
		T <i>Streptochilus latum</i>	219-9-1 219-9-2 (69-71)		
T <i>Discoaster hamatus</i>	219-9-4 219-9-5 (74-75)	T " <i>Globigerina</i> " <i>bulbosa</i>	219-9-4 219-9-5 (74-75)		
		B <i>Pulleniatina praespectabilis</i>	219-9-5 219-9-6 (75-77)		
		B <i>Turborotalia (Turborotalia) vincentae</i>	219-10-1 219-10-2 (78-80)		
		B <i>Streptochilus globigerum</i>	219-10-2 219-10-3 (80-81)		
		B <i>Sphaeroidinellopsis paenedehiscens</i>	219-10-4 219-10-5 (81-82)		
		B <i>Turborotalia (Turborotalia) humerosa praepulleniatina</i>	219-10-4 219-10-5 (81-82)		
		B <i>Pulleniatina primalis</i>	219-10-6 219-10, CC (81-82)		
		B <i>Streptochilus latum</i>	219-11-2 219-11-3 (84-85)		
T <i>Discoaster dilatus</i>	219-11-3 219-11-4 (85-87)				
		B <i>Globorotaloides hexagonus</i>	219-11-4 219-11-5 (87-88)		

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria		
Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)	
		B <i>Turborotalia (Turborotalia) pachyderma</i>	219-11-4 219-11-5 (87-88)			
		T <i>Turborotalia (Turborotalia) continuosa</i>	219-11-4 219-11-5 (87-88)			
		B " <i>Globigerina</i> " <i>bulbosa</i>	219-11-5 219-11-6 (88-90)			
		B <i>Globigerinoides conglobatus canimarensis</i>	219-12-3 219-12-4 (96-97)			
		B <i>Globigerinita uvula</i>	219-12-4 219-12-5 (96-97)			
		B <i>Candeina nitida praenitida</i>	219-12-5 219-12-6 (97-99)			
		B <i>Globigerinella siphonifera siphonifera</i>	219-12-5 219-12-6 (97-99)	Radiolarian preservation inadequate		
		B <i>Candeina nitida nitida</i>	219-12-6 219-12, CC (99-100)			
		B <i>Globigerina bulloides</i>	219-12-6 219-12, CC (99-100)			
		B <i>Globorotalia (Globorotalia) tumida plesiotumida</i>	219-12-6 219-12, CC (99-100)			
		B <i>Orbulina universa</i>	219-12-6 219-12, CC (99-100)			
		B <i>Sphaeroidinellopsis subdehiscens</i>	219-12-6 219-12, CC (99-100)			
		B <i>Sphaeroidinellopsis seminulina</i>	219-12-6 219-12, CC (99-100)			
		B <i>Turborotalia (Turborotalia) acostaensis tegillata</i>	219-12-6 219-12, CC (99-100)			
T <i>Sphenolithus heteromorphus</i>	219-12, CC 219-13-1 (100-119)	B " <i>Globigerina</i> " <i>rubescens decoraperta</i>	219-12, CC 219-13-1 (100-119)			
		B " <i>Globigerina</i> " <i>nepenthes</i>	219-12, CC 219-13-1 (100-119)			
		B <i>Globigerinella siphonifera involuta</i>	219-12, CC 219-13;1 (100-119)			
		B <i>Globigerinita glutinata ambitacrena</i>	219-12, CC 219-13-1 (100-119)			
		B <i>Globigerinita glutinata glutinata</i>	219-12, CC 219-13-1 (100-119)			

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)
		B <i>Globigerinoides obliquus extremus</i>	219-12, CC 219-13-1 (100-119)		
		B <i>Globigerinoides quadrilobatus sacculifer</i>	219-12, CC 219-13-1 (100-119)		
		B <i>Globigerinoides bollii</i>	219-12, CC 219-13-1 (100-119)		
		B <i>Globorotalia (Globorotalia) cultrata</i>	219-12, CC 219-13-1 (100-119)		
		B <i>Globorotalia (Globorotalia) limbata</i>	219-12, CC 219-13-1 (100-119)		
		B <i>Globorotalia (Globorotalia) merotumida</i>	219-12, CC 219-13-1 (100-119)		
		B <i>Globorotalia (Hirsutella) scitula scitula</i>	219-12, CC 219-13-1 (100-119)	Radiolarian preservation inadequate	
		B <i>Turborotalia (Turborotalia) humerosa humerosa</i>	219-12, CC 219-13-1 (100-119)		
		B <i>Turborotalia (Turborotalia) acostaensis acostaensis</i>	219-12, CC 219-13-1 (100-119)		
		B <i>Turborotalia "quinquloba"</i>	219-12, CC 219-13-1 (100-119)		
		T <i>Clavatorella bermudezi</i>	219-12, CC 219-13-1 (100-119)		
		T <i>Globigerinita boweni</i>	219-12, CC 219-13-1 (100-119)		
		T <i>Globigerinoides subquadratus</i>	219-12, CC 219-13-1 (100-119)		
		T <i>Globorotalia (Fohsella) peripheroronda</i>	219-12, CC 219-13-1 (100-119)		
		T <i>Globorotalia (Fohsella) peripheroacuta</i>	219-12, CC 219-13-1 (100-119)		
		T <i>Globorotalia (Globorotalia) praemenardii</i>	219-12, CC 219-13-1 (100-119)		
		T <i>Tenuitella clemenciae</i>	219-12, CC 219-13-1 (100-119)		
		T <i>Turborotalia (Turborotalia) siakensis</i>	219-12, CC 219-13-1 (100-119)		
		T <i>Turborotalia (Turborotalia) mayeri</i>	219-12, CC 219-13-1 (100-119)		

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)
		B <i>Clavatorella bermudezi</i>	219-13-1 219-13-2 (119-121)		
		B <i>Globorotaloides variabilis</i>	219-13-1 219-13-2 (119-121)		
		B <i>Orbulina suturalis</i>	219-13-1 219-13-2 (119-121)		
		B <i>Globorotalia (Fohsella) peripheroacuta</i>	219-13-1 219-13-2 (119-121)		
		B <i>Globorotalia (Globorotalia) praemenardii</i>	219-13-1 219-13-2 (119-121)		
		B <i>Turborotalia (Turborotalia) mayeri</i>	219-13-1 219-13-2 (119-121)		
		T <i>Globigerinoides diminutus</i>	219-13-1 219-13-2 (119-121)	Radiolarian preservation inadequate	
		T <i>Globigerinoides sicanus</i>	219-13-1 219-13-2 (119-121)		
		T <i>Globorotalia (Globorotalia) archeomenardii</i>	219-13-1 219-13-2 (119-121)		
		T <i>Globorotalia (Hirsutella) scitula praescitula</i>	219-13-1 219-13-2 (119-121)		
		T <i>Turborotalia (Turborotalia) birnageae</i>	219-13-1 219-13-2 (119-121)		
		B <i>Globorotalia (Globorotalia) archeomenardii</i>	219-13-2 219-13-3 (121-122)		
		T <i>Praeorbulina transitoria</i>	219-13-2 219-13-3 (121-122)		
		B <i>Praeorbulina transitoria</i>	219-13-3 219-13-4 (122-124)		
		T <i>Globigerinatella insueta</i>	219-13-4 219-13-5 (124-125)		
		B <i>Globigerinoides obliquus obliquus</i>	219-13-5 219-13-6 (125-127)		
		T <i>Cassigerinella chipolensis</i>	219-13-5 219-13-6 (125-127)		
		T <i>Globigerinoides aff. altiapertura</i>	219-13-5 219-13-6 (125-127)		
		B <i>Globigerinatella insueta</i>	219-13, CC 219-14-1 (128-128)		

TABLE 1 – Continued

Calcareous Nannofossils			Foraminifera		Radiolaria	
Events		Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom, Depth (m)
			T <i>"Globigerina" pseudodruryi</i>	219-13, CC 219-14-1 (128-128)		
T <i>Helicopontosphaera ampliapertura</i>		219-14-1 219-14-2 (128-130)	T <i>Globoquadrina dehiscens praedehiscens</i>	219-14-1 219-14-2 (128-130)		
			T <i>Globorotaloides suteri</i>	219-14-1 219-14-2 (128-130)		
			B <i>"Globigerina" pseudodruryi</i>	219-14-3 219-14-4 (131-133)		
			B <i>Globigerinoides subquadratus</i>	219-14-3 219-14-4 (131-133)		
			B <i>Globigerinoides diminutus</i>	219-14-3 219-14-4 (131-133)		
			B <i>Tenuitella clemenciae</i>	219-14-4 219-14-5 (133-134)		
			B <i>Globoquadrina larmei obesa</i>	219-14-5 219-14-6 (134-136)		
			B <i>Turborotalia (Turborotalia) continuosa</i>	219-14-5 219-14-6 (134-136)		
T <i>Sphenolithus predistentus</i>	220-8, CC 220-9-1 (117-150)	219-14, CC 219-15-1 (136-156)	B <i>Globigerinita boweni</i>	219-14, CC 219-15-1 (136-156)	<i>Petalospyris triceros</i> → <i>Dorcadospyrus ateuchus</i>	220-8, CC 220-9-1 (117-150)
			B <i>Globigerinoides quadrilobatus quadrilobatus</i>	219-14, CC 219-15-1 (136-156)		
			B <i>Globigerinoides sicanus</i>	219-14, CC 219-15-1 (136-156)		
			B <i>Globigerinoides aff. altiapertura</i>	219-14, CC 219-15-1 (136-156)		
			B <i>Globoquadrina altispira altispira</i>	219-14, CC 219-15-1 (136-156)		
			B <i>Globoquadrina venezuelana</i>	219-14, CC 219-15-1 (136-156)		
			B <i>Globoquadrina dehiscens dehiscens</i>	219-14, CC 219-15-1 (136-156)		
			B <i>Globoquadrina dehiscens praedehiscens</i>	219-14, CC 219-15-1 (136-156)		
			B <i>Globorotalia (Fohsella) peripheroronda</i>	219-14, CC 219-15-1 (136-156)		
			B <i>Globorotalia (Hirsutella) scitula praescitula</i>	219-14, CC 219-15-1 (136-156)		

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)
		B <i>Turborotalia (Turborotalia) siakensis</i>	219-14, CC 219-15-1 (136-156)		
		B <i>Turborotalia (Turborotalia) birnageae</i>	219-14, CC 219-15-1 (136-156)		
		T <i>Catapsydrax perus</i>	219-14, CC 219-15-1 (136-156)		
		T <i>Chiloguembelina cubensis</i>	219-14, CC 219-15-1 (136-156)		
		T <i>Globoquadrina galavisi</i>	219-14, CC 219-15-1 (136-156)		
		T <i>Globoquadrina tripartita tapuriensis</i>	219-14, CC 219-15-1 (136-156)		
		T <i>Globoquadrina tripartita tripartita</i>	219-14, CC 219-15-1 (136-156)		
		T <i>Pseudohastigerina nagewichiensis barbadoensis</i>	219-14, CC 219-15-1 (136-156)		
		T <i>Subbotina winkleri</i>	219-14, CC 219-15-1 (136-156)		
		T <i>Turborotalia (Turborotalia) opima nana</i>	219-14, CC 219-15-1 (136-156)		
T <i>Helicopontosphaera truncata</i>	220-10-2 220-10, CC (161-162)	T <i>Turborotalia (Turborotalia) prasaepis</i>	219-14, CC 219-15-1 (136-156)		
		T <i>Subbotina angiporoides</i>	219-15-1 219-15-2 (156-158)		
		T <i>Tenuitella gemma</i>	219-15-1 219-15-2 (156-158)		
		T <i>Catapsydrax unicavus primitivus</i>	219-15-2 219-15-3 (158-159)		
		T <i>Turborotalia (Turborotalia) ampliapertura</i>	219-15-2 219-15-3 (158-159)		
		T <i>Turborotalia (Turborotalia) pseudoampliapertura</i>	219-15-2 219-15-3 (158-159)		
T <i>Reticulofenestra umbilica</i>	219-15, CC 219-16-1 (165-165)			T <i>Theocampe pirum</i>	220-10-1 220-10-2 (159-161)
T <i>Helicopontosphaera reticulata</i>	219-15, CC 219-16-1 (165-165)				
		B <i>Cassigerinella chipolensis</i>	219-16-1 219-16-2 (165-167)		

TABLE 1 – Continued

Calcareous Nannofossils			Foraminifera		Radiolaria	
Events		Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)
			B <i>Globigerina angustumbricata</i>	219-16-1 219-16-2 (165-167)		
			B <i>Tenuitella gemma</i>	219-16-1 219-16-2 (165-167)		
			T <i>Hantkenina (Hantkenina) alabamensis</i>	219-16-2 219-16-3 (167-168)		
			B <i>Globoquadrina tripartita tapuriensis</i>	219-16-3 219-16-4 (168-170)		
			T <i>Pseudohastigerina micra</i>	219-16-3 219-16-4 (168-170)		
			T <i>Turborotalia (Turborotalia) cerroazulensis cerroazulensis</i>	219-16-3 219-16-4 (168-170)		
			T <i>Turborotalia (Turborotalia) cerroazulensis cocoaensis</i>	219-16-3 219-16-4 (168-170)		
			T <i>Turborotalia (Turborotalia) cerroazulensis pomeroli</i>	219-16-3 219-16-4 (168-170)		
			B <i>Subbotina winkleri</i>	219-16-4 219-16-5 (170-171)		
			B <i>Turborotalia (Turborotalia) prasaepis</i>	219-16-6 219-16, CC (173-174)		
			B <i>Turborotalia (Turborotalia) pseudoampliapertura</i>	219-16-6 219-16, CC (173-174)		
T <i>Discoaster barbadiensis</i>	220-10, CC 220-11-1 (162-198)	219-16, CC 219-17-1 (173-174)	B <i>Turborotalia (Turborotalia) opima nana</i>	219-16, CC 219-17-1 (173-174)	B <i>Dorcadospyris spinosa</i>	220-10, CC 220-11-1 (162-198)
			T <i>Subbotina linaperta</i>	219-16, CC 219-17-1 (173-174)	B <i>Theocorys spongoconum</i>	220-10, CC 220-11-1 (162-198)
					T <i>Lychnocanoma babylonis</i> group	220-10, CC 220-11-1 (162-198)
					B <i>Theocampe pirum</i>	220-10, CC 220-11-1 (162-198)
					T <i>Theocampe mongolfieri</i>	220-10, CC 220-11-1 (162-198)
					T <i>Lophocyrtis (?) jacchia</i>	220-10, CC 220-11-1 (162-198)
					T <i>Theocampe armadillo</i>	220-10, CC 220-11-1 (162-198)
					T <i>Periphaena decora</i>	220-10, CC 220-11-1 (162-198)

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)
				<i>Lithocyclus aristotelis</i> → <i>L. angustum</i>	220-10, CC 220-11-1 (168-198)
		B <i>Pseudohastigerina nagewichiensis barbadoensis</i>	219-17-1 219-17-2 (174-176)		
		T <i>Globanomalina laccadivensis</i>	219-17-1 219-17-2 (174-176)		
				T <i>Calocyclus turris</i>	219-17-2 219-17-3 (176-177)
		T <i>Hantkenina</i> (<i>Cribohantkenina</i>) <i>inflata</i>	219-17-3 219-17-4 (177-179)	T <i>Thyrsocyrtis tetracantha</i>	219-17-3 219-17-4 (177-179)
				T <i>Thyrsocyrtis bromia</i>	219-17-3 219-17-4 (177-179)
				T <i>Thyrsocyrtis rhizodon</i>	219-17-3 219-17-4 (177-179)
		B <i>Catapsydrax unicavus primitivus</i>	219-17-4 219-17-5 (179-180)		
		B <i>Hantkenina</i> (<i>Cribohantkenina</i>) <i>inflata</i>	219-17-4 219-17-5 (179-180)		
		B <i>Turborotalia</i> (<i>Turborotalia</i>) <i>ampliapertura</i>	219-17-4 219-17-5 (179-180)		
		T <i>Globigerinatheka semiinvoluta</i>	219-17-4 219-17-5 (179-180)		
		T <i>Catapsydrax africanus</i>	219-17-5 219-17, CC (180-181)	T <i>Eusyringium fistuligerum</i>	219-17-5 219-17, CC (180-181)
		T <i>Catapsydrax globiformis</i>	219-17-5 219-17, CC (180-181)	B <i>Lophocyrtis</i> (?) <i>jacchia</i>	219-17-5 219-17, CC (180-181)
		T <i>Globigerinatheka index tropicalis</i>	219-17-5 219-17, CC (180-181)	<i>Lychnocanoma bellum</i> → <i>L. amphitrite</i>	219-17-5 219-17, CC (180-181)
				<i>Thyrsocyrtis triacantha</i> → <i>T. tetracantha</i>	219-17, CC 219-18-1 (181-183)
				<i>Lithocyclus ocellus</i> → <i>L. aristotelis</i>	219-17, CC 219-18, CC (181-192)
				T <i>Phormocyrtis striata striata</i>	219-18-1 219-18-2 (183-185)
		B <i>Catapsydrax globiformis</i>	219-18-2 219-18-3 (185-186)		
		B <i>Subbotina angiporoides</i>	219-18-2 219-18-3 (185-186)		

TABLE 1 – Continued

Calcareous Nannofossils			Foraminifera		Radiolaria		
Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site Core, Section, Subbottom Depth (m)		
		T <i>Globigerinatheka mexicana mexicana</i>	219-18-2 219-18-3 (185-186)				
		T <i>Globigerinatheka senni</i>	219-18-2 219-18-3 (185-186)				
		T <i>Truncorotaloides collacteus</i>	219-18-2 219-18-3 (185-186)				
		T <i>Truncorotaloides pseudodubius</i>	219-18-2 219-18-3 (185-186)				
T <i>Chiasmolithus grandis</i>	220-12-1 220-12-2 (232-234)	219-18-3 219-18-4 (186-188)	B <i>Catapsydrax perus</i>	219-18-3 219-18-4 (286-288)	T <i>Calocyclus hispida</i>	220-11-1 220-11,CC (198-200)	219-18-3 219-18-4 (186-188)
			B <i>Catapsydrax africanus</i>	219-18-3 219-18-4 (186-188)	T <i>Podocyrctis papalis</i>		219-18-3 219-18-4 (186-188)
			B <i>Globigerinatheka semiinvoluta</i>	219-18-3 219-18-4 (186-188)	B <i>Calocyclus turris</i>		219-18-3 219-18-4 (186-188)
			T <i>Globanomalina pseudoscitula</i>	219-18-3 219-18-4 (186-188)	B <i>Petalospyris triceris</i>		219-18-3 219-18-4 (186-188)
			T <i>Globigerinatheka mexicana barri</i>	219-18-3 219-18-4 (186-188)			
			T <i>Globigerinatheka index index</i>	219-18-3 219-18-4 (186-188)			
			T <i>Morozovella coronata</i>	219-18-3 219-18-4 (186-188)			
					B <i>Thyrsocyrtis bromia</i>		219-18-4 219-18-5 (188-189)
			T <i>Subbotina eocaenica</i>	219-18-5 219-18-6 (189-191)			
			B <i>Turborotalia (Turborotalia) cerroazulensis cocoaensis</i>	219-18-6 219-18, CC (191-192)	T <i>Theocotyle ficus</i>		219-18-6 219-18, CC (191-192)
					T <i>Rhopalocanium ornatum</i>		219-18-6 219-18, CC (191-192)
T <i>Sphenolithus obtusus</i>	219-18, CC 219-19-1 (192-192)		B <i>Hantkenina (Hantkenina) alabamensis</i>	219-18, CC 219-19-1 (192-192)	T <i>Spongoatractus pachystylus</i>		219-18, CC 219-19-1 (192-192)
			T <i>Subbotina eocaena</i>	219-18, CC 219-19-1 (192-192)			
			B <i>Globoquadrina tripartita tripartita</i>	219-19-1 219-19-2 (192-194)			
			B <i>Globanomalina laccadivensis</i>	219-19-2 219-19-3 (194-195)			

TABLE 1 – Continued

Calcareous Nannofossil		Foraminifera		Radiolaria	
Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)
		B <i>Globigerinatheka index tropicalis</i>	219-19-3 219-19-4 (195-197)		
		B <i>Turborotalia (Turborotalia) cerroazulensis cerroazulensis</i>	219-19-3 219-19-4 (195-197)		
				T <i>Lithochytris vespertilio</i>	219-19-4 219-19-5 (197-198)
		B <i>Globoquadrina galavisi</i>	219-19-5 219-19-6 (198-200)	T <i>Heliostylus</i> spp.	219-19-5 219-19, CC (198-201)
		B <i>Globorotaloides suteri</i>	219-19-5 219-19-6 (198-200)	B <i>Podocyrtis mitra</i>	219-19-5 219-19, CC (198-201)
		B <i>Subbotina linaperta</i>	219-19-5 219-19-6 (198-200)	T <i>Phormocyrtis embolum</i>	219-19-5 219-19, CC (198-201)
		T <i>Acarinina boudreauxi</i>	219-19-5 219-19-6 (198-200)	T <i>Podocyrtis trachodes</i>	219-19-5 219-19, CC (198-201)
		T <i>Globigerinatheka subconglobata curryi</i>	219-19-5 219-19-6 (198-200)		
		T <i>Morozovella bandyi</i>	219-19-5 219-19-6 (198-200)		
		T <i>Subbotina kiersteadae</i>	219-19-5 219-19-6 (198-200)		
		T <i>Acarinina planodorsalis</i>	219-19-6 219-19, CC (200-201)		
		T <i>Acarinina punctocarinata</i>	219-19-6 219-19, CC (200-201)		
		T <i>Morozovella aragonensis aragonensis</i>	219-19-6 219-19, CC (200-201)		
		T <i>Pseudohastigerina wilcoxensis</i>	219-19-6 219-19, CC (200-201)		
		T <i>Subbotina patagonica</i>	219-19-6 219-19, CC (200-201)		
		B <i>Pseudohastigerina micra</i>	219-19, CC 219-20-1 (201-201)	B <i>Theocampe armadillo</i>	219-19, CC 219-20-1 (201-201)
				T <i>Podocyrtis ampla fasciolata</i>	219-19, CC 219-20-1 (201-201)
		T <i>Acarinina bulbrookii</i>	219-20-1 219-20-2 (201-203)		
		B <i>Globigerinatheka subconglobata curryi</i>	219-20-2 219-20-3 (203-204)	T <i>Lophocyrtis biaurita</i>	219-20-2 219-20-3 (203-204)

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)
		T <i>Globigerinatheka subconglobata subconglobata</i>	219-20-2 219-20-3 (203-204)	B <i>Podocyrtis trachodes</i>	219-20-2 219-20-3 (203-204)
		T <i>Globorotaloides turgida</i>	219-20-2 219-20-3 (203-204)	T <i>Podocyrtis helenae</i>	219-20-2 219-20-3 (203-204)
				T <i>Lithapium plegmacantha</i>	219-20-3 219-20-4 (204-206)
				T <i>Podocyrtis sinuosa</i>	219-20-3 219-20-4 (204-206)
				B <i>Podocyrtis ampla fasciolata</i>	219-20-4 219-20-5 (206-207)
		B <i>Globigerinatheka mexicana mexicana</i>	220-12-5 220-12, CC (238-239)	T <i>Periphaena tripyramis triangula</i>	219-20-5 219-20-6 (207-209)
				T sp. cf. <i>Lithomitra elizabethae</i>	219-20-5 219-20-6 (207-209)
		T <i>Globigerinatheka higginsi</i>	219-20-6 219-20, CC (209-210)		
		T <i>Hantkenina (hantkenina) mexicana aragonensis</i>	220-12, CC 220-13-1 (239-241)		
		B <i>Globigerinatheka mexicana barri</i>	219-20, CC 219-21-1 (210-210)	<i>Eusyringium lagena</i> → <i>E. fistuligerum</i>	220-12-1 220-12-2 (232-234)
		B <i>Globigerinatheka index index</i>	219-20, CC 219-21-1 (210-210)		
		B <i>Chiloguembelina cubensis</i>	219-21-1 219-21-2 (210-212)	B <i>Podocyrtis helenae</i>	219-21-1 219-21-2 (210-212)
		T <i>Globigerina index rubriformis</i>	220-12-1 (232-233)		
		T <i>Acarinina mattseensis mattseensis</i>	220-12-1 (232-233)		
		T <i>Acarinina soldadoensis soldadoensis</i>	220-12-1 (232-233)		
		B <i>Globigerinatheka index rubiformis</i>	220-12-2 220-12-3 (234-235)		
T <i>Sphenolithus spiniger</i>	220-12-3 220-12-4 (235-237)	T <i>Acarinina mattseensis wartsteinensis</i>	220-12-3 220-12-4 (235-237)		
		T <i>Subbotina boweri</i>	220-12-3 220-12-4 (235-237)		
				T <i>Spongodiscus phrix</i>	220-12-5 220-12, CC (238-239)
				T <i>Podocyrtis dorus</i>	220-12-5 220-12, CC (238-239)

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval, Site, Core, Section, Subbottom Depth (m)
				T <i>Theocotyle cryptocephala conica</i>	220-12, CC 220-13-1 (239-241)
		B <i>Morozovella coronata</i>	220-13-2 220-13-3 (243-244)		
		B <i>Hantkenina (hantkenina) mexicana aragonensis</i>	220-13-3 220-13-4 (244-246)		
		B <i>Morozovella bandyi</i>	220-13-3 220-13-4 (244-246)		
		B <i>Globigerinatheka subconglobata subconglobata</i>	220-13-4 220-13, CC (246-247)		
T <i>Chiasmolithus gigas</i>	220-13, CC 220-14-1 (247-250)	B <i>Acarinina planodorsalis</i>	220-13, CC 220-14-1 (247-250)	B <i>Eusyringium lagena</i>	220-13, CC 220-14-1 (247-250)
		B <i>Globigerinatheka index index</i>	220-13, CC 220-14-1 (247-250)	T <i>Amphicraspedum prolixum</i>	220-13, CC 220-14-1 (247-250)
		B <i>Turborotalia (turborotalia) cerroazulensis pomeroli</i>	220-13, CC 220-14-1 (247-250)	B <i>Podocyrtis dorus</i>	220-13, CC 220-14-1 (247-250)
				<i>Theocotyle cryptocephala</i> → <i>T. c. conica</i>	220-13, CC 220-14-3 (247-253)
		B <i>Truncorotaloides pseudodubius</i>	220-14-1 220-14-2 (250-252)	<i>Thyrsocyrtis hirsuta tensa</i> → <i>T. triacantha</i>	220-14-1 220-14, CC (250-255)
				T <i>Lamptonium fabaeforme (?) chaunothorax</i>	220-14-2 220-14-3 (252-253)
		B <i>Subbotina eocaenica</i>	220-14-3 220-14, CC (253-255)	T <i>Thyrsocyrtis hirsuta hirsuta</i>	220-14-3 220-14, CC (253-255)
		B <i>Truncorotaloides collacteus</i>	220-14-3 220-14, CC (253-255)	T <i>Lamptonium fabaeforme (?) constrictum</i>	220-14-3 220-14, CC (253-255)
				T <i>Periphaena delta</i>	220-14-3 220-14, CC (253-255)
				T <i>Thyrsocyrtis hirsuta robusta</i>	220-14-3 220-14, CC (253-255)
		T <i>Acarinina pentacamerata</i>	220-14, CC 220-15-2 (255-261)	T <i>Stylotrachus quadribachiatus quadribachiatus</i>	220-14, CC 220-15-2 (255-261)
		T <i>Acarinina soldadoensis angulosa</i>	220-15-2 220-15-3 (261-262)	T <i>Stylosphaera coronata sabaca</i>	220-15-2 220-15-3 (261-262)
T <i>Discoaster subladoensis</i>	220-14-3 220-15-4 (262-264)	B <i>Acarinina punctocarinata</i>	220-15-3 220-15-4 (262-264)	T <i>Lamptonium fabaeforme fabaeforme (?)</i>	220-15-3 220-15-4 (262-264)
				B <i>Lithapium plegmacantha</i>	220-15-3 220-15-4 (262-264)

TABLE 1 – Continued

Calcareous Nannofossils		Foraminifera		Radiolaria	
Events	Interval, Site, Core, Section, Subbottom Depth (m)	Events	Interval: Site Core, Section, Subbottom Depth (m)	Events	Interval: Site, Core, Section, Subbottom Depth (m)
		B <i>Acarinina mattseensis wartsteinensis</i>	220-15-4 220-15-5 (264-265)		
		T <i>Acarinina apanthesma</i>	220-15-5 220-15-6 (265-267)		
				<i>Lithochytris archaea</i> → <i>L. vespertilio</i>	220-15-5 220-16-2 (265-290)
				<i>Theocotyle cryptocephala nigriniaie</i> → <i>T. c. cryptocephala</i>	220-15-5 220-16-2 (265-290)
				B <i>Stylotrochus quadribachiatus quadribachiatus</i>	220-15-6 220-15, CC (266-267)
T <i>Discoaster lodoensis</i>	220-15, CC 220-16-2 (267-290)	B <i>Acarinina boudreauxi</i>	220-15, CC 220-16-2 (267-290)	B <i>Theocampe mongolfieri</i>	220-15, CC 220-16-2 (267-290)
		B <i>Subbotina patagonica</i>	220-15, CC 220-16-2 (267-290)		
		B <i>Subbotina boweri</i>	220-15, CC 220-16-2 (267-290)		
		T <i>Acarinina mattseensis alticonica</i>	220-15, CC 220-16-2 (267-290)		
		T <i>Morozovella aragonensis caucasica</i>	220-15, CC 220-16-2 (267-290)		
		B <i>Globigerinatheka senni</i>	220-16-2 220-16, CC (267-290)	T <i>Buryella clinata</i>	220-16-2 220-16, CC (290-290)
		T <i>Acarinina wilcoxensis</i>	220-16-2 220-16, CC (267-290)		
				T <i>Spongodiscus</i> sp. aff. <i>S. cruciferus</i>	220-16, CC 220-17-1 (290-297)
				T <i>Amphicraspedum murrayanum</i>	220-16, CC 220-17-1 (290-297)
		B <i>Acarinina mattseensis mattseensis</i>	220-17-1 220-18-2 (297-328)		
		T <i>Acarinina convexa</i>	220-17-1 220-18-2 (297-328)		
T <i>Marthasterites tribachiatus</i>	220-17, CC 220-18-2 (299-328)				
		B <i>Globorotaloides turgida</i>	220-18-2 220-18-3 (328-329)		
		T <i>Acarinina quetra</i>	220-18-2 220-18-3 (328-329)		

TABLE 2
Relationship of Microfossil Zones Observed at Sites 219 and 220

Calcareous Nannofossil Zones	Foraminiferal Zones	Radiolarian Zones	Epoch (Nannofossil Data)		
<i>Gephyrocapsa oceanica</i>	N.23	Radiolarian preservation inadequate	Quaternary		
<i>Pseudoemiliana lacunosa</i>	N.22				
<i>Discoaster brouweri</i> <i>Discoaster pentaradiatus</i>	N.21				
<i>Discoaster surculus</i>	N19 + N.20				
<i>Reticulofenestra pseudumbilica</i> <i>Discoaster asymmetricus</i>	N.18		Pliocene		
<i>Discoaster quinquerramus</i>	N.17				
<i>Discoaster hamatus</i>					
<i>Discoaster dilatus</i>					
			Miocene		
<i>Sphenolithus heteromorphus</i>	N.10				Late
<i>Helicopentospaera ampliapertura</i>	N.7 + N.8				Middle
			Early		
<i>Sphenolithus predistentus</i>	P.18 + P.19		Middle	Oligocene	
<i>Helicopontosphaera reticulata</i>			Early		
<i>Discoaster barbadiensis</i>	P.17		Late	Eocene	
	P.15				
<i>Chiasmolithus grandis</i>	P.14		<i>Thyrsocyrtis bromia</i>	Middle	
	P.11				
<i>Discoaster sublodoensis</i>	P.10		<i>Podocyrtis mitra</i>	Middle	
	P.9	<i>Podocyrtis ampla fasciolata</i>			
<i>Discoaster lodoensis</i>		<i>Thyrsocyrtis triacantha</i>	Middle		
		<i>Theocampe mongolfieri</i>			
			Early		
<i>Marthasterites tribrachiatus</i>	P.8	Unzoned Early Eocene	Early		
			Early		

Note: See text for a detailed explanation of table.