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9. AGGLUTINATED BENTHIC FORAMINIFERAL BIOSTRATIGRAPHY OF SITES 909 AND 913, NORTHERN NORTH ATLANTIC[1]

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ABSTRACT

Agglutinated benthic foraminifers occur in Eocene to Miocene sediments at Ocean Drilling Program (ODP) Sites 909 and 913 in the northern North Atlantic Ocean. At Site 909, in the Fram Strait, four assemblages, dominated by *Reticulophragmium* ex gr. *rotundidorsata* and *Reticulophragmium amplectens,* range in age from middle to late Miocene. At Site 913, in the Greenland Basin, five assemblages, containing *Reticulophragmium amplectens* and *Reophax abyssorum,* range in age from the early Eocene to Miocene. The stratigraphic ranges of the agglutinated benthic foraminifers of Site 913 agree with previously published species ranges. However, the stratigraphic ranges of many of the agglutinated species at Site 909 extend into the upper Miocene. These are the youngest reported ranges for some agglutinated species in the North Atlantic basins. These newly reported occurrences provide information about the deep-water exchange between the North Atlantic and the Arctic Ocean during the Eocene to Miocene. This study suggests that during the Miocene, the Fram Strait was a high sedimentation-rate, depositional basin with isolated bottom water. This depositional environment favored the preservation of the agglutinated benthic foraminiferal assemblages long after their disappearance from the rest of the North Atlantic.

INTRODUCTION

Deep-sea agglutinated foraminifers have been found in widely scattered Paleogene localities within the North Atlantic (Gradstein and Berggren, 1981; Kaminski et al., 1989a; Kaminski et al., 1990; Miller et al., 1982). Inasmuch as agglutinated foraminifers are a relatively consistent microfossil present in many high-latitude stratigraphic sequences, their further study is valuable. As new material is discovered, their North Atlantic stratigraphy can be continually refined. This paper documents the agglutinated benthic foraminifers found at two ODP sites in the northern North Atlantic Ocean, Sites 909 and 913 (Fig. 1).

Site 909 (78°35.096′N, 3°4.222′E) is located at 2518 meters water depth (mwd) in the Fram Strait. This site was chosen to allow the study of this climatically sensitive passageway between the North Atlantic and the Arctic Oceans. Additionally, the deep Hole 909C was drilled with the goal of resolving the timing of plate tectonic events that led to the opening of the Fram Strait. The initiation of deep water exchange between the Arctic and Atlantic Oceans may have occurred as early as the early Oligocene (Crane et al., 1982) or in the late Miocene (Eldholm, 1990). Site 913 (75°29.365′N, 6°56.810′W) is located at 3318.6 mwd in the deep Greenland Basin on crust of magnetic anomaly 24B. This site was chosen to determine the age of the basement and overlying sediments, and the age of initial rifting.

This study of deep-water agglutinated benthic foraminifers was undertaken to help refine their North Atlantic biostratigraphy, as well as to document the anomalously young fauna at Site 909. In this paper we will treat each site separately. We present the age control and lithostratigraphy of the intervals only where the agglutinated fauna occur, followed by the agglutinated benthic foraminiferal results for each site. We conclude with a comparison to Site 643 and a brief discussion.

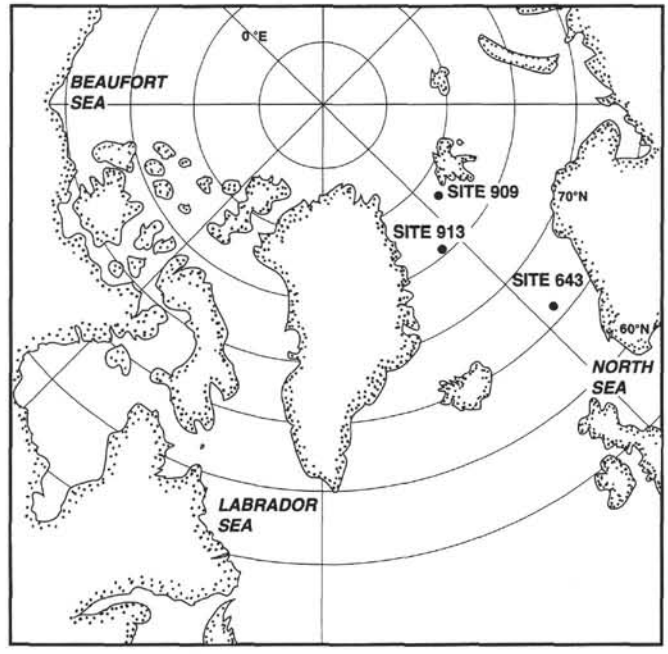

Figure 1. Location map of ODP Site 909 in the Fram Strait, Site 913 in the East Greenland Basin, and Site 643 on the Vøring Slope. Deep-water agglutinated benthic foraminifers are also found in the Labrador Sea, North Sea, and Beaufort Sea.

SITE 909

Age Control of Hole 909C

The age control at Hole 909C is accomplished by using planktonic foraminifers, calcareous nannofossils, and palynomorphs. Upper Pliocene to Miocene sediments are indicated from Cores 151-909C-27R-CC to 50R-CC (345.3 to 566.6 mbsf). The upper to middle Miocene occurs from Cores 151-909C-51R-CC to 92R-CC (576.2 to

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Table 1. Agglutinated benthic foraminifers of Site 909.

Core, section, interval (cm)	Depth (mbsf)	Barren in agglutinated foraminifers	*Nothia robusta*	*Rhabdammina abyssorum*	*Nothia latissima*	*Haplophragmoides walteri*	*Reticulophragmium* ex gr. *rotundidorsata*	*Hyperammina rugosa*	*Saccammina placenta*	*Recurvoides contortus*	*Recurvoidella lamella*	*Trochammina* cf. *deformis* (fine)	*Haplophragmoides stomatus*	*Paratrochammina challengeri*	*Hyperammina elongata*	*Reticulophragmium placenta*	*Ammodiscus tenuissimus*	*Verneuilina* sp.	*Haplophragmoides walteri excavatus*	*Spirosigmoilinella compressa*	*Glomospira charoides*	*Trochammina* cf. *deformis* (coarse)	*Reophax nodulosus*	*Reticulophragmium amplectens*	*Ammodiscus nagyi*	*Ammodiscus cretaceous*	*Reophax elongatus*	*Bathysiphon annulatus*	*Ammolagena clavata*	*Nothia excelsa*	*Trochammina globigerinaeformis*	*Rhizammina? indivisa*	*Hormosina globulifera*	*Tolypammina vagans*	*Hormosinella carpenteri*	*Subreophax scalaria*	*Recurvoides* sp.	*Dorothia siegliei*	*Budashevella multicamerata*	*Saccammina sphaerica*	*Rzhehakina minima*	*Hormosinella* sp.	*Haplophragmoides* cf. *kirki*	*Reophax scorpiurus*	*Spirosigmoilinella* sp.	*Karreriella siphonella*	Amber	Megaspores	Assemblages and environment
151-909C-																																															
50R-CC	566.60	B																																													
51R-CC	576.20	B																																													
52R-CC	585.80		R	R		R																																								
53R-CC	595.50	B																																												
54R-CC	605.10					R																																								
55R-1, 76–78	605.86		R	R	R	R	R	R	R	R	R	R																																		
55R-2, 31–32	606.91				R	R																																							
55R-2, 139–141	607.99				R	C	R		R		R		R	R	R	R	R	R	R																										
55R-CC	614.80						R										R																												
56R-CC	624.40					R	R										R																												
57R-CC	634.10	B																																											
58R-1, 44–48	634.54	B																																											
58R-CC	643.70	B																																											
59R-5, 46–48	650.16			R		C	R										R	R		R																									
59R-CC	653.40		R		R	R	R					R					C	R																										
60R-1, 93–95	654.33			R		R											C	R																										
60R-2, 93–95	655.83				R	R	R								R		R			C	R																							
60R-3, 93–95	657.33				C	C	C						R						R																									
60R-4, 93–95	658.83					R	R					R	R					R	R																									
60R-5, 93–95	660.33		R	R	C	R				R	R	R					R	R		R			R	R																			
60R-6, 93–95	661.83		R	C					R			R					R	R		R																								
60R-CC	663.00			R		R						R					R	R																									
61R-1, 91–96	663.91									R									R																									
61R-2, 90–95	665.40				R		R			C		R						R	R																									
61R-3, 93–95	666.93				R	R	C			C		R		R					R																									
61R-4, 93–97	668.43				R		R			R	R	R						R							R																		
61R-5, 91–94	669.91					R	C			R	C						R									R																		
61R-CC	672.70			R			R				R	R						R																									
62R-1, 92–97	673.62	B																																										
62R-2, 92–97	675.12						R					R								R	R																						
62R-3, 92–97	676.62						R					R		R		C				R																							
62R-4, 92–97	678.12	B																																										
62R-5, 92–97	679.62					R	C					R		R				R						R			R	R															
62R-6, 89–94	681.09		R		R	A				R								R						R				R														
62R-CC	682.30		R			C				R		R						R		R																						
63R-1, 92–96	683.22					C				R		R					R			R								R														
63R-2, 90–95	684.70		R	R		R						R				R				R																						
63R-3, 92–96	686.22			R		R				R	R	R	R							R						R			R													
63R-CC	692.00				R	C					R				R					R						R																
64R-1, 92–96	692.92			R		C						R					R	R								R																
64R-1, 92–96	694.42			R		R	A								R	R										R	R	R															
64R-3, 92–96	695.92				R	C	C			R								R		R								R														
64R-4, 92–96	697.42		R	R			C			R		R				R				R						R	R															
64R-5, 92–96	698.92				R		R				R	R				R				R																						
64R-CC	701.60				R	R	R			R		R	R	R				R	R			R							R	R												
65R-1, 91–96	702.51					R	C					R	R	R		R		R		R		R				R			R	R												
65R-2, 93–97	704.03			R			C		R			C				R							R				R			R	R												
65R-3, 91–95	705.51			R	R	R	R									R								R					R		R											
65R-4, 94–98	707.04		R	R		R			R			R	R			R	R											R														
65R-5, 92–97	708.52		C	R	R	C	R		R				R			C			R			R	R			R	R	R		R												
65R-6, 93–97	710.03				R	C	C					R	R	R																R	R											
65R-CC	711.10				R	C	C				R	R	R						R				R				R		R													
66R-1, 94–98	712.04					C	C				R	R	R	R		R		R				R	R				R			C												
66R-2, 93–97	713.53					C	R	R	R		R	C	R		R				R			R	R				R			R	R	R										
66R-CC	720.80			C		C		R	R			R	R									R	R				R		R	R			R									
67R-1, 92–96	721.72					R	C				R	R	R				R		R			R				R	R															
67R-2, 92–96	723.22					C	R				C	C	R			C	R	R													R												
67R-3, 92–96	724.72			R		R	R		R			R	R																			R	C										
67R-4, 89–93	726.19					C	R			R	C	R				C																											
67R-5, 94–98	727.74			R		R	C				R	R		R																R			R									
67R-6, 91–95	729.21					C						R	R			R						R				R				R			R	R								
67R-CC	730.40			R	R	C	C	R		R		C		R		R		R												R			R									
68R-1, 53–57	730.93		R		R	R	R					R	R			R		R		R																						
68R-2, 53–57	732.43				R	C	R		R			R				R																										
68R-3, 53–57	733.93					C						R	R			R										R							R		R							
68R-CC	740.00				R		C		R			R				C																			R							
69R-1, 93–96	740.93			R		R	R					R				R		R	R	R																						
69R-2, 93–96	742.43					R	R					R							R			R				R															
69R-3, 93–96	743.93					R						R				R																				R						
69R-4, 93–96	745.43			R	R	C						R	R			R			R	R			R					R							R	R	R					
69R-5, 93–96	746.93					R						R							R		R															R	R	R				
69R-6, 93–96	748.43					R					R	R							R	R																	R	C				
69R-CC	749.60				C		R		R		R	R	R			R		R	R		R			R		R											C	R				

Reticulophragmium ex gr. *rotundidorsata*

?

Table 1 (continued).

Core, section, interval (cm)	Depth (mbsf)	Barren in agglutinated foraminifers	*Nothia robusta*	*Rhabdammina abyssorum*	*Nothia latissima*	*Haplophragmoides walteri*	*Reticulophragmium* ex gr. *rotundidorsata*	*Hyperammina rugosa*	*Saccammina placenta*	*Recurvoides contortus*	*Recurvoidella lamella*	*Trochammina* cf. *deformis* (fine)	*Haplophragmoides stomatus*	*Paratrochammina challengeri*	*Hyperammina elongata*	*Reticulophragmium placenta*	*Ammodiscus tenuissimus*	*Verneuilina* sp.	*Haplophragmoides walteri excavatus*	*Spirosigmoilinella compressa*	*Glomospira charoides*	*Trochammina* cf. *deformis* (coarse)	*Reophax nodulosus*	*Reticulophragmium amplectens*	*Ammodiscus nagyi*	*Ammodiscus cretaceous*	*Reophax elongatus*	*Bathysiphon annulatus*	*Ammolagena clavata*	*Nothia excelsa*	*Trochammina globigerinaeformis*	*Rhizammina? indivisa*	*Hormosina globulifera*	*Tolypammina vagans*	*Hormosinella carpenteri*	*Subreophax scalaria*	*Recurvoides* sp.	*Dorothia siegfliei*	*Budashevella multicamerata*	*Saccammina sphaerica*	*Rzehakina minima*	*Hormosinella* sp.	*Haplophragmoides* cf. *kirki*	*Reophax scorpiurus*	*Spirosigmoilinella* sp.	*Karreriella siphonella*	Amber	Megaspores	Assemblages and environment
70R-1, 90–96	750.50											R R				C			R																												
70R-2, 90–95	752.00			R		R R			R				R			R			R														R		C R		R									
70R-3, 94–97	753.54				R	R R			R		R					C			R			R	R		R									R											
70R-4, 92–97	755.02		R		R				R		R R		R						R										R					R C											
70R-5, 89–93	756.49		R	R	R				R			R						R	R			R	R		R			R				R		R										
70R-CC	759.30		R	R	R	R						R	R			R			R	R			C			R		R						R	R	R									
71R-1, 95–99	760.25	R	R					R	R		C									R				C			R		R	R	R			R										
71R-2, 95–99	761.75				R	R		R	R		R R					R			R			R	R	R								R		R										
71R-3, 95–99	763.25		R		R			R	R R	R	R R		R R			R R			R				R			R																		
71R-4, 95–99	764.75								R		R R		R			R		R	R				R									R		R		R								
71R-CC	769.00								R		R		R			C			R R	R		R	R										R		R									
72R-1, 95–99	769.95		R								C R					R			R		R		R									R		R										
72R-2, 95–99	771.45		R				R		R R					R						R		R									R		R										
72R-3, 95–99	772.95				R				R		R R	R	R						R R				R											R R		R								
72R-4, 95–99	774.45		R								R					R			R									R																
72R-5, 95–99	775.95				R R						R R					R			R				R													R								
72R-6, 95–99	777.45				R						R					R																											
72R-CC	778.70		R	R	R						C R	R	R			C						R		R									R			R	R							
73R-1, 97–99	779.67		R							R	R R	R				R								R																				
73R-2, 96–99	781.16								R	R	R R					R				R				R						R					R									
73R-3, 93–97	782.63								R		R R					C				R																								
73R-4, 95–98	784.15								R	C	C	R							R					R									R											
73R-5, 93–97	785.63		C		R				R	C	R R									R															R									
73R-CC	788.30										R					R			R																R									
74R-1, 94–96	789.24		R		R						R R																							R									
74R-2, 94–96	790.74								R							R								R										R									
73R-3, 94–96	792.24				R											R								R																		
74R-4, 96–98	793.76										R												R	R						R		R										
74R-5, 95–97	795.25					R				R																R		R				C										
74R-CC	798.00					R			R								R									R						C										
75R-1, 95–99	798.95					R				R R		R	R			R	R											C			R											
75R-2, 95–99	800.45			C	R											R								C				R			C										
75R-3, 95–99	801.95				R						R	R												R				C													
75R-4, 95–99	803.45																							R								R	R		R							
75R-5, 93–97	804.93										R					R			R					R				R													
75R-6, 94–97	806.44				R					R																	R		C												
75R-CC	807.60		C	R	R						R R	R												R							R		C			R					
76R-1, 96–98	808.56		R		R									R		R	R		R					C																	
76R-2, 96–98	810.06													R					R								R		C				C	R							
76R-3, 96–98	811.56				R				R	R R						R								R		R		C					R			R			C		
76R-5, 96–98	814.56				R				R			R	R			R			R					R			R						R			R			C		
76R-CC	817.30		C						R	R						R			R					R									C								
77R-1, 94–97	818.24				R							R				R								R									R								
77R-3, 94–97	821.24				R		R		R	R R		R				R								R								R		C		R					
77R-4, 94–97	822.74				R				R			R				R								R				R													
77R-CC	827.00											R				R			R													R		R		R				R	
78R-1, 96–98	827.96				R	R		R		R		R		R					R					R																	
78R-2, 94–97	829.44				R		R			R	R								R									R													
78R-CC	836.60				R						R			R										R				R			R		C			R		R			
80R-1, 95–99	847.15		R	C						R	R R					R								R																	
80R-2, 95–99	848.65		C	R				R			R		R															R								R	R				
80R-4, 95–99	851.65		C	R							R					R	R											C									R				
80R-6, 92-97	854.62		R	R								R				R								R															R	R	
80R-CC	855.90		R		R						R			R							R					R		R												R	
81R-1, 95–100	856.85		C													C								R				R												R	
81R-2, 95–99	858.35		R					R			R	C												R																R	
81R-4, 95–99	861.35				R			R				R							R																						
81R-CC	865.50		C		R			R				R	C	R		R												C	C							R	R			R	
82R-1, 95–99	866.45				R			R						R					R					R														R			
82R-CC	875.10	R	R	R								R	R			R			R					R													R		R			
83R-1, 94–97	876.04		R		R							C											R	R													R				
83R-2, 94–97	877.54				R						R R	R																			R						R R				
83R-3, 94–97	879.04										R R																										R				
83R-CC	884.80		C								R R	R	R			R			R					R				C	R								R				
84R-1, 96–00	885.76										R	R	R R	R			R		R					R				R	R												
84R-2, 95–98	887.25			R	R						R R						R							R				R													
84R-3, 98–102	888.78				R						C																														
84R-4, 93–97	890.23			R							R							R				R		R																	
84R-CC	894.40					R						R				R			R					R													R				
85R-1, 96–98	895.36				R						R			R		R											R														
85R-2, 20–22	896.10	R									C			R			R																									
85R-CC	904.10				R																																				
86R-1, 95–97	905.05										C R	R				R			R					R	R													R				
86R-2, 95–97	906.55										R					R									R													R				

Reticulophragmium amplectens

Table 1 (continued).

Core, section, interval (cm)	Depth (mbsf)	Barren in agglutinated foraminifers	*Nothia robusta*	*Rhabdammina abyssorum*	*Nothia laitissima*	*Haplophragmoides walteri*	*Reticulophragmium* ex gr. *rotundidorsata*	*Hyperammina rugosa*	*Saccammina placenta*	*Recurvoides contortus*	*Recurvoidella lamella*	*Trochammina* cf. *deformis* (fine)	*Haplophragmoides stomatus*	*Paratrochammina challengeri*	*Hyperammina elongata*	*Reticulophragmium placenta*	*Ammodiscus tenuissimus*	*Verneuilina* sp.	*Haplophragmoides walteri excavatus*	*Spirosigmoilinella compressa*	*Glomospira charoides*	*Trochammina* cf. *deformis* (coarse)	*Reophax nodulosus*	*Reticulophragmium amplectens*	*Ammodiscus nagyi*	*Ammodiscus cretaceous*	*Reophax elongatus*	*Bathysiphon annulatus*	*Ammolagena clavata*	*Nothia excelsa*	*Trochammina globigerinaeformis*	*Rhizammina? indivisa*	*Hormosina globulifera*	*Tolypammina vagans*	*Hormosinella carpenteri*	*Subreophax scalaria*	*Recurvoides* sp.	*Dorothia siegfliei*	*Budashevella multicamerata*	*Saccammina sphaerica*	*Rzehakina minima*	*Hormosinella* sp.	*Haplophragmoides* cf. *kirki*	*Reophax scorpiurus*	*Spirosigmoilinella* sp.	*Karrerielia siphonella*	Amber	Megaspores	Assemblages and environment
86R-CC	913.80					R					C	C								R																											
87R-1, 95–97	914.75			R					R		R	R				R	R																														
87R-2, 90–92	916.20					R		R	R			R					R	R		R								R				C	R	R		R										
87R-CC	923.40			C		R						C					R	R		R				R		R			R			C		R												
88R-1, 97–99	924.37			cf								R										R														R								R		Redeposited fauna
88R-2, 97–99	925.87				cf																																									
88R-CC	933.10	B																		R																									C	
89R-1, 97–100	934.07				cf																																								Slumping
89R-2, 97–99	935.57				cf						R		R																															C	
89R-CC	942.80			cf																																									
90R-1, 96–99	943.76	B																																										?	
90R-2, 96–99	945.26				cf											R																													
90R-CC	952.40			R	R		R	R	R		R	C	R						R	R				R			R		R	R			C	C	C		R	R	R		R					
91R-1, 94–97	953.34			R							R	R					R												R												R				
91R-2, 94–97	954.84			R		R			C		R		R			R								R				R				R		R	C			R			R		R		
91R-CC	962.10		R				R					R							R										R	C					R							C	R		
92R-1, 93–97	963.03										R		R	R										C			R	R							R								R		
92R-2, 97–100	964.57			R		R					C		R			R			R	R				R										R										
92R-CC	971.70			C			R																	R			R		R	R	R				R	R									
93R-1, 94–97	972.64			R	R		R	R				R					R		R	R				R			R						R	R				R						
93R-2, 96–100	974.16						R													R																			R						
93R-CC	981.30				R	R	R					R		R							R																			R						
94R-1, 92–96	982.22						R	R				R	R				R		R					R											C	C		R							
94R-2, 92–96	983.72						R	R	C			R							R	R					R			R												C	R				
94R-CC	990.70			R				R					R			R			R				R	R			R									R				R					
95R-1, 96–100	991.66			C		R	R	R	R			C	R						C								R	R		C						R	R	R	R						
95R-CC	1000.40			R		R	R					R	R			R	R		R	R		R		R						C								R						
96R-1, 94–97	1001.34						R					C				R			C	R				R									R	R	R	R					R				
96R-CC	1010.00																													R											R				
97R-1, 95–98	1010.95			R	R				R				R			R			R	R			R				R														R				
97R-CC	1019.70			R	R		R	R	R			R	R						R	R				C						R	R				R						R				
98R-1, 94–97	1020.64				R		R	R	R			R	R						R											R					R										
98R-2, 35–38	1021.55				R							R	R						C					R			R																		
98R-CC	1029.20			R								C							R	R							R						R	R	R	R		R							
99R-1, 95–99	1030.15			R	R		R										R		R								R								R		C								
99R-CC	1038.80			R	C		R	R				R				R				R				R			R								R						R	R	R		
100R-1, 95–99	1039.75			R	R			R						R						R				R			R								R	R									
100R-CC	1048.40																																			C						R		R		
101R-1, 94–99	1049.34											R								R																R						R				
191R-CC	1052.70											R								R																R										
102R-1, 95–97	1053.65	B																																													
102R-2, 101–103	1055.21			R	R																															R						R				
102R-3, 103–105	1056.73	B																																												
102R-CC	1058.00			R	R												R											R								R						R				
103R-1, 3–7	1058.03			R																																							R				
103R-1, 95–99	1058.95	B																																												
103R-2, 3–7	1059.53	B																																												
103R-2, 92–96	1060.42				R															R																					R					
103R-3, 3–7	1061.03			R	C				R																																		R				
103R-3, 95–99	1061.95			R	R				R							R				R																							R				
103R-CC, 3–7	1062.16			R	C				C																		R														C					
103R-CC	1062.80			R	R															R																							R				

Notes: Abbreviations: B = barren in agglutinated foraminifers, R = rare, less than 5 specimens, C = common, 6–25 specimens, A = abundant, more than 25 specimens, ? = too few fossils to assign zones or environmental interpretation.

971.7 mbsf) (Poulsen et al., this volume). The base of the hole is constrained as no older than early Miocene based on the occurrence of the calcareous nannofossil *Helicosphaera carteri* in Cores 151-909C-101R-2 through 102R-CC (Shipboard Scientific Party, 1995a). The occurrence of the planktonic foraminifer *Globigerina scitula* in Sample 151-909C-103R-2, 3–7 cm (1059.53 mbsf) indicates an age younger than 15.1 Ma at this depth (Spiegler, this volume). The majority of the agglutinated foraminiferal assemblage at Site 909 occur in middle to upper Miocene sediments (1062.8 to 570 mbsf).

Lithostratigraphy of Hole 909C

The predominantly agglutinated benthic foraminiferal assemblage occurs in lithologic Subunits 3A and 3B of Hole 909C. Lithologic Subunit 3A occurs from Sample 151-909C-46R-1, 0 cm, to 87R-CC, 20 cm (518.3 to 923.4 mbsf) and is described as an extensively laminated, very dark gray silty clay with extensive bioturbation. The upper two benthic foraminiferal assemblages occur in this sedimentary unit.

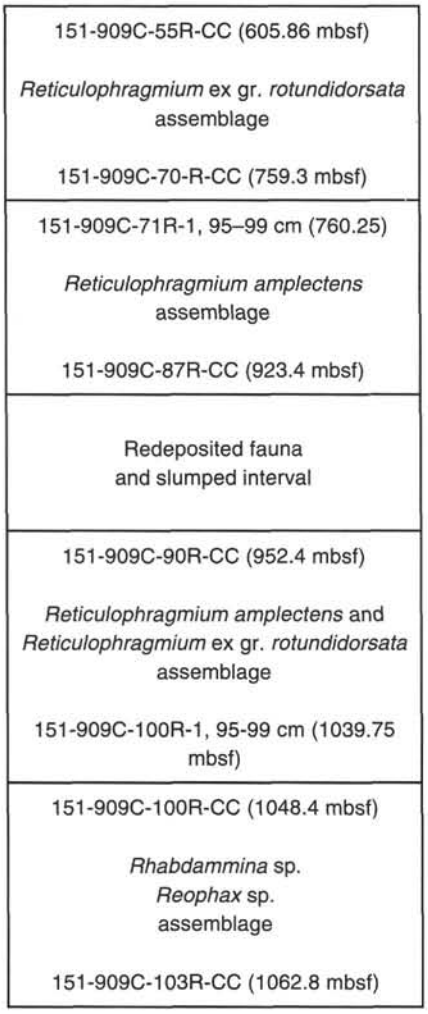

Figure 2. Agglutinated benthic foraminiferal assemblages of Hole 909C.

Subunit 3B occurs from Sample 151-909C-88R-1, 0 cm, through 103R-CC, 20 cm (923.4 to 1061.8 mbsf). Subunit 3B is described as containing alternating units of normal (i.e., Subunit 3A) sediment with meter-scale intervals of slumping. The slumping was an episodic event, believed to have resulted from high sedimentation rates in the basin during this entire interval (Shipboard Scientific Party, 1995a). The lower two foraminiferal assemblages occur in this sedimentary unit.

Benthic Foraminifers of Hole 909C

Hole 909C contains an assemblage of agglutinated benthic foraminifers dominated by *Reticulophragmium* ex gr. *rotundidorsata* and *Reticulophragmium amplectens* (Table 1). *Reticulophragmium amplectens* has never been reported in sediments of Miocene age. The hole has been divided into four assemblages (Fig. 2). From oldest to youngest these are (1) the *Rhabdammina/Reophax* assemblage (Samples 151-909C-100R-CC to 103R-CC; 1048.4 to 1062.8 mbsf), (2) the *Reticulophragmium* ex. gr. *rotundidorsata* and *Reticulophragmium amplectens* assemblage (Samples 151-909C-90R-CC to 100R-1, 95–99 cm; 952.4 to 1039.75 mbsf), (3) the *Reticulophragmium amplectens assemblage* (Samples 151-909C-71R, 95–99 cm, to 87R-CC; 760.25 to 923.4 mbsf), and (4) the *Reticulophragmium* ex. gr. *rotundidorsata* assemblage (Samples 151-909C-51R-1, 76–78 cm to 70R-CC, 605.86 to 759.3 mbsf). The *R. amplectens* assemblage and the underlying *R. amplectens/R.* ex gr. *rotundidorsata* assemblage are separated by a barren and slumped interval containing reworked and redeposited megaspores and amber and no other microfossils from 923.4 to 952.4 mbsf.

Based on the calcareous nannofossil biostratigraphy, the lowermost *Rhabdammina/Reophax* assemblage (1062.8 to 1048.4 mbsf) is of early to middle Miocene age. The agglutinated benthic foraminiferal fauna consists of rare to common *Rhabdammina abyssorum, Nothia latissima,* and *Reophax scorpiurus*. Additional species include *Budashevella multicamerata, Spirosigmoilinella compressa* and the only occurrence of *Karreriella siphonella* in Hole 909C.

A middle Miocene age is proposed for the *R.* ex gr. *rotundidorsata* and *R. amplectens* assemblage (1039.75 to 952.4 mbsf). This assemblage is characterized by the co-occurrence of both of these species as well as the most diverse agglutinated assemblage in Hole 909C. Additional species in this assemblage include *Trochammina* cf. *deformis* (fine), *Haplophragmoides stomatus, Reticulophragmium placenta, Haplophragmoides walteri excavatus, S. compressa, Nothia excelsa,* and the entire range of *Spirosigmoilinella* sp.

Above a slumped interval, the *R. amplectens* assemblage occurs in middle Miocene sediments (923.4 to 760.25 mbsf). This assemblage is characterized by the presence of *R. amplectens* and the lack of *R.* ex gr. *rotundidorsata.* This assemblage contains the last occurrences of *Hormosinella* sp., *Saccammina sphaerica,* and *B. multicamerata,* as well as the entire range of *Haplophragmoides* cf. *kirki.*

Diversity continues to decline up the core through the middle Miocene to upper Miocene of the youngest agglutinated benthic foraminiferal assemblage of Hole 909C (759.3 to 605.86 mbsf). The *R.* ex gr. *rotundidorsata* assemblage contains the last occurrence of a number of important species including *D. siegliei, Hormosina globulifera, N. excelsa, A. clavata, Ammodiscus cretaceus, T.* cf. *deformis, Glomospira charoides, S. compressa, H. walteri excavatus,* and *R. placenta.*

SITE 913

Age Control at Site 913

The age control at Hole 913B is based on diatoms, radiolarians, planktonic foraminifers, and palynomorphs. The silica-rich Core 151-913B-19W is assigned to the middle Miocene based on radiolarians and diatoms (Hull, this volume; Scherer, this volume). Even though Core 151-913B-19W is a wash core, it includes a short, relatively undisturbed siliceous sedimentary sequence with both diatoms and radiolarians that were used to assign a biostratigraphic age. Miocene sediments are separated from those of the Oligocene by an interval of no recovery in the lower part of Core 151-913B-19W. Core 151-913B-20R is of early Oligocene age based on siliceous microfossils and palynomorphs (Hull, this volume; Scherer, this volume; Firth, this volume). The upper Eocene ranges from about Core 913B-30R up to 24R (Hull, this volume; Firth, this volume). The interval from Core 913B-21R to 23R is largely barren of siliceous microfossils and palynomorphs, and its age is uncertain. The middle to upper Eocene boundary occurs between Cores 913B-33R and 29R (Hull, this volume; Firth, this volume). Lower Eocene sediments are indicated by planktonic foraminifers in Samples 151-913B-44R-3, 55–60 cm (658.09 mbsf), and 45R-1, 11–14 cm (664.51 mbsf). Sediments from 664.99 to 721.9 mbsf are most likely early Eocene in age, based on the Anomaly 24B crust below and the occurrence of early Eocene planktonic foraminifers above (Spiegler, this volume).

Lithostratigraphy of Site 913

The lower part of Hole 913B is divided into two lithologic units. Lithologic Unit 3 occurs from 378.7 to 674.1 mbsf in Hole 913B and contains the upper four benthic foraminiferal assemblages. Lithologic Unit 3 is subdivided into three subunits. Subunit 3A (378.7 to

462.0 mbsf) consists of interbedded massive and laminated silty clays and clays. Subunit 3B (462 to 500.3 mbsf) consists of biosilica-bearing clays, and Subunit 3C (500.3 to 674.1 mbsf) consists of massive and laminated clays with rare microfossils. The lowermost sediments are described as Unit 4 (674.1 to 770.3 mbsf), which consists of laminated clays, silty clays, and massive silty clays (Shipboard Scientific Party, 1995b) and corresponds to the oldest benthic foraminiferal assemblage at this site.

Benthic Foraminifers of Hole 913B

The benthic foraminifers of Hole 913B are divided into five main assemblages that show an increase and then decrease in diversity uphole (Table 2; Fig. 3). The lowest sediments from 716.98 to the base of the hole at 770.3 mbsf are barren of any biota. Above these barren sediments is a poorly fossiliferous sequence from Samples 151-913B-45R-1, 59–62 cm, to 50R-4, 10–14 cm (664.99 to 716.47 mbsf). These samples contain scattered agglutinated benthic foraminifers, and only 10 taxa are observed. This sequence is interpreted to represent nearshore marine sediments with megaspores and *Skolithos* burrows. The first observation of *Karrerulina conversa* occurs in this interval in Sample 151-913B-46R-3, 12–14 cm. The age of these sediments are believed to be early Eocene. *Karrerulina conversa* also occurs in abundance in the early Eocene of the North Sea (Gradstein et al., 1994)

The deformed agglutinated benthic foraminiferal assemblage occurs from Sample 151-913B-41R-CC to 44R-5, 116–120 cm (635.4 to 661.76 mbsf). These sediments are interpreted to be middle Eocene in age. This assemblage consists of a more diverse assemblage with 19 taxa which have been post-depositionally crushed. Roughly 75% of the 40 samples contain foraminifers. This assemblage includes the first occurrences of *Haplophragmoides porrectus* and *Nothia excelsa* and the entire range of the Eocene marker *Spiroplectammina spectabilis.*

The upper three assemblages all contain *R. abyssorum* and are assigned the names of the upper, middle, and lower *R. abyssorum* assemblage. The lower *R. abyssorum* assemblage occurs from Sample 151-913B-35R-6, 59–61 cm, to 41R-4, 59–63 cm (575.83 to 629.96 mbsf). This interval contains a diverse assemblage of 41 taxa with 89% of the samples containing agglutinated benthic foraminifers, and it contains the last occurrences of *K. conversa* and *H. porrectus,* as well as the entire range of *R. amplectens* and *Cribrostomoides* sp. The lower *R. abyssorum* assemblage occurs in middle to upper Eocene sediments.

The middle *R. abyssorum* assemblage is found in Samples 151-913B-30R-1, 12–15 cm, to 35R-6, 11–13 cm (519.63 to 575.35 mbsf). This assemblage occurs in the middle to late Eocene and contains only 18 taxa in 66% of the samples. Diversity drops even further in the upper *R. abyssorum* Assemblage from Samples 151-913B-19W-1, 11–15 cm, to 29R-CC (375.31 to 519.5 mbsf). This assemblage corresponds to the middle to upper Eocene, Oligocene, and Miocene sediments and contains only eight taxa in 27% of the samples, the remainder being barren of foraminifers.

COMPARISON TO OTHER SITES

Widespread similarities exist between the Cenozoic benthic foraminiferal biostratigraphies from high-latitude localities (King, 1983; McNeil, 1989; Osterman and Qvale, 1989). In general, Paleocene and Eocene assemblages are predominantly agglutinated, Oligocene and Miocene are mixed calcareous and agglutinated, and Miocene to Holocene are predominantly calcareous. This faunal shift has been interpreted to represent the transition from deep stratified basins of the Paleogene into more oxygenated ocean basins that allowed the preservation of carbonate faunas during the Neogene.

On the Beaufort Sea shelf, the Paleocene and Eocene agglutinated faunas are endemic and attest to the isolation of the Arctic Ocean during this interval (McNeil, 1989). However, in the Oligocene and earliest Miocene calcareous benthic foraminifers begin to occur in the shallower water. During the same interval the deeper water Beaufort Sea sites contain a primarily agglutinated assemblage of *Recurvoides brideauxi* and *N. excelsa* (McNeil, 1989; Schröder-Adams and McNeil, 1994).

At Site 643 on the Vøring Slope, Osterman and Qvale (1989) also reported a predominantly agglutinated assemblage in Eocene to Oligocene sediments, with mixed calcareous and agglutinated benthic foraminifers in the Miocene. Further work by Kaminski et al. (1990) refined the agglutinated benthic foraminiferal stratigraphy of Site 643. The Eocene through Miocene interval of this site contains numerous unconformities, making the assignment of exact ages difficult. Assignment of various core fragments to ages is accomplished by using the biostratigraphic synthesis of Goll (1989): Section 643A-62X-CC to 50X-1 = lower to middle Eocene boundary (50 to 55 Ma); Section 643A-49X-CC to 46X-5 = upper Eocene to lower Oligocene boundary (36 to 38 Ma); Section 643A-46X-6 to 43X-CC = upper Oligocene (25 to 23.7 Ma); Section 643A-43X-CC to 30X-1 = lower Miocene (20 to 23.7 Ma), but may extend into the upper Oligocene.

Kaminski et al. (1990) assigned five benthic foraminiferal assemblage zones to the lower section of Hole 643A. These include (1) an Eocene *Rhabdammina/Cyclammina* assemblage (104-643A-62X-1, 77–81 cm to 56X-1, 77–82 cm); (2) an middle Eocene *Glomospira* assemblage (104-643A-54X-5, 64–69 cm to 50X-1, 79–84 cm); (3) a lower Oligocene *Spirosigmoilinella compressa* Assemblage (104-643A-49X-5, 79–84 cm to 47X-1, 79–84 cm); (4) a *Psamminopelta* sp./*Reticulophragmium amplectens* assemblage (104-643A-46X-5, 65-69 cm to 643A-42X-1, 74–77 cm), which straddles the upper Oligocene/lower Miocene boundary at 104-643A-43X-CC; and (5) a lower Miocene *Psamminopelta* sp. assemblage (104-643A-41X-1, 105–107 cm to 35X-1, 71–74 cm).

Kaminski et al. (1990) reported that the ages of the agglutinated benthic foraminifers at Site 643 are slightly younger than the reported ranges of the same species from both the North Sea (Gradstein et al., 1994) and the Labrador Sea (Miller et al., 1982). Deep-water agglutinated foraminifers that are found in Eocene sediments of the North and Labrador Seas are found in Oligocene sediments at Site 643. The youngest deep-water agglutinated benthic foraminifers at Site 643 are of late Oligocene age, and the upper boundary of the *Psamminopelta* sp./*Reticulophragmium amplectens* assemblage at Sample 104-643A-42X-1, 74–77 cm (Early Miocene to latest Oligocene?) marks the last occurrence of several important species including *R. amplectens, R. placenta,* and *T. deformis.* Kaminski et al. (1990) theorized that the Norwegian Sea may have remained stratified for a longer period and environmental conditions favored an agglutinated fauna, while to the south in the Labrador and North Seas oxygenated bottom waters allowed the preservation of calcareous benthic foraminifers.

DISCUSSION

The stratigraphic ranges of the agglutinated fauna of Site 643 (Kaminski et al., 1990) agrees closely with what we have found in the Eocene sediments of Site 913 (Fig. 4). In fact, the Eocene age of the agglutinated fauna at Site 913 agrees more closely with the Labrador and North Seas than the slightly younger, Eocene–Oligocene, assemblages at Site 643. However, a problem arises when we consider the results of Site 909. The same deep-water agglutinated assemblages that are recorded in Eocene to Oligocene sediments elsewhere range into the upper Miocene at Site 909 (Fig. 4). Several species found in the Miocene sediments of Site 909, including *Reticulophragmium amplectens* and *Nothia excelsa,* have never been reported in sedi-

Table 2. Agglutinated benthic foraminifers in Site 913.

Core, section, interval (cm)	Depth (mbsf)	Number of samples barren in aggl. F.	*Rhabdammina abyssorum*	*Reophax elongatus*	*Hyperammina rugosa*	*Ammolagena clavata*	*Reophax nodulosus*	*Bathysiphon filiformis*	*Psammosphaera fusca*	*Haplophragmoides walteri*	*Haplophragmoides* sp. 1	*Recurvoides* sp. 1	*Bathysiphon* sp. 1	*Bathysiphon capillaris*	*Rhizammina ? indivisa*	*Trochammina deformis*	*Paratrochammina challengeri*	*Saccammina placenta*	*Ammodiscus incertus*	*Haplophragmoides horridus*	*Cribrostomoides* sp.	*Nothia latissima*	*Ammodiscus tenuissimus*	*Rhabdammina* sp.	*Nothia excelsa*	*Hyperammina elongata*	*Ammodiscus incertus*	*Bathysiphon annulatus*	*Nothia robusta*	*Praecystammina* sp.	*Saccammina sphaerica*	*Haplophragmoides* cf. *kirki*	*Reticulophragmium* sp.	*Reophax elongatus*	*Reticulophragmium amplectens*	*Recurvoidella lamella*	*Cribrostomoides subglobosus*	*Conotrochammina* sp.	*Haplophragmoides porrectus*	*Karrerulina conversa*	*Haplophragmoides suborbicularis*	*Paratrochamminoides heteromorphus*	*Nubecularia lucifuga*	*Spiroplectammina spectabilis*	*Trochamminopsis* sp.	*Reophax difflugiformis*	*Haplophragmoides* sp. 2	*Trochamminoides grzybowskii*	*Skolithos*	Rhodochrosite	Amber	Megaspores	Assemblages and environment
151-913B-																																																					
19W-1, 11–15	375.31	1																																																				
19W-2, 11–15	376.81		R																																																		
19W-3, 11–15 to	378.31	8																																																		
19W-CC	423.50																																																			
20R-1, 13–15 to	423.63	3																																																		
20R-3, 10–13	426.60																																																			
20R-CC	433.10		R																																																	
21R-1, 11–15	433.21		R																																																	
21R-2, 13–17	434.73	1																																																		
21R-3, 13–17	436.23		C																																																	
21R-4, 15–19	437.75		R																																																	
21R-CC to	442.80	4																																																		
22R-4, 12–17	447.42		R																																																	
22R-5, 10–15	448.90	1																																																	
22R-CC	452.40		R																																																
23R-1, 11–14	452.51	1																																																	
23R-CC	462.00		R																																																
24R-1, 11–15 to	462.11	3																																																	
24R-4, 10–14	466.60		F																																																
24R-4, 134–138 to	467.84	23																																																	
27R-4, 11–14	495.31		R	R	R	R																																													
27R-4, 58–62 to	495.78	2																																																	
27R-5, 58–62	497.28		R																																																
27R-6, 11–14	498.37		F				R																																											
27R-6, 58–62	498.84		F					R	R																																									
27R-CC	500.30		C					R	R																																									
28R-1, 11–14 to	500.41	3																																																	
28R-2, 57–61	502.37							R																																										
28R-3, 11–14	503.41	1																																																	
28R-3, 57–61	503.87		R																																															
28R-4, 11–14	504.91		C																																															
28R-4, 59–61	505.37		C																																															
28R-5, 11–14 to	506.41	3																																																	
28R-CC	509.90		R								R																																							
29R-1, 11–14	510.01		F																																															
29R-1, 59–62	510.49	1																																																
29R-2, 11–14	511.51		R																																															
29R-2, 59–62	511.99	1																																																
29R-3, 11–14	513.01		A																																															
29R-3, 5962 to	513.49	4																																																
29R-5, 59–62	516.49		R																																															
29R-CC	519.50		F						R																																									
30R-1, 12–15	519.62		R								F	R	F																																						
30R-1, 56–69	520.06	1																																																	
30R-2, 12–15	521.12		R			R			R	R	F	R	R	R																																			
30R-2, 58–61	521.58		R																																															
30R-3, 12–15	522.62		R	R		R			R	R	F	F	R			R																																	
30R-3, 57–61	523.07		R	R					F		R	R																																						
30R-4, 12–15	524.12		R						R																																									
30R-4, 56–59	524.56	1																																																
30R-5, 12–15	525.62		F			R					R					R																																	
30R-5, 55–59	526.05		F								F					R																																	

upper *Rhabdammina abyssorum*

Table 2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Number of samples barren in aggl. F.	*Rhabdammina abyssorum*	*Reophax elongatus*	*Hyperammina rugosa*	*Ammolagena clavata*	*Reophax nodulosus*	*Bathysiphon filiformis*	*Psammosphaera fusca*	*Haplophragmoides walteri*	*Haplophragmoides* sp. 1	*Recurvoides* sp. 1	*Bathysiphon* sp. 1	*Bathysiphon capillaris*	*Rhizammina ? indivisa*	*Trochammina deformis*	*Paratrochammina challengeri*	*Saccammina placenta*	*Ammodiscus incertus*	*Haplophragmoides horridus*	*Cribrostomoides* sp.	*Nothia latissima*	*Ammodiscus tenuissimus*	*Rhabdammina* sp.	*Nothia excelsa*	*Hyperammina elongata*	*Ammodiscus incertus*	*Bathysiphon annulatus*	*Nothia robusta*	*Praecystammina* sp.	*Saccammina sphaerica*	*Haplophragmoides* cf. *kirki*	*Reticulophragmium* sp.	*Reophax elongatus*	*Reticulophragmium amplectens*	*Recurvoidella lamella*	*Cribrostomoides subglobosus*	*Conotrochammina* sp.	*Haplophragmoides porrectus*	*Karrerulina conversa*	*Haplophragmoides suborbicularis*	*Paratrochamminoides heteromorphus*	*Nubecularia lucifuga*	*Spiroplectammina spectabilis*	*Trochamminopsis* sp.	*Reophax difflugiformis*	*Haplophragmoides* sp. 2	*Trochamminoides grzybowskii*	*Skolithos*	Rhodochrosite	Amber	Megaspores	Assemblages and environment
30R-5, 70–74	526.20	1																																																M			
30R-CC	529.20		F									F				R	R																																	C			
31R-1, 11–14	529.31		R																																																		
31R-1, 61–13	529.81		R																																															R			
31R-2, 11–14	530.81		F																																																		
31R-2, 27–31	530.97	1																																																M			
31R-2, 65–68	531.35		R																																															A			
31R-CC	538.80		F																																															C			
32R-1, 10–14	538.90	1																																																			
32R-1, 59–62	539.39		R																																															R			
32R-2, 12–16	540.42		R																																																		
32R-2, 57–59 to	540.87	6																																																R			
32R-4, 59–63	543.98		R																																																		
32R-5, 11–15	545.05		R															R																																			
32R-5, 58–62 to	545.52	2																																																			
33R-1, 13–16	548.53		R																																															R	R		
33R-2, 12–15	550.02											R																																									
33R-3, 9–12 to	551.49	6																																																			
33R-CC, 10–13	557.17		C																																																		
33R-CC,	558.10		C										R																																								
34R-1, 10–14	558.20	1																																																			
34R-1, 61–64	558.71		C									R																																									
34R-2, 10–14	559.75	1																																																			middle *Rhabdammina abyssorum*
34R-2, 58–62	560.23		R																																																		
34R-3, 10–14	561.31		F																																																		
34R-3, 56–60	561.77		F																																																		
34R-4, 10–14	562.84		F																																															R			
34R-4, 59–61	563.31		F		R				F			R						R																																F	R		
34R-5, 10–14	564.38		F					R	R																																												
34R-5, 58–62	564.86		F																																															M	R		
34R-6, 10–14	565.92		C					R				F																																							R		
34R-6, 68–62	566.40	1																																																F			
34R-CC	567.70		R																																															F			
35R-1, 11–13	567.81							R																																													
35R-1, 59–61	568.29		F					R																																													
35R-2, 11–13	569.32		R				R																																														
35R-2, 59–61	569.80		C																																																		
35R-3, 11–13	570.83		F																																																		
35R-3, 59–61	571.31		C																																																		
35R-4, 11–13	572.35		C																R	R																																	
35R-4, 59–61	572.83		F																																																		
35R-5, 11–13	573.85		R																																																		
35R-5, 59–61	574.33		R				R																																														
35R-6, 11–13	575.35		R																																																		
35R-6, 59–61	575.83		R					R						R		R					R																																
35R-CC	572.40		R													R					R																													R			
36R-1, 10–12	577.50	1																																																R			
36R-1, 59–61	577.99		F					R			R	R										R	R																											R	R		
36R-2, 10–12	578.98		F		R							C								R																																	
36R-2, 59–61	579.47		F			R						F		R	R																																						
36R-3, 10–12	580.49		C		R							F												R	R																											R		
36R-3, 59–61	580.98		R																																																R		
36R-4, 10–12	582.01		R									R																																									
36R-4, 59–61	582.50		C	R	R	R						F		R						R				R	R	R			R																								
36R-CC	587.20		F			R			R			R		R	R					R					R	R	R	R	R																								

Table 2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Number of samples barren in aggl. F.	*Rhabdammina abyssorum*	*Reophax elongatus*	*Hyperammina rugosa*	*Ammolagena clavata*	*Reophax nodulosus*	*Bathysiphon filiformis*	*Psammosphaera fusca*	*Haplophragmoides walteri*	*Haplophragmoides* sp. 1	*Recurvoides* sp. 1	*Bathysiphon* sp. 1	*Bathysiphon capillaris*	*Rhizammina ? indivisa*	*Trochammina deformis*	*Paratrochammina challengeri*	*Saccammina placenta*	*Ammodiscus incertus*	*Haplophragmoides horridus*	*Cribrostomoides* sp.	*Nothia latissima*	*Ammodiscus tenuissimus*	*Rhabdammina* sp.	*Nothia excelsa*	*Hyperammina elongata*	*Ammodiscus incertus*	*Bathysiphon annulatus*	*Nothia robusta*	*Praecystammina* sp.	*Saccammina sphaerica*	*Haplophragmoides* cf. *kirki*	*Reticulophragmium* sp.	*Reophax elongatus*	*Reticulophragmium amplectens*	*Recurvoidella lamella*	*Cribrostomoides subglobosus*	*Conotrochammina* sp.	*Haplophragmoides porrectus*	*Karrerulina conversa*	*Haplophragmoides suborbicularis*	*Paratrochamminoides heteromorphus*	*Nubecularia lucifuga*	*Spiroplectammina spectabilis*	*Trochamminopsis* sp.	*Reophax difflugiformis*	*Haplophragmoides* sp. 2	*Trochamminoides grzybowskii*	*Skolithos*	Rhodochrosite	Amber	Megaspores	Assemblages and environment
37R-1, 6–11	587.16								R																																												lower *Rhabdammina abyssorum*
37R-1, 58–61	587.68		R		C				R			R													R					C	R																						
37R-2, 11–14	588.65		R		C	R			R	R				R	R		R						R							F																							
37R-2, 58–61	589.12		R		R	R				R				R	R																																						
37R-3, 11–14	590.15		R		R	R	F		F	R			R	F										R		R	R	R				R																					
37R-3, 58–61	590.62		F			R	R		R	R					R												R					R	R																				
37R-4, 11–14	591.65		R			C			R	R		R	F	R	R				R									R	R	R		R	R	R																			
37R-4, 58–61	592.12		R		R	F				R			R		R											R						R	F																				
37R-5, 11–14	593.16		R		F	F				R			F																				R		R	R																	
37R-5, 58–61	593.63		R			F				F			F	R	R								R									R	R																				
37R-CC	596.70		R		F	F	R		R	R	R	R		R	R	R			R	R												R	R		R			R	R														
38R-1, 8–12	596.78		F		R	F	R			R			F		R		R										F	R							R																		
38R-2, 8–12	597.34		F		F	F				R			F	R	R		R			R							R						R		F															R			
38R-2, 23–27	597.49				C		R		R	R				F	R		R									R	R					R	R		F																		
38R-2, 61–66 to	597.87	2																																																M			
38R-3, 8–12	598.84		R		R	R						R	C		F						R					R	F						R	R			F													R			
38R-3, 61–66	599.37		F		R	R				R			F		F		R									R	R						R																	R			
38R-4, 8–12	600.34		R		R	R	F			R			R	R	R						R				R	R									R		R														R		
38R-4, 61–66	600.87		R		R	R				R			R							R															R															F			
38R-5, 8–12	601.84		R		F	R			R				F	F	R						R				R	R							F				R																
38R-5.61–66	602.37		R		R	F	R			R				R	F									R									R																				
38R-6, 8–12	603.34				R	F	R			C			R	R	F											R							R																		R		
38R-6, 61–66	603.87		R			F	R		R				R	R													R						R				R													R	R		
38R-6, 139–143	604.65																																				R													M			
38R-CC	606.40					R			R	R				R	F												F						C			R	C																
39R-1, 12–16	606.52		R										R	R	R													R					R																				
39R-1, 60–63	607.00		R				R		F	R															R							R	R																				
39R-2, 12–16	608.02												R												R																									R			
39R-2, 60–63	608.50		R		R				R		R	R		R															R																								
39R-3, 12–16	609.54		R							R			R	R						R							R						F				R																
39R-3, 60–63	610.02		F		F	F			R	R		R	R		F					R													R					R															
39R-3, 80–83	630.02		R		R																				R	R																											
39R-4, 12–16	611.04		R																																																		
39R-4, 60–63 to	611.52	3																																																			
39R-5, 60–63	613.02		F				R			R			R	R												R						R			R																		
39R-6, 12–16	614.04	1																																																			
39R-6, 60–63	614.52		R											R	R																				R																		
39R-CC	616.00				F				R				R	R	F									R	R										R		F																
40R-1, 11–15	616.11		F		F	R			R				R	R																			R			R	F													F			
40R-1, 60–63	616.60		R		C	R			R	R			R	R								R			R	R																											
40R-2, 11–15	617.61		R		F				F				R																								F																
40R-2, 23–25	617.73	1																																																			
40R-2, 58–62	618.08																											R																									
40R-3, 11–15	619.11																											R																									
40R-3, 58–62	619.58		R		F				R	F			R	R																							F																
40R-4, 12–16	620.63		F			R			R	C			R	R												R											R																
40R-4, 60–64	621.11		F							A			R	R																							R																
40R-5, 11–15	622.12		F			R							F	R																		R	R				R																
40R-5, 57–61	622.58		F			R			R				R	R	R																		R						R											R			
40R-6, 11–15	623.65		R			R	R					R		F																			F				R													R			
40R-6, 57–61	624.11		R									R																																						R			
40R-7, 11–15	625.15		R							R																																											
40R-7, 6–64	625.64				F	R				C				R				R				R				R		R					F							R										F			
40R-CC	625.70		R		R	R																							R				R																				
41R-1, 9–13	625.79	1																																																			

Table 2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Number of samples barren in aggl. F.	*Rhabdammina abyssorum*	*Reophax elongatus*	*Hyperammina rugosa*	*Ammolagena clavata*	*Reophax nodulosus*	*Bathysiphon filiformis*	*Psammosphaera fusca*	*Haplophragmoides walteri*	*Haplophragmoides* sp. 1	*Recurvoides* sp. 1	*Bathysiphon* sp. 1	*Bathysiphon capillaris*	*Rhizammina* ? *indivisa*	*Trochammina deformis*	*Paratrochammina challengeri*	*Saccammina placenta*	*Ammodiscus incertus*	*Haplophragmoides horridus*	*Cribrostomoides* sp.	*Nothia latissima*	*Ammodiscus tenuissimus*	*Rhabdammina* sp.	*Nothia excelsa*	*Hyperammina elongata*	*Ammodiscus incertus*	*Bathysiphon annulatus*	*Nothia robusta*	*Praecystammina* sp.	*Saccammina sphaerica*	*Haplophragmoides* cf. *kirki*	*Reticulophragmium* sp.	*Reophax elongatus*	*Reticulophragmium amplectens*	*Recurvoidella lamella*	*Cribrostomoides subglobosus*	*Conotrochammina* sp.	*Haplophragmoides porrectus*	*Karrerulina conversa*	*Haplophragmoides suborbicularis*	*Paratrochamminoides heteromorphus*	*Nubecularia lucifuga*	*Spiroplectammina spectabilis*	*Trochamminopsis* sp.	*Reophax difflugiformis*	*Haplophragmoides* sp. 2	*Trochamminoides grzybowskii*	*Skolithos*	Rhodochrosite	Amber	Megaspores	Assemblages and environment
41R-1, 58–61	626.28		R											F																			C						R		R									R			
41R-2, 11–14	626.48		F																																																R		
41R-2, 58–61	626.95		C		R							R												R				R					F								C									F			
41R-3, 11–14	627.98		C											F														R					F								F												
41R-3, 56–60	628.43		C			F				F						R									R			C												R	F	R											
41R-4, 11–14	629.48									F													R		R	R							R							R													
41R-4, 59–63	629.96					C										C																								C	C		R							R			
41R-4, 91–94	630.28	1																																																M			
41R-CC	635.40																					R		R									R																	R		F	
42R-1, 11–15	635.51																					R																					R							R			
42R-1, 59–63	635.99																																R																	R			
42R-2, 11–15	637.01																					R						R																R									
42R-2, 59–63	637.49												R									R						R																						R			
42R-3, 11–15	638.51																				R																								R		F						
42R-3, 58–62	638.98																																												R	R	C			R			
42R-4, 11–15	640.01																					F																									C						
42R-4, 60–64	640.50									F																R							F																	R			
42R-5, 11–15	641.54																	R				F	R			R			R																R					R			
42R-6, 61–65	642.01																					R						R																						R			
42R-CC	645.10	1																																																			
43R-1, 13–16	645.23																					R																									F						
43R-1, 59–62	645.69																									R																					F						
43R-2, 12–16	646.48																					F																															
43R-2, 59–62	646.95																																														F						
43R-2, 72–75	647.08	1																																																			
43R-3, 12–16	647.98																																														FR						
43R-3, 59–62	648.45																																																				Sequence with deformed agglutinated foraminifers
43R-4, 11–14	649.47												R					R					R	R																													
43R-4, 58–61	649.94	1																																																			
43R-5, 11–14	650.97																	F							F														F														
43R-5, 60–63	651.46	1																																													F						
43R-6, 12–15	652.48																	R							R															R							R						
43R-6, 60–63	652.96																					R						R																									
43R-CC	654.70	1																																													R						
44R-1, 11–15	654.81																																											C			R						
44R-1, 58–60	655.28																					R			R			R																			F						
44R-2, 11–15	656.12																					R			F			F																R									
44R-2, 58–60	656.59																						R																														
44R-3, 11–15	657.62	1																																																R	R		
44R-3, 58–60	658.09																					R	R					R											R								F						
44R-4, 11–15	659.12																					R						R											R								C						
44R-4, 58–60	659.59	1																																																			
44R-5, 11–15	660.62												R									R						R											C								C						
44R-5, 58–60	661.09																								C																						C						
44R-5, 116–120	661.67																																						R								R						
44R-CC	664.40	2																																																			
45R-1, 59–62	664.99												R																																					R			
45R-CC	674.10	1																																																R		R	

Table 2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Number of samples barren in aggl. F.	*Rhabdammina abyssorum*	*Reophax elongatus*	*Hyperammina rugosa*	*Ammolagena clavata*	*Reophax nodulosus*	*Bathysiphon filiformis*	*Psammosphaera fusca*	*Haplophragmoides walteri*	*Haplophragmoides* sp. 1	*Recurvoides* sp. 1	*Bathysiphon* sp. 1	*Bathysiphon capillaris*	*Rhizammina* ? *indivisa*	*Trochammina deformis*	*Paratrochammina challengeri*	*Saccammina placenta*	*Ammodiscus incertus*	*Haplophragmoides horridus*	*Cribrostomoides* sp.	*Nothia latissima*	*Ammodiscus tenuissimus*	*Rhabdammina* sp.	*Nothia excelsa*	*Hyperammina elongata*	*Ammodiscus incertus*	*Bathysiphon annulatus*	*Nothia robusta*	*Praecystammina* sp.	*Saccammina sphaerica*	*Haplophragmoides* cf. *kirki*	*Reticulophragmium* sp.	*Reophax elongatus*	*Reticulophragmium amplectens*	*Recurvoidella lamella*	*Cribrostomoides subglobosus*	*Conotrochammina* sp.	*Haplophragmoides porrectus*	*Karrerulina conversa*	*Haplophragmoides suborbicularis*	*Paratrochamminoides heteromorphus*	*Nubecularia lucifuga*	*Spiroplectammina spectabilis*	*Trochamminopsis* sp.	*Reophax difflugiformis*	*Haplophragmoides* sp. 2	*Trochamminoides grzybowskii*	*Skolithos*	Rhodochrosite	Amber	Megaspores	Assemblages and environment
46R-1, 12–14	674.22																											F																			R						Marine, nearshore sediments
46R-1, 61–63	674.71																											R																						F		R	
46R-2, 12–14	675.72																																																	R			
46R-2, 61–63	676.21																																														R			R		R	
46R-3, 12–14	677.22																																							R										R			
46R-3, 61–63 to	677.71	4																																																F		R	
47R-2, 11–14	685.31																					F																													R	F	
47R-2, 85–87	686.05									R																		F																			F					F	
47R-3, 11–14	686.81																																														R			R		R	
47R-3, 59–61 to	687.29	2																																																		R	
47R-CC, 11–14	688.27	1																																																			
47R-CC	693.00																																								R											R	
48R-1, 11–14	693.11									R																																					R					A	
48R-1, 60–63 to	693.50	14																																																	R	A	
50R-4, 10–14	716.47																																			R												R	C				
50R-4, 61–64 to	716.98	2																																																			
50R-CC	721.90																																																				B

Notes: Abbreviations: B = barren in agglutinated foraminifers, R = rare, less than 5 specimens, F = few, 6–10 specimens, C = common, 11–25 specimens, A = abundant, more than 25 specimens.

151-913B-19W-1, 11–15 cm (375.31 mbsf)
Upper *Rhabdammina abyssorum* assemblage
151-913B-29R-CC (519.5 mbsf)
151-913B-30R-1, 12–15 cm (519.62)
Middle *Rhabdammina abyssorum* assemblage
151-913B-35R-6, 11–13 cm (575.35)
151-913B-35R-6, 59–61 cm (575.83 mbsf)
Lower *Rhabdammina abyssorum* assemblage
151-913-41R-4, 59–63 cm (629.96 mbsf)
151-913B-41R-CC (635.4 mbsf)
Deformed assemblage
151-913B-44R-5, 116–120 cm (661.67)
151-913B-45R-1, 59–62 cm (664.99 mbsf)
Nearshore marine sequence with megaspores
151-913B-50R-4, 10–14 cm (716.47 mbsf)
151-913B-50R-4, 61–64 cm (717.98 mbsf)
Barren
151-913B-52R-CC (770.3 mbsf)

Figure 3. Agglutinated benthic foraminiferal assemblages of Hole 913B.

ments of this age. Kaminski et al. (1990) reported that the agglutinated benthic foraminiferal stratigraphies become increasingly difficult to correlate in high latitude and semi-isolated basins, and suggest a decreasing age for agglutinated faunas with increasing latitude. Our research supports both these ideas and extends them farther north into the Fram Strait. Nevertheless, the specific reason for the occurrence of the Miocene deep-water agglutinated fauna of Site 909 (Fig. 4) may be difficult to fully resolve.

The anomalous Miocene occurrence of previously recorded Eocene and Oligocene species may be due to several causes. First, it is not inconceivable that the entire interval at Site 909 consists of reworked Eocene and Oligocene deep-water agglutinated benthic foraminifers. Second, it is possible that Site 909 may have remained isolated from the remainder of the North Atlantic well into the Miocene. A third possibility is that the deep-water agglutinated assemblages of the North Atlantic may be strongly facies-controlled, and their presence attests to a particular paleoenvironmental basin of deposition that is independent of age.

In the first case, reworking may explain the occurrence of an older fauna in a younger deposit. However, a certain amount of tectonic uplift would be necessary to allow the erosion of the Eocene deep-water deposits containing the agglutinated fauna into Miocene deposits of any water depth. Additionally, no other microfossils in this interval appear to be reworked and all indicate a Miocene age (Shipboard Scientific Party, 1995a). Therefore, reworking does not seem to explain the Miocene agglutinated benthic fauna, which is believed to be in situ at Site 909.

In the second case, determining the tectonic history of this particular basin at Site 909 was one of the goals of Leg 151. Isolated, oxygen-depleted bottom waters favor the preservation of agglutinated benthic faunas. The deep-water agglutinated benthic foraminiferal fauna of Site 909 suggests that the bottom water of the Fram Strait area remained isolated from the rest of the North Atlantic well into the Miocene.

Lastly, the environmental control of the agglutinated faunas may explain the occurrence of this assemblage. The Miocene sediments at Site 909 were deposited rapidly throughout the basin as evidenced by the meter-scale slump features and laminated nature of the sediments (Shipboard Scientific Party, 1995a). Possibly the optimum habitat of the agglutinated faunas migrated northward to the high sedimentation-rate basins created during the rifting of the North Atlantic. Anomalously young agglutinated benthic foraminifers have also been reported from the Oligocene–Miocene deeper basin sediments of the Beaufort Sea (Schröder-Adams and McNeil, 1994). It is generally accepted that deep, cold, stratified basins with high sedimentation rates may favor this particular assemblage. At present this seems to be the most reasonable explanation for the anomalously young occurrence of deep-water foraminifers at Site 909. Additional work is needed to fully understand the depositional and tectonic history of the Fram Strait as well as the agglutinated biostratigraphy at this high latitude.

CONCLUSIONS

The newly recorded agglutinated benthic foraminiferal stratigraphy from ODP Site 913 agrees with the general patterns of biostratigraphies as reported by numerous researchers for the North Sea (Gradstein et al., 1994), the Labrador Sea (Miller et al., 1982), the Norwegian Sea (Kaminski, et al., 1990) and the North Atlantic (Gradstein and Berggren, 1981). Similar species occur at all localities throughout the Eocene and Oligocene. However, the occurrence of the same species in the Miocene sediments of Site 909 (Fig. 4) is more difficult to resolve, because these species are previously unreported from Miocene sediments. Given the latitude and possible isolation of Site 909, we believe that the agglutinated fauna represents a particular paleoenvironment. This implies that during the Miocene a deep-water, high-sedimentation basin existed in the Fram Strait that favored the preservation of the agglutinated benthic foraminiferal assemblages long after their disappearance from the rest of the North Atlantic. Furthermore, isolation of the bottom water from the remainder of the North Atlantic is also implied by the lack of calcareous faunas at this site.

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Taxonomic Note

This paper gives the first reported occurrence of *Reticulophragmium amplectens* in the Miocene deposits of Site 909. However, while *Reticulophragmium amplectens* has not been previously reported in Miocene sediment, its assumed descendant *Cyclammina pusilla* has been. In this study there does not appear to be any difference between the Miocene specimens of *R. amplectens* at Site 909 and the Eocene-aged specimens of *R. amplectens* at Site 913.

	Site 643	Site 913	Site 909
late Miocene			*Hyperamina rugosa* *T. deformis* (fine) *R. placenta* *H. walteri excavatus* *G. charoides* *T. deformis* (coarse) *R. amplectens* *A. clavata* *Nothia excelsa* *Hormosina globulifera*
mid. Mio.			*Dorothia seigliei* *B. multicamerata* *H. kirki*
early Miocene l. Oligocene?	*Dorothia siegliei* *Ammodiscus cretaceus* *R. amplectens* *T. deformis* *R. placenta* *Ammolagena clavata*		
late Olig.	*H. walteri* *B. multicamerata*		
early Oligocene	*H. kirki* *Hyperamina rugosa* *H. walteri excavatus* *Glomospira charoides* *Hormosina globulifera*		
middle Eocene		*Ammolagena clavata* *H. walteri* *T. deformis* *N. excelsa* *H. kirki* *R. amplectens*	
early Eocene	*Spiroplectammina spectablis* *Nothia excelsa*	*S. spectablis*	

Figure 4. Comparison of the last observations of selected agglutinated benthic foraminifers at Sites 643, 913, and 909. Agglutinated benthic foraminiferal ranges generally agree between Sites 643 and 913. However, agglutinated benthic foraminiferal ranges are extended into the Miocene at Site 909. (Site 643 after Kaminski et al., 1990).

Therefore, we do not consider the Miocene species to be *C. pusilla.* Further investigation of this species will be needed to resolve this problem.

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APPENDIX

Faunal Reference List

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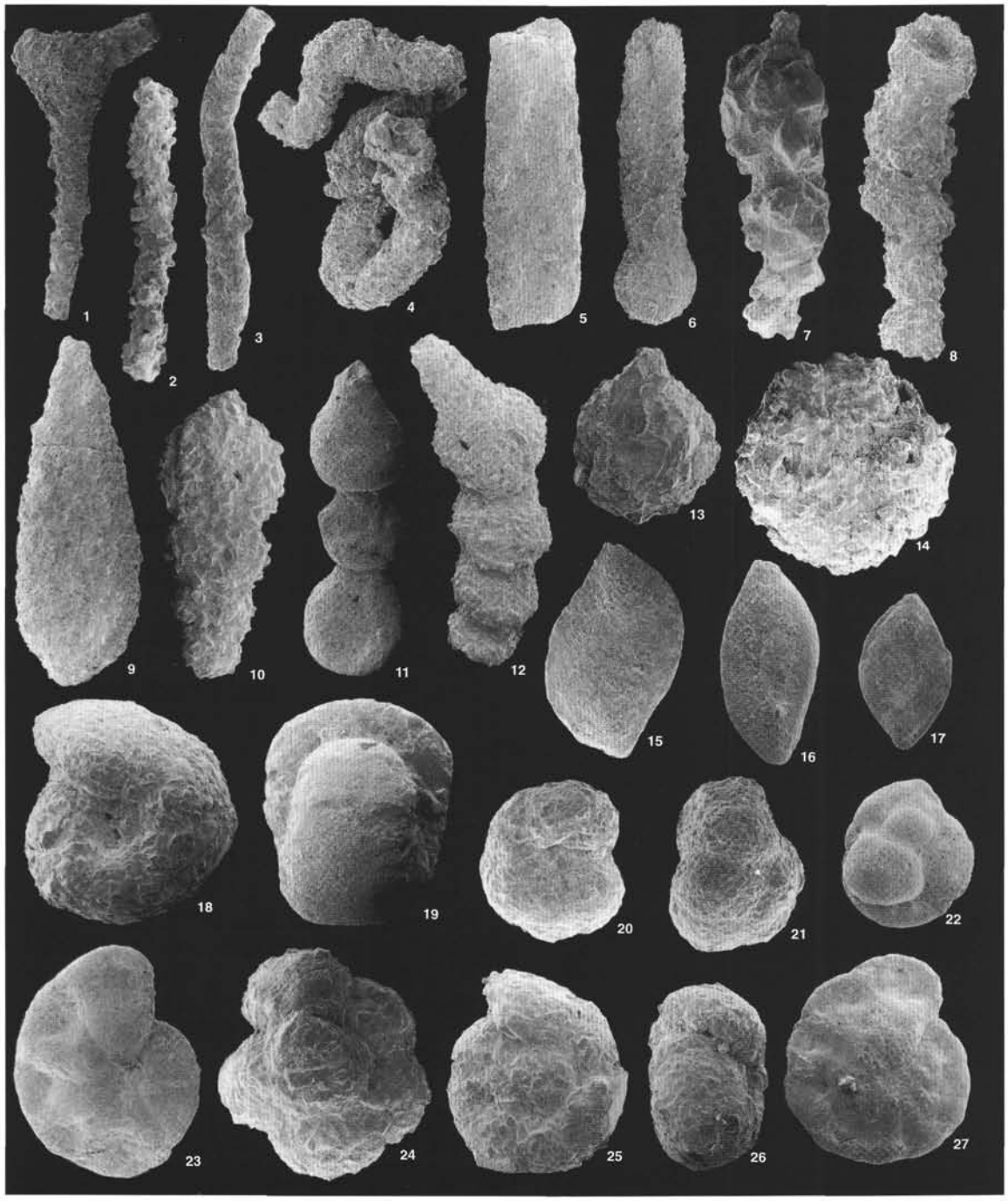

Plate 1. Miocene agglutinated benthic foraminifers, Site 909. L = length, Dm = diameter. **1-2.** *Rhabdammina abyssorum* Sars, 1. Sample 151-909C-93R-1, 94–97 cm, L: 4.40 mm. 2. Sample 151-909C-97R-CC, L: 1.85 mm. **3.** *Rhizammina*? *indivisa* Brady, Sample 151-909C-94R-CC, L: 2.20 mm. **4.** *Tolypammina vagans* (Brady), Sample 151-909C-93R-1, 94–97 cm, L: 1.10 mm. **5.** *Nothia latissima* Grzybowski, Sample 151-909C-99R-1, 95–99 cm, L: 1.35 mm. **6.** *Hyperammina elongata* Brady, Sample 151-909C-84R-1, 96–99 cm, L: 3.10 mm. **7.** *Reophax* sp., Sample 151-909C-97R-1, 95–99 cm, L: 1.25 mm. **8.** *Subreophax scalaria* (Grzybowski), Sample 151-909C-93R-CC, L: 2.60 mm. **9.** *Hormosinella* sp. Sample 151-909C-90R-CC, L: 1.54 mm. **10.** *Hormosina globulifera* Brady, Sample 151-909C-96R-1, 94–97 cm, L: 2.20 mm. **11-12.** *Hormosinella carpenteri* (Brady), 11. Sample 151-909C-87R-2, 90–92, L: 6.00 mm, 12. Sample 151-909C-95R-1, 96-100 cm, L: 4.00 mm. **13.** *Saccammina sphaerica* Brady, Sample 151-909C-78R-CC, Dm: 0.52 mm. **14.** *Saccammina sphaerica* (Grzybowski), Sample 151-909C-95R-CC, Dm: 1.20 mm. **15.** *Spirosigmoilinella* sp., Sample 151-909C-91R-CC, L: 0.70 mm. **16.** *Spirosigmoilinella* sp., Sample 151-909C-9OR-CC, L: 0.66 mm. **17.** *Spirosigmoilinella compressa* Matsunaga, Sample 151-909C-101R-CC, L: 0.50 mm. **18-19.** *Reticulophragmium* ex. gr. *rotundidorsata* (Hantken),18. Sample 151-909C-66R-1, 94–98 cm, Dm: 0.80 mm, 19. Sample 151-909C-69R-CC, Dm: 0.85 mm. **20-21.** *Trochammina* cf. *deformis* Grzybowski, 20. coarse agglutinated specimen, Sample 151-909C-95R-CC, Dm: 0.52 mm, 21. Sample 151-909C-99R-1, 95–99 cm, L: 0.60 mm. **22.** *Trochammina* cf. *deformis* Grzybowski, fine agglutinated specimen, Sample 151-909C-75R-5, 93–97 cm, Dm: 0.50 mm. **23.** *Haplophragmoides walteri* (Grzybowski), Sample 151-909C-75R-6, 94–98 cm, L: 0.75 mm. **24.** *Paratrochammina challengeri* (Brönnimann and Whittaker), Sample 151-909C-71R-3, 95–99 cm, Dm: 0.75 mm. **25.** *Recurvoides contortus* (Grzybowski), Sample 151-909C-67R-CC, Dm: 0.70 mm. **26.** *Recurvoidella lamella* (Grzybowski), Sample 151-909C-75R-CC, cm, L: 0.75 mm. **27.** *Reticulophragmium amplectens* (Grzybowski), Sample 151-909C-75R-5, 93–97 cm, Dm: 1.00 mm.

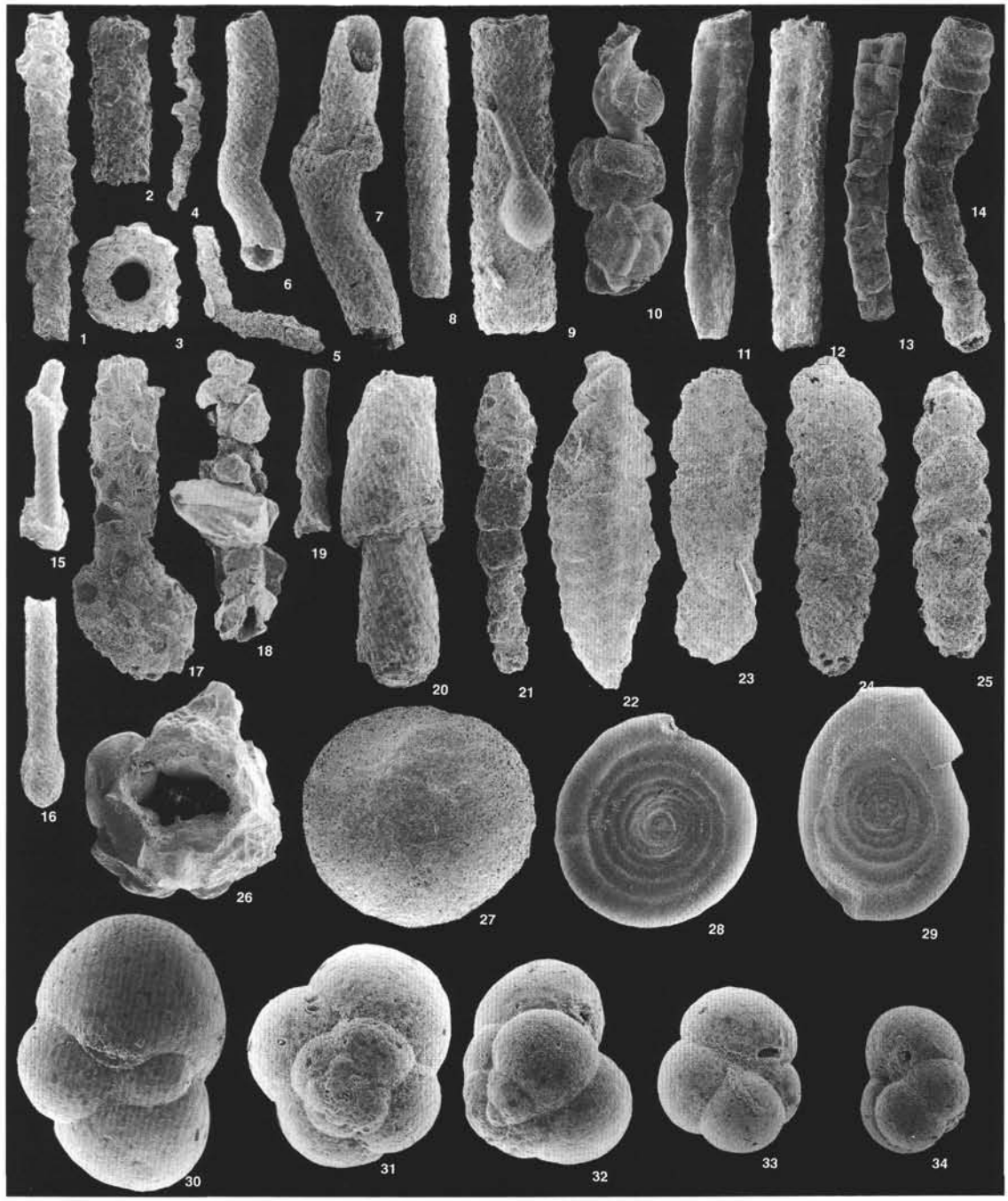

Plate 2. Eocene agglutinated benthic foraminifers, Site 913. L = length, Dm = diameter. **1-3.** *Rhabdammina abyssorum* Sars, 1. Sample 151-913B-39R-2, 60–63 cm, L: 2.7 mm, 2-3. Sample 151-913B-28R-4, 59–61 cm, 2. L: 0.85 mm, 3. Dm: 0.50 mm. **4-5.** *Nothia excelsa* (Grzybowski), Sample 151-913B-39R-CC, 4. L: 1.5 mm, 5. L: 1.7 mm. **6-7.** *Rhizammina*? *indivisa* Brady, 6. Sample 151-913B-39R-CC, L: 1.7 mm, 7. Sample 151-913B-40R-5, 57–61 cm, L: 0.7 mm. **8.** *Nothia robusta* (Grzybowski), Sample 151-913B-36R-4, 59–61 cm, L: 2.3 mm. **9.** *Nothia robusta* (Grzybowski) and *Ammonalagena clavata* (Jones and Parker), Sample 151-913B-41R-4, 59–63 cm, L: *N. robusta* 1.8 mm. **10.** *Nubecularia lucifuga* Defrance, Sample 151-913B-41R-4, 59–63 cm, L: 1.36 mm. **11.** *Bathysiphon* sp., Sample 151-913B-37R-4, 11–14 cm, L: 1.4 mm. **12.** *Bathysiphon filiformis* Brady, Sample 151-913B-36R-1, 59–61 cm, L: 2.2 mm. **13-14.** *Bathysiphon annulatus* Andreae, Sample 151-913B-41R-3, 56–60 cm, 13. L: 0.86 mm, 14. L: 1.0 mm. **15.** *Bathysiphon capillaris* Folin, Sample 151-913B-39R-2, 60–63 cm, L: 1.28 mm. **16-17.** *Hyperammina elongata* Brady, 16. Sample 151-913B-38R-1, 8–12 cm, L: 1.58 mm, 17. Sample 151-913B-42R-5, 11–15 cm, L: 0.72 mm. **18.** *Hyperammina rugosa* Verdenius and Hinte, Sample 151-913B-39R-CC, L: 1.52 mm. **19-20.** *Reophax elongatus* Grzybowski, 19. Sample 151-913B-27R-4, 11–14 cm, L: 1.4 mm, 20. Sample 151-913B-36R-4, 59–61 cm, L: 0.92 mm. **21.** *Reophax nodulosus* (Brady), Sample 151-913B-37R-3, 58–61 cm, L:1.2 mm. **22-23.** *Spiroplectammina spectabilis* (Grzybowski), Sample 151-913B-44R-1, 11–15 cm, 22. macrospheric form, L: 0.68 mm, 23. microspheric form, L: 0.60 mm. **24-25.** *Karrerulina conversa* (Grzybowski), Sample 151-913B-41R-4, 59–63 cm, 24. L: 0.62 mm, 25. L: 0.52 mm. **26.** *Psammosphaera fusca* Schulze, broken specimen, Sample 151-913B-30R-3, 12–15 cm, Dm: 0.8 mm. **27.** *Saccammina placenta* (Grzybowski), Sample 151-913B-43R-5, 11–14 cm, Dm: 0.52 mm. **28-29.** *Ammodiscus incertus* Orbigny, 28. Sample 151-913B-38R-1, 8–12 cm, Dm: 0.8 mm, 29. Sample 151-913B-38R-CC, Dm: 0.85 mm. **30.** *Praecystammina* sp. Kaminski et al. 1990, Sample 151-913B-37R-2, 11–14 cm, L: 0.34 mm. **31-34.** *Conotrochammina* sp. Kaminski et al. 1990, Sample 151-913B-39R-3, 60–63 cm, 31. Dm: 0.20 mm, 32. Dm: 0.20 mm, 33. Dm: 0.17 mm. 34. Dm: 0.15 mm.

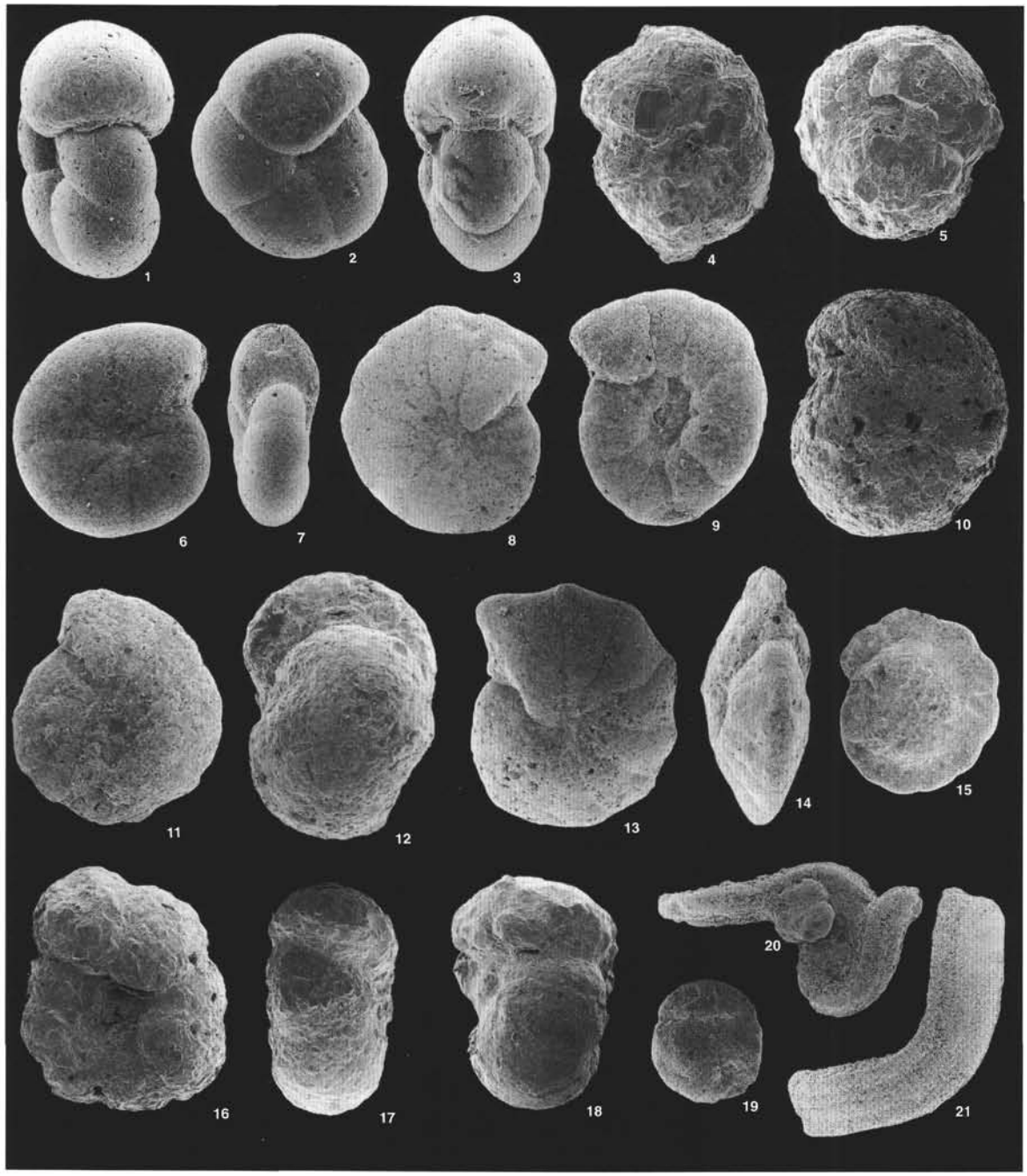

Plate 3. Eocene agglutinated benthic foraminifers, Site 913. L = length, Dm = diameter. **1-2.** *Haplophragmoides* cf. *kirki* Wickenden, Sample 151-913B-40R-5, 11–15 cm, 1. Dm: 0.26 mm, 2. Dm: 0.22 mm. **3.** *Haplophragmoides porrectus* Maslakova, Sample 151-913B-37R-CC, Dm: 0.24 mm. **4-5.** *Haplophragmoides horridus* (Grzybowski), 4. Sample 151-913B-35R-4, 11–13 cm, Dm: 0.62 mm, 5. Sample 151-913B-36R-2, 10–12 cm, Dm: 0. 62 mm. **6-9.** *Haplophragmoides walteri* (Grzybowski), 6. with eight chambers, Sample 151-913B-37R-CC, Dm: 0.30 mm, 7. Sample 151-913B-38R-CC, Dm: 0.28 mm, 8. with twelve chambers, Sample 151-913B-41R-3, 56–61 cm, Dm: 0.32 mm, 9. very thin, *H. walteri,* forma *excavatus* Cushman and Waters, Sample 151-913B-41R-3, 56–60 cm, Dm: 0.36 mm. **10.** *Haplophragmoides* sp. 1, coarse, chambers indistinct, Sample 151-913B-37R-CC, Dm: 0.74 mm. **11.** *Haplophragmoides* sp. 2, fine, flat, chambers indistinct, Sample 151-913B-42R-3, 58–62 cm, Dm: 0.52 mm. **12.** *Haplophragmoides suborbicularis* (Grzybowski), Sample 151-913B-41R-3, 56–60 cm, Dm: 0.61 mm. **13-14.** *Reticulophragmium* sp., 13. Sample 151-913B-41R-2, 58–61 cm, Dm: 0.67 mm, 14. Sample 151-913B-40R-7, 60–64 cm, Dm: 0.66 mm. **15.** *Reticulophragmium amplectens* (Grzybowski), Sample 151-913B-38R-2, 23–27 cm, Dm: 0. 60 mm. **16-18.** *Recurvoides* sp.1, 16. Sample 151-913B-37R-CC, Dm: 0.80 mm, 17. Sample 151-913B-30R-2, 12–15 cm, Dm: 0.70 mm, 18. Sample 151-913B-36R-2, 10–12 cm, Dm: 0.60 mm. **19.** *Trochammina deformis* Grzybowski, Sample 151-913B-35R-CC, Dm: 0.40 mm. **20-21.** *Skolithos*, Sample 151-913B-50R-4, 10–14 cm, 34. L: 0.65 mm, 35. L: 0.70 mm.