

8. PLANKTONIC FORAMINIFER CENOZOIC BIOSTRATIGRAPHY OF THE ARCTIC OCEAN, FRAM STRAIT (SITES 908–909), YERMAK PLATEAU (SITES 910–912), AND EAST GREENLAND MARGIN (SITE 913)¹

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ABSTRACT

The resolution of a planktonic foraminifer Cenozoic biostratigraphy in the Greenland Sea and in the Arctic Ocean is quite low, because of the scarcity of calcareous microfossils and the low diversity of assemblages. The *Neogloboquadrina pachyderma* sin. Zone spans the entire Quaternary, whereas the *Neogloboquadrina atlantica* Superzone occupies the Pliocene and parts of the upper Miocene. Biogenic ice-rafted debris such as *Inoceramus*-prisms, indicative of glacial conditions, are first documented during the late Pliocene at the Fram Strait sites and at the Yermak Plateau. Conversely, brief warm-temperate to subtropical surface-water incursions, documented by the occurrence of single specimens of *Menardella menardii*, *M. limbata*, *Globigerinoides ruber*, *Gls. conglobatus*, *Gls. extremus*, *Gls. trilobus*, *Globigerinella aequilateralis*, *Sphaeroidinellopsis* sp. juv., aff. *S. paenedehiscens*, and *Dentoglobigerina altispira* are observed locally at the Yermak Plateau in the upper Pliocene sequence. Surface-water exchange to the north is documented by the occurrence of the Pacific planktonic foraminifer *Neogloboquadrina asanoi* in upper Pliocene sediments at the Fram Strait. Rare occurrences of planktonic foraminifers in Miocene and Paleogene sediments prevent the construction of a zonation.

INTRODUCTION

Seven sites (Sites 907–913) were drilled during Ocean Drilling Program (ODP) Leg 151. The sites were located in four regions to investigate the paleoceanography and paleoclimatology of the northern high latitudes (Fig. 1). A north-south transect was drilled involving Sites 908 through 912. Site 911 with three holes drilled (between 80°28.466'N–80°28.485'N and 8°13.636'E–8°13.640'E) is the most northerly site. Site 908 with Hole 908A (78°23.112'N; 1°21.637'E) and Hole 908B (78°23.125'N; 1°21.644'E) is the most southerly tie point in this transect. The study of planktonic foraminifers encountered in the sediments at these five sites is the main objective of this paper. The biostratigraphy of Site 913, drilled in the Greenland Basin, is also studied by means of planktonic foraminifers. Site 907, drilled on the eastern Iceland Plateau, is not considered in this study.

Generally, at the northern high latitudes most of the samples are poor in planktonic foraminifers or barren, owing to cold-water temperatures and/or dissolution of the calcareous microfossils. Another factor is dilution by high amounts of detrital material and ice-rafted debris (IRD).

The high-latitude planktonic foraminifer associations are low diversity faunas composed of long-ranging species. The standard zonations established for low latitudes (Blow, 1969, 1979; Bolli and Saunders, 1985), and for northern temperate regions (Berggren, 1972; Poore and Berggren, 1975; Poore, 1979; and Weaver and Clement, 1986) are generally not applicable because the index fossils used for these zonal definitions are often absent in high latitudes. Only in a few short Neogene intervals at the investigated sites do single observations of immigrant warm-adapted species of planktonic foraminifers allow a rough correlation to the above-mentioned zonations. Studies of the Leg 104 sites in the Norwegian Sea have pro-

duced a local high-latitude Neogene zonation (Spiegler and Jansen, 1989), which is more useful for the interpretation of the Leg 151 data.

METHODS

Stratigraphic results and paleotemperature estimations for Leg 151 were obtained by the investigation of planktonic foraminifers from about 1400 samples. Samples were taken from the core catchers and from the calcareous sediments. About one 20-cm³ sample per section of core was used. The preparation methods used to obtain foraminifers differed depending on the degree of sediment induration. Soft sediments were washed over a 63- μ m screen. Slightly indurated sediments were soaked in diluted H₂O₂ solution and then wet sieved. Indurated samples were freeze-dried, soaked in hot paraffin, and boiled in a soda lye solution until disintegration occurred. This method was repeated until a reasonable amount of loose particles was obtained. Range tables summarize the main characteristics used for planktonic foraminifer studies (Tables 1–11).

PLANKTONIC FORAMINIFER BIOSTRATIGRAPHY

The *Neogloboquadrina pachyderma* sin. Zone spans the entire Quaternary. The nearly monospecific association of *N. pachyderma* sin. shows highly variable abundances, ranging from several periods containing a hundred thousand specimens in 10-cm³ sediment to intervals barren of planktonic foraminifers (Myhre, Thiede, Firth, et al., 1995). Such alternations seem to be typical of the changes between glacial and interglacial conditions, as absolute abundances of planktonic foraminifers correlate best with surface seawater temperatures calculated from oxygen isotopes (Paul, 1992).

The *Neogloboquadrina atlantica* Superzone is defined by the range of the zonal marker, spanning the whole Pliocene and reaching into the late Miocene. Using the change in coiling direction, local zones are defined (Weaver and Clement, 1986; Spiegler and Jansen, 1989). The last occurrence of *N. atlantica* marks the Quaternary/Pliocene boundary, whereas the Pliocene/Miocene boundary cannot be defined in high latitudes by planktonic foraminifers.

¹Thiede, J., Myhre, A.M., Firth, J.V., Johnson, G.L., and Ruddiman, W.F. (Eds.), 1996. *Proc. ODP. Sci. Results*, 151: College Station, TX (Ocean Drilling Program).

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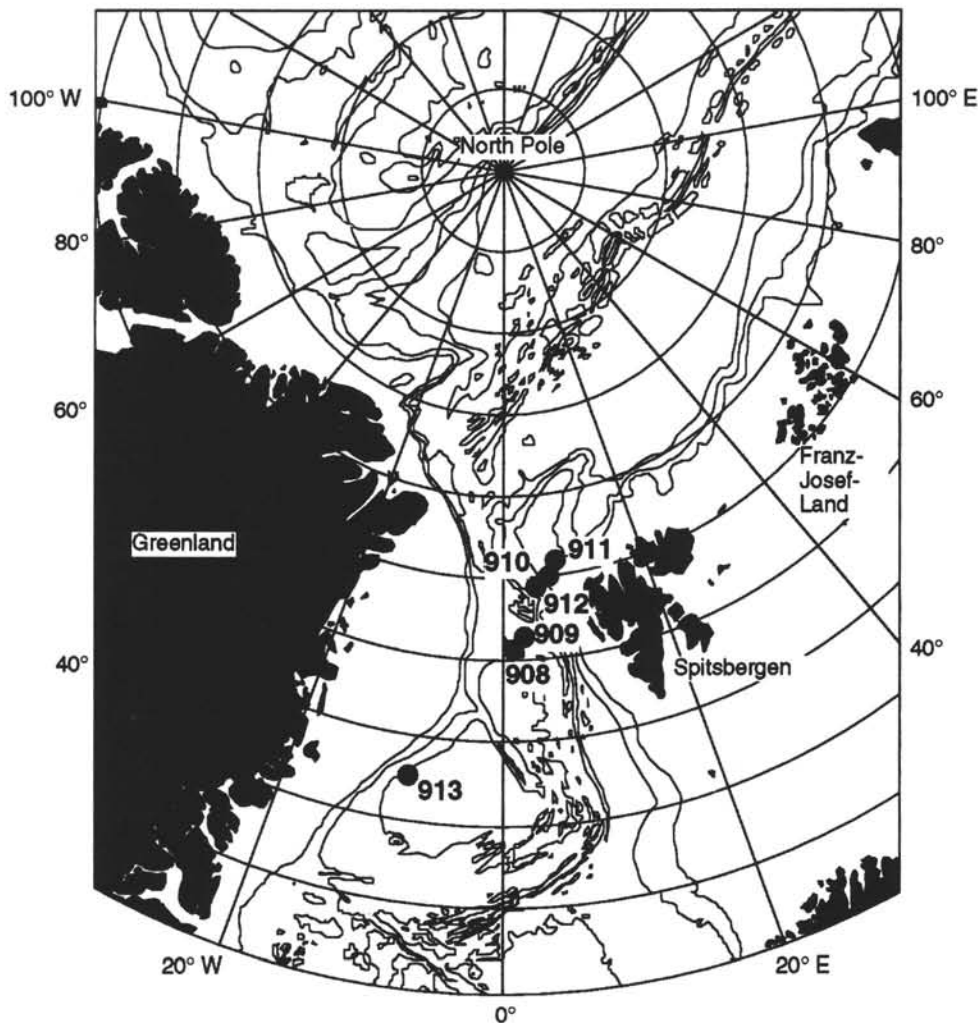


Figure 1. Location map of Sites 908 through 913.

The Miocene and Eocene sediments in the area of investigation contain only some spot observations of planktonic foraminifers. No planktonic foraminifers were found in Oligocene sediments.

YERMAK PLATEAU

The Yermak Plateau extends for about 400 km in a north-northwest direction from the shelf of Svalbard into the Arctic Ocean. The area is well suited for paleoceanographic analysis of Pliocene/Quaternary glacial/interglacials and the preglacial conditions. A north-south transect was drilled across the plateau with Site 911 in the north, Site 912 in the south, and Site 910 between.

Site 911

Site 911 was the most northerly site drilled during Leg 151 and is located on the southeastern part of the Yermak Plateau, 35 km east-northeast of Site 910. It was drilled in about 900-m water depth on the upper slope toward the Nansen Basin, at approximately 80°28.5'N, 8°13.6'E. The biostratigraphic results obtained by the investigation of planktonic foraminifers are based on Hole 911A (Table 1). Down to 505 meters below seafloor (mbsf), 342 samples (one per section) were analyzed. Planktonic foraminifers occurred in the Qua-

ternary section in 62% of the samples, and foraminifers are rare in the Pliocene sequences, where only 23% of the samples contained planktonic foraminifers. Hole 911A reached Miocene sediments.

The Quaternary/Pliocene boundary is defined by the last observation of *Neogloboquadrina atlantica* in dextral coiling direction in Sample 151-911A-25X-1, 112–115 cm (227.52 mbsf), which is situated just above the paleomagnetic Chron C2n, the Olduvai Event (Myhre, Thiede, Firth, et al., 1995), at approximately 1.7 Ma.

In the 228-m-thick Quaternary sequence the associations of planktonic foraminifers of low diversity show highly variable abundances. Such alternations seem to be typical of the changes between glacial and cold (interglacial) conditions. The assemblages consist mainly of *Neogloboquadrina* and *Globigerina* taxa, dominated by the polar *N. pachyderma* sin. Ice-rafted Cretaceous *Inoceramus*-prisms are found in the sediments between 35.66 and 47.50 mbsf, at 114.03 mbsf, from 128.30 to 129.80 mbsf, and at 171.25 mbsf. Rare occurrence of temperate-adapted *Orbulina universa*, *Globoconella inflata*, and *Globorotalia scitula* in the sequence from 144.06 to 145.56 mbsf and a single observation of *Globigerinoides ruber* at 194.95 mbsf document the fact that temperate to warm surface water sporadically reached into high latitudes. The single presence of these indices may be related to short warmer episodes, not long enough to produce rich and well-diversified assemblages. Therefore, at Site 911 the whole Quaternary may be characterized generally as cold. A sequence of

7.55 m barren of planktonic foraminifers separated the fossiliferous Quaternary and the Pliocene, containing foraminifers.

The Pliocene sediments of Hole 911A are extremely poor in planktonic foraminifers. Large parts of the sequence are almost barren or contained no age diagnostic planktonic foraminifers. Because of these difficulties, a clear subdivision of the 275-m-thick Pliocene sequence is impossible. The uppermost sample of the Pliocene sequence, Sample 151-911A-25X-1, 112–115 cm, contains *Globigerinoides ruber* and *Neogloboquadrina atlantica* dextral. The latter species is indicative of the *Neogloboquadrina atlantica* dextral Zone of the latest Pliocene (Spiegler and Jansen, 1989). Down to 318.93 mbsf (Sample 151-911A-34X-4, 113–117 cm), only a few samples yielded *N. atlantica* in its sinistral or dextral coiling mode. These rare occurrences do not allow the distinguishing of zones by coiling direction. Spheres of amber indicate reworking down to 365.44 mbsf, and ice-rafted *Inoceramus*-prisms down to 318.93 mbsf document glacial conditions back into the late Pliocene. The sediments below 318.93 mbsf down to 335.23 mbsf contain no age diagnostic fossils. From Sample 151-911A-36X-3, 115–119 cm, at 336.71 mbsf, down to Sample 151-911A-53X-5, 111–113 cm, at 502.29 mbsf, the sediments contain *N. atlantica* sin., which is indicative of the *Neogloboquadrina atlantica* sin. Zone, spanning Pliocene to latest Miocene (Spiegler and Jansen, 1989). The last observations of *Globigerina praebulloides* in Sample 151-911A-52X-2, 115–119 cm, at 488.40 mbsf, and a single specimen of *Paragloborotalia continuosa* in Sample 151-911A-52X-4, 115–119 cm, at 491.40 mbsf, indicate Pliocene to Miocene age. On the Vøring Plateau the LO (last occurrence) of *P. continuosa* is not younger than 4.7 Ma (Spiegler and Jansen, 1989). Miocene is confirmed in Sample 151-911A-53X-5, 113–117 cm, at 502.31 mbsf, by the co-occurrence of *N. pachyderma* dextral, *Globigerina praebulloides*, *G. officinalis*, *Globorotalia* cf. *zealandica*, *Catapsydrax unicavus*, *Paragloborotalia continuosa*, and *P. acostansis*. According to Kennett and Srinivasan (1980 and 1983), *P. continuosa* intergrades with *N. pachyderma* in late Miocene to early Pliocene in temperate to polar regions. The last 3 m of the cored sediment are barren in planktonic foraminifers.

Site 910

Site 910 is located on the summit of the central inner Yermak Plateau and is the shallowest site of the drilled transect. Holes 910A–910D were drilled in 556 m water depth at approximately 80°15.8'N, 6°35.4'E. The biostratigraphic results are largely based on Hole 910C (Table 2) and were completed with the results of Hole 910D (Table 3). Holes 910A and 910B stopped in Quaternary sediments, reaching only 34.0 mbsf and 15.6 mbsf, respectively. We analyzed 191 samples from Hole 910C (down to 507 mbsf) and 58 samples from Hole 910D (5.80 through 156.30 mbsf). Planktonic foraminifers occurred in 63% of the samples from Hole 910C and in 38% of the samples from Hole 910D. All 25 analyzed samples from Hole 910A (Table 4) contain abundant and well-preserved planktonic foraminifers of Quaternary age.

Nearly monospecific associations of the polar *N. pachyderma* sin. characterize the upper part of the Quaternary sequence. The assemblages also sporadically contain specimens of *N. pachyderma* in its dextral coiling mode, the five-chambered *N. cf. dutertrei*, and small *Globigerina* cf. *bulloides*. Below 35.30 mbsf, the lower sequence of the Quaternary in Holes 910C and 910D is extremely poor or barren of planktonic foraminifers. Ice-rafted *Inoceramus*-prisms are found at several levels in the Quaternary. Consequently, during the whole Quaternary, the surface-water masses at Site 910 may be characterized as cold.

The Quaternary/Pliocene boundary is well documented in Core 151-910D-10X: the base of the *N. pachyderma* sin. Zone (Quaternary) lies in Sample 151-910D-10X-2, 75–77 cm, at 76.35 mbsf, and Pliocene is documented in Sample 151-910D-10X-3, 74–76 cm, at

77.84 mbsf by a small (350 µm in diameter) juvenile or immature *Sphaeroidinellopsis* sp., aff. *S. paenedehiscens* (Blow). Bolli and Saunders (1985) placed *S. paenedehiscens* within the *S. seminulina* plexus. Weaver and Clement (1986) dated the LO of *S. seminulina* with 3 Ma. Therefore, if the observed specimen of *Sphaeroidinellopsis* sp. is not reworked, parts of the upper Pliocene may be missing. The planktonic foraminifer Zone N21 (Blow) can be determined in the Samples 151-910D-10X-3, 74–76 cm, 151-910D-15X-3, 74–76 cm, and 151-910D-16X-2, 74–76 cm. The co-occurrence of *Menardella limbata* (N12 to Recent), *Dentoglobigerina altispira* (N4B to N21, LO 2.95 Ma), *Globorotalia dutertrei*, which starts in N21, and *Globigerinoides extremus* (N16 to N21) is indicative. Below 153 mbsf in Hole 910D, down to 504 mbsf in Hole 910C, the entire sequence is assigned to the *Neogloboquadrina atlantica* sinistral Zone of the Pliocene. Further stratigraphic subdivision is impossible because of the scarcity of the assemblages. Ice-rafted *Inoceramus*-prisms are documented down to 178.9 mbsf (Sample 151-910C-19R-CC).

The spot observations of the above-mentioned subtropical to warm-temperate planktonic foraminifers are indicative for several short, distinct, warm to subtropical surface-water incursions during the generally cold late Pliocene. The topmost Pliocene sequence at Site 910 (Samples 151-910D-10X-3, 74–76 cm, and 10X-CC) contains assemblages with *N. pachyderma* dextral, *Sphaeroidinellopsis* sp., *Globigerinoides trilobus*, and *Turborotalia quinqueloba*, indicating warm surface water. The downhole 41 m of sediment (down to 124.74 mbsf in Hole 910D) is barren of planktonic foraminifers, except Samples 151-910D-13X-2, 74–76 cm, and 14X-2, 74–76 cm, which contain *Globigerinella aequilateralis*. The latter species also characterize temperate surface-water masses. The most distinct warm-water assemblages are documented in Samples 151-910D-15X-2, 74–76 cm, 16X-2, 74–76 cm, 16X-3, 74–76 cm, and 16X-3, 74–76 cm. *Menardella menardii*, *M. limbata*, *Neogloboquadrina dutertrei*, *Dentoglobigerina altispira*, *Globigerinoides ruber*, *Gls. conglobatus*, *Gls. extremus*, and *Gls. trilobus* indicate subtropical surface-water temperatures. These warm intervals lie in a sequence mainly barren of planktonic foraminifers that contains ice-rafted *Inoceramus*-prisms and assemblages of cold-adapted benthic foraminifers. Therefore, the climatic scenario in the area of investigation may be interpreted as containing episodic incursions of warm and subtropical surface-water masses into a generally cold ocean during the late Pliocene. The cold conditions of the late Pliocene are further documented by *N. pachyderma* sin. in Cores 151-910D-17X and 18X. In Sample 151-910D-18X-2, 74–76 cm, *N. pachyderma* sin. occurs together with *N. atlantica* sin., indicative of northern high latitude Pliocene and late Miocene (Spiegler and Jansen, 1989).

Site 912

Site 912 is located on the southwestern part of the Yermak Plateau, 45 km southwest of Site 910. Three holes were drilled on the slope toward the Molloy Rift and the Spitsbergen Fracture Zone in about 1037 m water depth at approximately 79°57.5'N, 5°27.4'E. All holes had to be abandoned because of advancing ice. Hole 912A penetrated 145.4 m of sediment, reaching the top of the Pliocene sequence. Hole 912B drilled only 40.5 m into Quaternary sediments, and Hole 912C was stopped at 209.1 mbsf in the Pliocene sequence.

Planktonic foraminifer biostratigraphy of Site 912 is based on the examination of all core-catcher samples from Hole 912A (Samples 151-912A-1H-CC through 15X-CC; Table 5), Hole 912B (Samples 151-912B-1H-CC through 5H-CC; Table 6), and Hole 912C (Samples 151-912C-1R-CC through 12R-CC; Table 7). Six additional samples were analyzed from Cores 151-912A-15X to study the Quaternary/Pliocene boundary and three samples from Core 151-912C-12X to examine the fossil content of the *Neogloboquadrina atlantica* sin. Zone.

Table 2. Distribution of planktonic foraminifers in Hole 910C.

Core, section, interval (cm)	Depth (mbsf)	Number of samples	Preservation and barren	<i>Neogloboquadrina pachyderma</i> sinistral	<i>Neogloboquadrina pachyderma</i> dextral	<i>Neogloboquadrina</i> cf. <i>dutertrei</i>	<i>Globigerina bulloides</i>	<i>Neogloboquadrina</i> sp. juv. dextral	<i>Neogloboquadrina atlantica</i> sinistral	<i>Neogloboquadrina atlantica</i> dextral	<i>Inoceramus</i> prisms	Paleotemperature of the surface water	Zone	Epoch
151-910C-1R-1, 0-3	0.00	1	B											
1R-1, 64 to	0.64	4	G	C	R	R	R					Cold	<i>N. pachy. sin.</i>	Quaternary
2R-1, 68-73	9.18	10	G	C	R							Cold		
2R-CC to	17.40		M	R							*	Cold		
5R-2, 38-42	37.18		M	R								Cold		
5R-CC	44.90		B									Cold		
6R-CC	54.50	G	R								*	Cold		
7R-CC	64.20	G	R								*	Cold		
8R-CC	73.80		B											
9R-CC to	83.40		/									No recovery		
10R-CC	93.10		/									No recovery		
11R-CC	102.80		G				R							
12R-CC to	112.40	4	B											
16R-CC	150.90		B											
17R-1, 99-103 to	151.89	12	M	R		R		R			*	Cold	<i>Neogloboquadrina atlantica</i> sinistral	Pliocene
20R-1, 69-72 to	180.49	4	G					R				Temperate		
20R-5, 69-72	186.49		B											
20R-CC	189.40		G					F	R					
21R-1, 42-44	189.82		B											
21R-CC	199.00		B											
22R-1, 99-103	199.99		G					F	R					
22R-2, 100-103 to	201.50	8	B											
23R-4, 97-102	214.17		B	R										
23R-5, 97-102	215.67		G						R					
23R-CC	218.30		G						R					
24R-1, 82-85 to	219.12	4	B			cf								
25R-CC to	237.60	8	G						R					
33R-1, 102-104 to	306.12	4	B											
34R-1, 110-114	315.90		G			cf								
34R-2, 110-114 to	317.40	5	B											
34-CC	324.40		B					R						
35R-1, 115-119	325.55		B											
35R-2, 115-119	327.05		G					R	R					
35R-3, 115-119	328.55		G					R	R					
35R-4, 115-119	330.05		M					R	R					
35R-5, 115-119 to	331.55	5	B											
36R-3, 100-184 to	338.10	12	G			cf		R	R					
38R-2, 42-47 to	355.32	31	G					R	R					
44R-5, 110-114	417.90		G			R		F						
44R-6, 109-113	419.39		B											
44R-CC	420.50		G					R						
45R-1, 100-103	421.50		B											
45R-2, 100-103	423.00		B											
45R-3, 100-103	424.50		G					R	R					
45R-4, 99-102 to	425.99	20	G			R		R	R					
49R-2, 118-122 to	461.68	29	G					R						
53-CC	507.40		B											

Note: For abbreviations see Table 1.

Planktonic foraminifers are abundant and well preserved in the upper sequence of the Quaternary sediments and occur sporadically in the downhole sequence. Monospecific *Neogloboquadrina pachyderma* sin. assemblages indicate Quaternary age for Cores 151-912A-1H through 3H, and 912B-1H through 4H. Core-catcher samples from Cores 151-912A-4H through 15X are barren with the exception of a single specimen of *N. pachyderma* sin. in Sample 151-912A-7H-CC. Cores 151-912A-12X and 14X have no recovery. Six additional samples from Core 151-912A-15X were processed to define the boundary between the Quaternary and the Pliocene. Samples from Sections 151-912A-15X-1, 15X-2, and 15X-4 are barren. Samples from Sections 15X-3 and 15X-5 contain *N. pachyderma* sin., indicating a Quaternary age. Sample 151-912A-15X-5, 33-37 cm, has the dextral coiling juvenile *Neogloboquadrina*, similar to the se-

quence observed at Site 910, where they were observed in the uppermost Pliocene. Sample 151-912A-15X-CC is barren. In the lowermost part of the sequence at Site 912, planktonic foraminifers from Core 151-912C-12R indicate the presence of the Pliocene *Neogloboquadrina atlantica* sin. Zone.

Ice-rafted *Inoceramus*-prisms (Cretaceous) are found in Quaternary sediments of Hole 912A and in Samples 151-912C-4R-CC through 11R-CC in Pliocene sediments.

FRAM STRAIT

The opening of the Fram Strait induced deep-water exchange between the Arctic and the Atlantic Oceans and forced long-term paleo-

Table 3. Distribution of planktonic foraminifers in Hole 910D.

Core, section, interval (cm)	Depth (mbsf)	Number of samples	Preservation and barren	<i>Neogloboquadrina pachyderma</i> sinistral	<i>Globigerinoides trilobus</i>	<i>Turborotalia quinqueloba</i>	<i>Sphaeroidinellopsis</i> sp. juv., aff. <i>seminulina</i>	<i>Neogloboquadrina pachyderma</i> dextral	<i>Globigerinella aequililateralis</i>	<i>Menardella menardii</i>	<i>Menardella limbata</i>	<i>Neogloboquadrina dutertrei</i>	<i>Dentoglobigerina altispira</i>	<i>Globigerinoides ruber</i>	<i>Globigerinoides conglobatus</i>	<i>Globigerinoides extremus</i>	<i>Globigerina bulloides</i>	<i>Neogloboquadrina atlantica</i> sinistral	<i>Inoceramus</i> -prisms	Paleotemperature of the surface water	Zone	Epoch	
151-910D-1H-CC to 6X-1, 74-76	5.80	6	G A																	Cold	<i>N. pach.</i> sin.	Quaternary	
6X-1, 74-76 to 6X-CC to 8X-1, 74-76	37.04	2	M R																*	Cold			
6X-CC to 8X-1, 74-76 to 9X-2, 75-76	45.30	2	B																	Cold			
8X-1, 74-76 to 9X-2, 75-76 to 10X-2, 75-77	55.64	3	M R																	Cold			
9X-2, 75-76 to 10X-2, 75-77	66.74	3	B R																	Cold			
10X-2, 75-77	76.35	3	P R																	Cold			
10X-3, 74-76	77.84	12	P		R	R	R													Temperate	N21	upper Pliocene	
10X-CC	83.70		G					R												*			Temperate
11X-1, 74-76 to 13X-2, 74-76	84.44		B																	*			Cold
13X-2, 74-76 to 13X-3, 74-76 to 14X-2, 74-76	105.24		P						R											*			Warm-temp.
13X-3, 74-76 to 14X-2, 74-76	106.74		B																	*			Cold
14X-2, 74-76 to 14X-3, 74-76 to 15X-3, 74-76	114.89		P						R														Warm-temp.
14X-3, 74-76 to 15X-3, 74-76	116.34		B																				Subtropical
15X-3, 74-76 to 15X-4, 74-76 to 16X-2, 74-76	126.24		G						R	R	R	R	R	R	R	R							Subtropical
15X-4, 74-76 to 16X-2, 74-76	127.74		B																				Subtropical
16X-2, 74-76 to 16X-3, 74-76	134.14		G		C				R	R	R	R				R							Temperate
16X-3, 74-76	135.64	G		R													R						
16X-5, 74-76 to 17X-2, 74-76	138.64	2	B																*	Cold	Pliocene		
17X-2, 74-76 to 17X-3, 74-76 to 17X-6, 74-76	142.24	M	R																	Cold			
17X-3, 74-76 to 17X-6, 74-76	143.74	3	B																	Cold			
17X-6, 74-76 to 18X-1, 74-76	148.24	P	R																	Cold			
18X-1, 74-76	151.84	B																		Cold			
18X-2, 74-76	153.34	G	R															R		Cold	<i>N. atl.</i> sin.		
18X-3, 74-76	154.84	G																R		Cold			
18X-4, 74-76	156.34	B																		Cold			

Note: For abbreviations see Table 1.

climatic changes. Therefore, knowledge of the evolution of the Fram Strait is one of the keys to understanding global oceanic circulation.

Site 909

Site 909 is located in the Fram Strait, north of Hovgård Ridge, on a small abyssal terrace in 2519 m water depth at approximately 78°35'N, 3°4'E. Three holes were drilled. The investigation of planktonic foraminifers is based on Hole 909A (Table 8), which penetrated 92.5 m sediment, and on Hole 909C (Table 9) cored from 85 mbsf into Miocene sediments down to 1061.8 mbsf. Dissolution may strongly affect the sediments in the Miocene sequence at this site, and the original planktonic foraminifer assemblages are not preserved. Therefore other fossil groups need to be examined to produce a useful biostratigraphy. We analyzed 64 samples from Hole 909A, and 335 samples from Hole 909C.

The Quaternary *Neogloboquadrina pachyderma* sin. Zone is documented in Hole 909A from the top of the sequence down to Sample 151-909A-8H-CC. The assemblages are low in diversity and dominated by the polar *N. pachyderma* sin. The planktonic foraminifer abundance varies considerably (as documented in Myhre, Thiede, Firth, et al., 1995), typifying the changes between glacial and more interglacial conditions. An interval barren in planktonic foraminifers separates the Quaternary *N. pachyderma* sin. Zone from the Pliocene *Neogloboquadrina atlantica* sin. Zone. This barren interval is documented in Samples 151-909A-9H-CC through 11H-CC and in Samples 151-909C-1R-CC through 8R-CC. The Pliocene *N. atlantica* sin.

Zone is present from Samples 151-909C-9R-1, 86-88 cm, to 32R-3, 28-32 cm. The first observation of ice-rafted *Inoceramus*-prisms was in Sample 151-909C-10R-CC at 181.60 mbsf in this zone. Planktonic foraminifer species of the late Pliocene include *N. atlantica* sin. and *Neogloboquadrina asanoi*. The latter species is more common in the Pacific region than in the Atlantic. A single observation of *Globocconella inflata* in Sample 151-909C-31R-3, 23-28 cm, confirms the upper Pliocene down to 377.33 mbsf. The *N. atlantica* Superzone, spanning Pliocene to latest Miocene (Spiegler and Jansen, 1989) is documented down to Sample 151-909C-32R-3, 28-32 cm at 386.88 mbsf. All samples between Section 151-909C-32R-5, 28-32 cm, and 44R-1, 32-35 cm, are barren of planktonic foraminifers. Downhole, agglutinated foraminifers dominate the assemblages. Nevertheless, planktonic foraminifers occurred in 10% of the samples. In Sample 151-909C-76R-1, 96-98 cm, at 808.56 mbsf the FO (first observation) of *Globigerina bulloides* indicates the upper Miocene. The FO of *Orbulina universa* in Sample 151-909C-89R-1, 97-100 cm, at 934.07 mbsf is important, because this FA (first appearance) defines a worldwide datum that coincides approximately with the beginning of planktonic foraminifer Zone N9 in the middle Miocene at 15.1 Ma. The occurrence of *Globorotalia scitula* (range N9 to Recent) in Sample 151-909C-103R-2, 3-7 cm, at 1059.53 mbsf indicates also an age younger than 15.1 Ma. Therefore, the oldest fossiliferous sediments penetrated at Site 909 are of early middle Miocene age. Section 151-909C-103R-3 and the core-catcher sample of Core 103R are barren. Reworking is evident by abundances of megaspores in Samples 151-909C-88R-CC and 89R-2, 97-99 cm.

Table 4. Distribution of planktonic foraminifers in Hole 910A.

Core, section, interval (cm)	Depth (mbsf)	Preservation	<i>Neogloboquadrina pachyderma</i> sinistral	<i>Neogloboquadrina pachyderma</i> dextral	<i>Neogloboquadrina</i> cf. <i>dutertrei</i>	<i>Globigerina</i> cf. <i>bullioides</i>	<i>Inoceramus</i> -prisms	Paleotemperature of the surface water	Zone	Epoch
151-910A-1H-1, 24-26	0.24	G	A					Cold	<i>Neogloboquadrina pachyderma</i> sinistral	Quaternary
1H-2, 24-26	1.74	G	C					Cold		
1H-3, 4-6	3.04	G	C					Cold		
1H-4, 8-10	4.58	G	C			R	R	Cold		
1H-CC	5.50	G	A	R	C	F	*	Cold		
2H-1, 20-22	5.70	G	C			R		Cold		
2H-2, 20-22	7.20	G	C			R		Cold		
2H-3, 20-22	8.70	G	C			R		Cold		
2H-4, 20-22	10.20	G	C			R	R	Cold		
2H-5, 20-22	11.70	G	C			R	R	Cold		
2H-6, 20-22	13.20	G	C	R		R	R	Cold		
2H-CC, 20-22	14.70	G	C			R	R	Cold		
2H-CC	15.00	G	A	R	R		*	Cold		
3H-1, 15-19	15.15	G	R			R	R	Cold		
3H-2, 15-19	16.65	G	R			R	R	Cold		
3H-3, 15-19	18.15	G	C			R		Cold		
3H-CC, 14-18	19.50	G	C			R		Cold		
3H-CC	19.50	G	C			R		Cold		
4H-1, 13-17	19.63	G	C			R		Cold		
4H-2, 24-28	21.24	G	C			R		Cold		
4H-3, 13-17	22.63	G	C			R		Cold		
4H-4, 4-8	24.04	G	C			R		Cold		
4H-CC	24.50	G	C			R		Cold		
5X-CC, 9-13	34.00	G	C	R			*	Cold		
5X-CC	34.00	G	C					Cold		

Note: For abbreviations see Table 1.

Table 5. Distribution of planktonic foraminifers in Hole 912A.

Core, section, interval (cm)	Depth (mbsf)	Number of samples	Preservation and barren	<i>Neogloboquadrina pachyderma</i> sinistral	<i>Neogloboquadrina pachyderma</i> dextral	<i>Neogloboquadrina</i> cf. <i>dutertrei</i>	<i>Neogloboquadrina</i> sp. juv. sinistral	<i>Neogloboquadrina</i> sp. juv. dextral	<i>Inoceramus</i> -prisms	Paleotemperature of the surface water	Zone	Epoch	
151-912A-1H-CC to 4H-CC to 7H-CC	0.04 to 61.00	4	M	F	R	R				Cold	<i>Neoglob. pachyderma</i> sin	Quaternary	
8H-CC to 12H-CC	70.50 to 106.90	4	B					*	Cold				
13H-CC	116.50	/	B						No recovery				
14H-CC	126.10	/	B						No recovery				
15H-1, 33-37 to 15X-3, 33-37	126.43 to 128.98	2	B					*	Cold				
15X-4, 33-37	130.48	B	R						Cold				
15X-5, 33-37	131.93	P				R			Cold				
15X-6, 33-37	133.43	P				R			Cold	#1			#2
15X-CC	135.80	B											Barren

Notes: #1 = *Neogloboquadrina* sp. juv. dextral, #2 = Pliocene. For other abbreviations see Table 1.

Table 6. Distribution of planktonic foraminifers in Hole 912B.

Core, section, interval (cm)	Depth (mbsf)	PF %	Preservation and barren	<i>Neogloboquadrina pachyderma</i> sinistral	<i>Neogloboquadrina pachyderma</i> dextral	<i>Neogloboquadrina</i> cf. <i>dutertrei</i>	<i>Neogloboquadrina</i> sp. juv. dextral	<i>Globigerina</i> cf. <i>bullioides</i>	Paleotemperature of the surface water	Zone	Epoch
151-912B-1H-CC	5.70	95	M	A					Cold	<i>Neoglob. pachyd. sin.</i>	Quaternary
2H-CC	14.80	0	B								
3H-CC	24.30	90	G	C	R	R	R		Cold-temp. Cold		
4H-CC	31.00	50	G	R			R				
5H-CC	40.50	0	B								

Note: For abbreviations see Table 1.

Table 7. Distribution of planktonic foraminifers in Hole 912C.

Core, section, interval (cm)	Depth (mbsf)	Preservation and barren	<i>Neogloboquadrina atlantica</i> sinistral	<i>Neogloboquadrina</i> sp. juv. sinistral	<i>Inoceramus</i> -prisms	Paleotemperature of the surface water	Zone	Epoch
151-912C-1R-CC	103.10	B			*		Barren of planktonic foraminifers	
2R-CC	112.70	B						
3R-CC	122.40	B						
4R-CC	132.00	B			*	Cold		
5R-CC	141.70	B						
6R-CC	151.30	B			*	Cold		
7R-CC	160.90	B			*	Cold		
8R-CC	170.60	B						
9R-CC	180.20	B			*	Cold		
10R-CC	189.90	/				No recovery		
11R-CC	199.50	B			*	Cold		
12R-1, 89-94	200.39	G	R				<i>Neoglob. atl. sin.</i>	Pliocene
12R-2, 39-43	202.39	G		R				
12R-3, 16-19	202.66	G	R					
12R-CC	209.10	G	R					

Note: For abbreviations see Table 1.

Site 908

The southern opening of the Fram Strait is almost completely blocked by the Hovgård Ridge (Myhre, Thiede, Firth, et al., 1995). Small sediment basins on the Hovgård Ridge contain sediments documenting the geological history of the structural high after subsidence and the opening of Fram Strait. Site 908 is located on top of the Hovgård Ridge in about 1273 m water depth at approximately 78°23'N, 1°22'E. Hole 908A (Table 10) penetrated 344.6 m of sediment, reaching upper Oligocene sediments. Hole 908B drilled 83.4 m and terminated in Pliocene sediments.

The biostratigraphic results are based on Hole 908A. Unfortunately, planktonic foraminifers occurred only in the upper 15 m of the sequence, down to Sample 151-908A-2H-CC. In this interval nearly monospecific associations of the polar-adopted *N. pachyderma* sin.

Table 8. Distribution of planktonic foraminifers in Hole 909A.

Core, section, interval (cm)	Depth (mbsf)	Number of samples	Preservation and barren	<i>Neogloboquadrina pachyderma</i> sinistral	<i>Neogloboquadrina pachyderma</i> dextral	<i>Neogloboquadrina</i> cf. <i>dutertrei</i>	<i>Globigerina</i> cf. <i>bulloides</i>	<i>Turborotalia quinqueloba</i>	<i>Inoceramus</i> -prisms	Paleotemperature of the surface water	Zone	Epoch
151-909A-												
1H-1, 15-17	0.15		P	C	R	R				Cold-temperate		
1H-1, 69-71	0.69		G	A	R	R	R			Cold-temperate		
1H-1, 82-84	0.82		G	A	R	C	R			Cold-temperate		
1H-2, 26-28	1.76		B									
1H-2, 103-105	2.53		G	A	R	C				Cold-temperate		
1H-3, 17-19	3.17		G	A						Cold		
1H-3, 105-107	4.05		B									
1H-4, 6-8	4.56		M	C			R			Cold		
1H-4, 18-20	4.68		G	R						Cold		
1H-4, 41-43	4.91		G	A				R		Cold		
1H-4, 69-71	5.19		G	A						Cold		
1H-4, 116-118	5.66		G	A	R	C	R			Cold-temperate		
1H-5, 5-7 to	6.05	8	M	R						Cold		
2H-2, 92-96	9.95		G	C	R	R				Cold-temperate		
2H-2, 106-108 to	10.06	4	G	C						Cold		
2H-4, 37-39	12.37		B									
2H-4, 82-84	12.82		G	C						Cold		
2H-4, 104-106	13.04		M	A						Cold		
2H-5, 13-15	13.63		G	R						Cold		
2H-5, 95-97	14.45		B									
2H-6, 6-8 to	15.06	3	P	C						Cold		
2H-6, 120-122 to	16.20	2	B									
2H-7, 62-64	17.00		P	R						Cold		
2H-CC	17.00		G	C						Cold		
3H-1, 46-48 to	17.46	3	B									
3H-4, 88-90	22.38		P	R						Cold		
3H-5, 27-29	23.27		B									
3H-5, 80-82	23.80		G	C	R	R	R			Cold-temperate		
3H-5, 103-108	24.09		G	A						Cold		
3H-6, 42-44	24.92		G	R						Cold		
3H-7, 2-4	26.02		B									
3H-CC	26.50		M	C	R					Cold		
4H-1, 44-46	26.94		G	C				*		Cold		
4H-2, 72-73	28.22		G	A	R					Cold		
4H-3, 26-28 to	29.26	5	B									
4H-CC	36.00		M	R						Cold		
5H-1, 128-130	37.28		G	A						Cold		
5H-2, 44-46 to	37.94	5	B									
6H-1, 77-79	46.27		B	R	R			*		Cold		
6H-1, 131-133	46.81		B									
6H-CC	55.50		M	R						Cold		
7H-CC	65.00		B									
8H-CC	74.00		G	R						Cold		
9H-CC to	82.60	3	B									
11H-CC	92.50		B									Barren

occurred, suggesting an age assignment to the Quaternary. The assemblages show highly variable abundances, fluctuating several times from abundant to intervals rare or even barren in planktonic foraminifers. Further, one sample per section down to Sample 151-908-28X-6, 95-100 cm (263.05 mbsf) was analyzed. Because of no success, analysis was halted.

EAST GREENLAND MARGIN

Site 913

Site 913 is located in the Greenland Basin. Two holes were drilled at 3.318 m water depth at 75°29.3'N, 6°56.8'W. This site was selected to evaluate the onset and history of the East Greenland Current, to monitor the development of deep-water formation in the Greenland

Sea, and to document the history of IRD input, as well as to determine the age and character of sediments overlying basement (Myhre, Thiede, Firth, et al., 1995).

Hole 913A (Table 11) penetrated to 84.40 m. The planktonic foraminifer assemblages are low in diversity and dominated by the polar *N. pachyderma* sin. The abundance varies considerably, as documented above, in the other northern sites of this leg. Ice-rafted *Inoceramus*-prisms are documented down to 65.10 mbsf. Sample 151-913A-12X-CC was barren, and the last core of Hole 913A had no recovery. We analyzed 38 samples from Hole 913A.

Poor recovery severely hampered the analysis of the Quaternary and late Neogene sediments of Hole 913B to 375.20 mbsf. After washing down to 423.50 m, all core-catcher samples of this hole were analyzed. They contained no planktonic foraminifers. Osterman and Spiegler (this volume) analyzed the agglutinated benthic assemblages of Site 913. Out of the 300 samples studied, planktonic foraminifers were seen in only three samples. Sample 151-913B-24R-4, 10-14 cm, at 466.60 mbsf contained a single broken specimen of a small *Acarinina* sp., aff. *A. rotundimarginata* Subbotina (1953), a species that is typical for the middle Eocene. Silicified *Subbotina triangularis* (White) were found in the Samples 151-913B-44R-3, 58-60 cm, and 45R-1, 11-14 cm, at 658.09 mbsf and 664.51 mbsf, respectively, reaching stratigraphically from Zone P2 (Paleocene) to Zone P8a (early Eocene). Nevertheless, lacking Paleocene species in this sequence, an age assignment to early Eocene is supposed.

SUMMARY

Age determinations of the sediments recovered during Leg 151 are difficult due to the scarcity of planktonic foraminifers and poorly diversified assemblages. Temperature is the most important factor controlling habitat of planktonic foraminifers in high latitudes.

The summary of the planktonic foraminifer zones and some ages, derived from different FOs or LOs of planktonic foraminifers at Sites 908 through 913, is given in Figure 2.

In the Quaternary sediments, the polar *Neogloboquadrina pachyderma* sin. is the dominant species and shows highly variable abundances. The alternations seem to be related to the changes between glacial and cold (interglacial) conditions. The whole Quaternary may be characterized as the *Neogloboquadrina pachyderma* sin. Zone. The LO of *Neogloboquadrina atlantica* marks the Quaternary/Pliocene boundary. The *N. atlantica* Superzone spans the whole Pliocene and reaches into the late Miocene. A further subdivision of this interval by coiling changes of *N. atlantica* is impossible. Warm to subtropical intervals in the upper *Neogloboquadrina atlantica* sin. Zone can be correlated with the planktonic foraminifer Zone N21. Therefore, the late Pliocene may be characterized as cold or cold-temperate with episodic incursions of warm to subpolar surface water. The co-occurrence of *Neogloboquadrina asanoi* marks the influence of Pacific surface water in the late Pliocene.

Rare and spot occurrences of planktonic foraminifers in the Miocene and Paleogene sediments prevent a zonation. The oldest sediments recovered at the East Greenland Margin are of early Eocene age.

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Table 9 (continued).

Core, section, interval (cm)	Depth (mbsf)	Number of samples	Preservation and barren	<i>Neogloboquadrina atlantica</i> sinistral	<i>Neogloboquadrina asanoi</i>	<i>Globocornella inflata</i>	<i>Neogloboquadrina</i> sp.	<i>Globigerina bulloides</i>	<i>Neogloboquadrina atlantica</i> dextral	<i>Globigerinita glutinata</i>	<i>Globorotalia scitula</i>	<i>Globigerinella obesa</i>	<i>Orbulina universa</i>	<i>Neogloboquadrina continuosa</i>	<i>Neogloboquadrina pachyderma</i> sinistral	<i>Globigerina ciperensis</i>	<i>Globigerina praebulloides</i>	<i>Globigerinoides ruber</i>	<i>Turborotalia quinqueloba</i>	<i>Neogloboquadrina cf. nama</i>	<i>Inoceramus</i> -prisms	Megaspores	Amber	Remarks	Zone	Epoch		
81R-2, 95-99	858.35		G		R										R													
85R-1, 96-98	895.36		G						R	R					R													
85R-2, 20-22	896.10		G										R															
88R-CC	933.10		B																			A						
89R-1, 97-100	934.07		G										R									A						
89R-2, 97-100	935.57		G																			A						
103R-1, 3-7	1058.03		G															cf										
103R-1, 95-99	1058.95		B																									
103R-2, 3-7	1059.53		G																									
103R-2, 92-96	1060.42		P					R		R	R					R		C	R									
103R-3, 3-7 to 103R-CC, 3-7	1061.03 to 1062.16	3	B B																									

Note: For abbreviations see Table 1.

Table 10. Distribution of planktonic foraminifers in Hole 908A.

Core, section, interval (cm)	Depth (mbsf)	Number of samples	Preservation and barren	<i>Neogloboquadrina pachyderma</i> sinistral	<i>Neogloboquadrina pachyderma</i> dextral	<i>Turborotalia quinqueloba</i>	<i>Inoceramus</i> -prisms	Paleotemperature of the surface water	Zone	Epoch
151-908A-										
1H-1, 5-10	0.05		M	R	R			Cold		
1H-1, 21-23	0.21	1	B					Cold-temp.		
1H-1, 43-46	0.43		M	A	R			Cold		
1H-1, 47-48	0.47		M	A				Cold		
1H-1, 70-75	0.70	1	B					Cold		
1H-1, 134-139	1.34	9	M	R	R			Cold		
1H-4, 64-66	5.14	1	B					Cold		
1H-CC, 17-19	5.34		M	R				Cold		
1H-CC	5.40		G	C	R	R		Cold-temp.		
2H-1, 69-72	6.09		M	R				Cold		
2H-2, 71-75	6.11		P	R				Cold		
2H-3, 38-42	8.78	1	B					Cold		
2H-3, 135-139	9.75	5	G	A		*		Cold		
2H-6, 54-57	13.44	1	B					Cold		
2H-6, 57-69	13.57		G	R				Cold		
2H-7, 65-69	ca. 14.50	1	B					Cold		
2H-CC	14.90		M	R				Cold		
3H-1, 37-42 to 28X-6, 95-100	15.27 to 263.05	150	B B							Barren of PF

Note: For abbreviations see Table 1.

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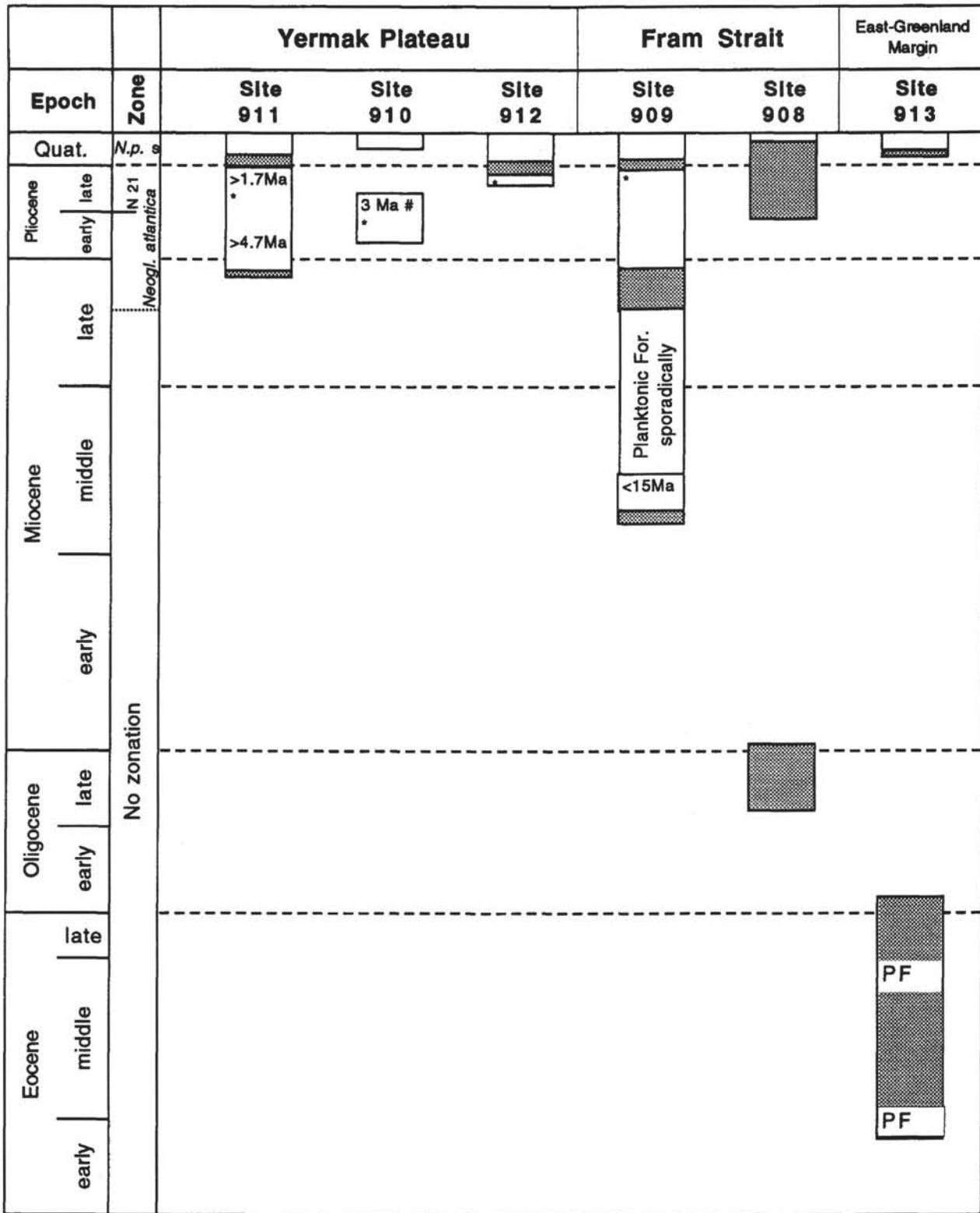
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Table 11. Distribution of planktonic foraminifers in Hole 913A.

Core, section, interval (cm)	Depth (mbsf)	Number of samples	Preservation and barren	<i>Neogloboquadrina pachyderma</i> sinistral	<i>Neogloboquadrina pachyderma</i> dextral	<i>Globigerinita glutinata</i>	<i>Neogloboquadrina</i> cf. <i>diterraei</i>	<i>Globigerina</i> cf. <i>bulloides</i>	<i>Neogloboquadrina</i> sp. juv. sinistral	<i>Turborotalia quinqueloba</i>	<i>Inoceramus</i> -prisms	Paleotemperature of the surface water	Zone	Epoch
151-913A-														
1H-1, 10-14	0.10		G	A	R	C	R	R				Cold-temp.	<i>Neogloboquadrina pachyderma</i> sinistral	Quaternary
1H-1, 52-55	0.52		G	A			R					Cold-temp.		
1H-1, 86-90	0.86		G	A	C				C			Cold-temp.		
1H-2, 10-14	1.60		G	A	R							Cold-temp.		
1H-2, 86-90	2.36		G	A	R				C			Cold-temp.		
1H-2, 129-133	2.79		G	A	C	R	R	R	A	R		Cold-temp.		
1H-3, 10-14	3.10		G	A	A	R	C	R	A	R		Cold-temp.		
1H-CC	4.40		G	A							*	Cold		
2H-CC	9.30		G	A	R					R		Cold-temp.		
3H-1, 0-2	9.31		M	R			R					Cold		
3H-1, 10-14	9.40		G			R						Cold		
3H-2, 10-12	10.90	1	B									Cold		
3H-3, 10-14	12.40		G	R								Cold		
3H-5, 10-14 to	15.40	3	B								*	Cold		
4H-2, 11-15	19.21		G	R								Cold		
4H-3, 9-13 to	20.69	3	B								*	Cold		
4H-CC, 9-13	23.30		G	C								Cold		
4H-CC	23.60		G	C	R							Cold		
5H-1, 10-14	23.70		G	C	R							Cold		
5H-2, 6-10	25.16		G	C				R				Cold		
5H-3, 7-11	25.76		G	C			R					Cold		
5H-CC	26.40		G	C								Cold		
6H-CC to	36.10	3	B								*	Cold		
7X-CC	45.80		G	R								Cold		
8X-CC	55.50		M	R								Cold		
9X-1, 13-15 to	55.63	2	B								*	Cold		
10X-1, 9-12	65.19		G	R		R						Cold		
10X-1, 25-29	65.35		G	C								Cold		
10X-1, 87-89	65.97		G	C	R							Cold		
10X-CC	74.70		G	R								Cold		
11X-CC	84.40		G	C								Cold		
12X-CC	94.00		B									Gravel	Barren	
13X-CC	103.60		/									No recovery		

Note: For abbreviations see Table 1.




 = Barren in PF N.p. s. = *Neogloboquadrina pachyderma* sinistral
 # = Subtropical PF = Planktonic foraminifers
 * = First ice-rafted *Inoceramus*-prisms

Figure 2. Summary of planktonic foraminifer zones recovered at Sites 908 through 913.

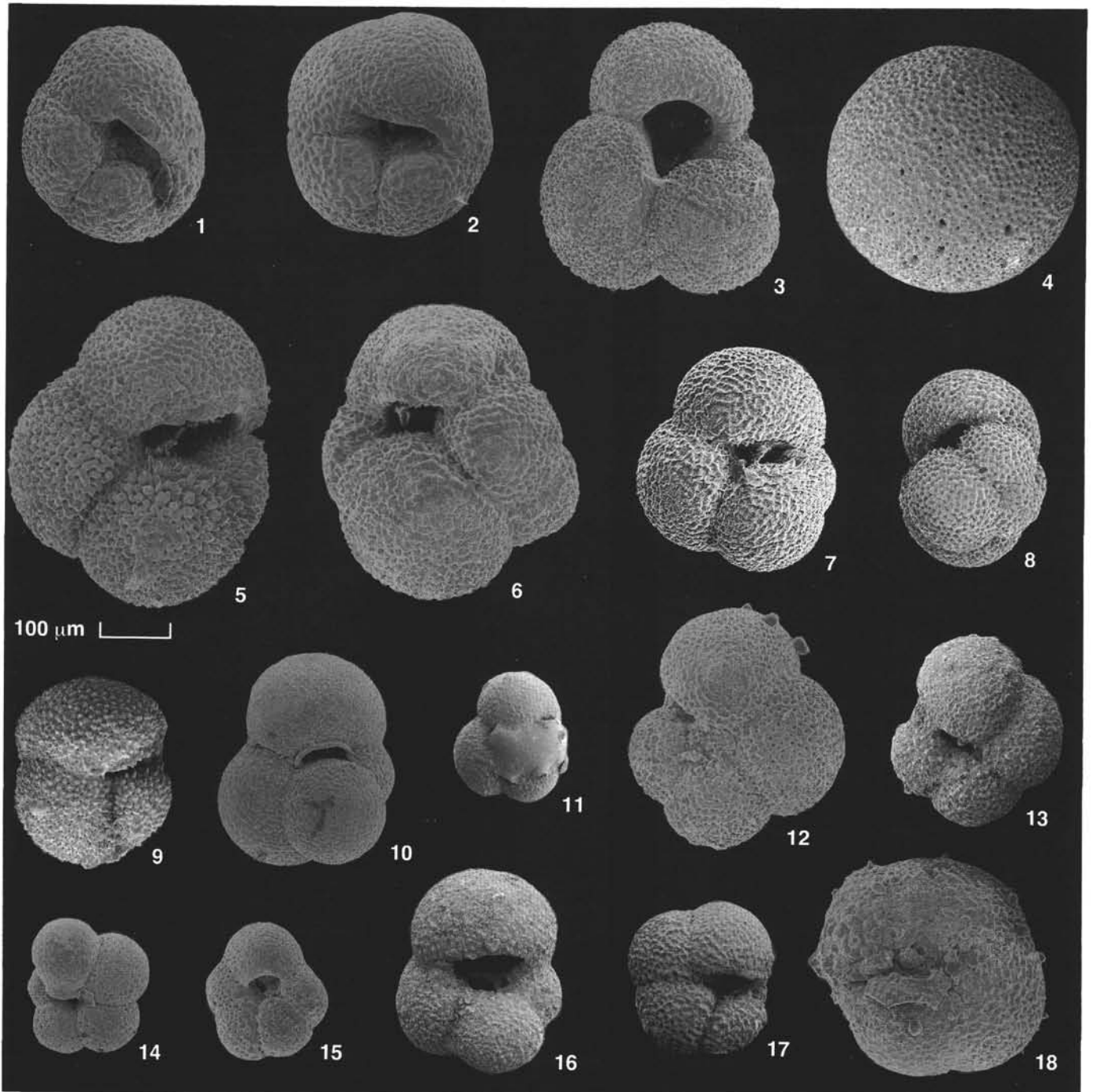


Plate 1. 1–2. *Neogloboquadrina pachyderma* (Ehrenberg), sinistral, Sample 151-910A-2H-CC, 20–22 cm, Quaternary. 3. *Globigerina bulloides* Orbigny, Sample 151-909C-103R-2, 3–7 cm, middle Miocene. 4. *Orbulina universa* Orbigny, Sample 151-911A-16X-3, 116–120 cm, Quaternary. 5–6. *Neogloboquadrina asanoi* (Maiyasaito and Sato), Sample 151-909C-10R-5, 43–47 cm, upper Pliocene. 7–8. *Neogloboquadrina atlantica* (Berggren) sinistral, 7. Sample 151-910C-20R-CC, upper Pliocene. 8. Sample 151-910C-20R-2, 69–72 cm, upper Pliocene. 9. *Globoconella* cf. *inflata* (Orbigny), Sample 151-911A-16X-3, 116–120 cm, Quaternary. 10. *Globigerinita glutinata* (Egger), Sample 151-909C-32R-1, 28–32 cm, upper Pliocene. 11. *Globigerinita glutinata* (Egger), forma *ambitacrena* (Loeblich and Tappan), Sample 151-909C-103R-2, 3–7 cm, Miocene. 12–13. *Paragloborotalia continuosa* (Blow), Sample 151-911A-53X-5, 113–117 cm, Miocene. 14–15. *Turborotalia quinqueloba* (Natland), Sample 151-909C-103R-2, 3–7 cm, Miocene. 16. *Globigerina praebulloides* Blow, Sample 151-911A-53X-5, 113–117 cm, Miocene. 17. *Paragloborotalia nana* (Bolli), Sample 151-911A-53X-5, 113–117 cm, Miocene. 18. *Neogloboquadrina pachyderma* (Ehrenberg), dextral, Sample 151-911A-53X-5, 113–117 cm, Miocene.

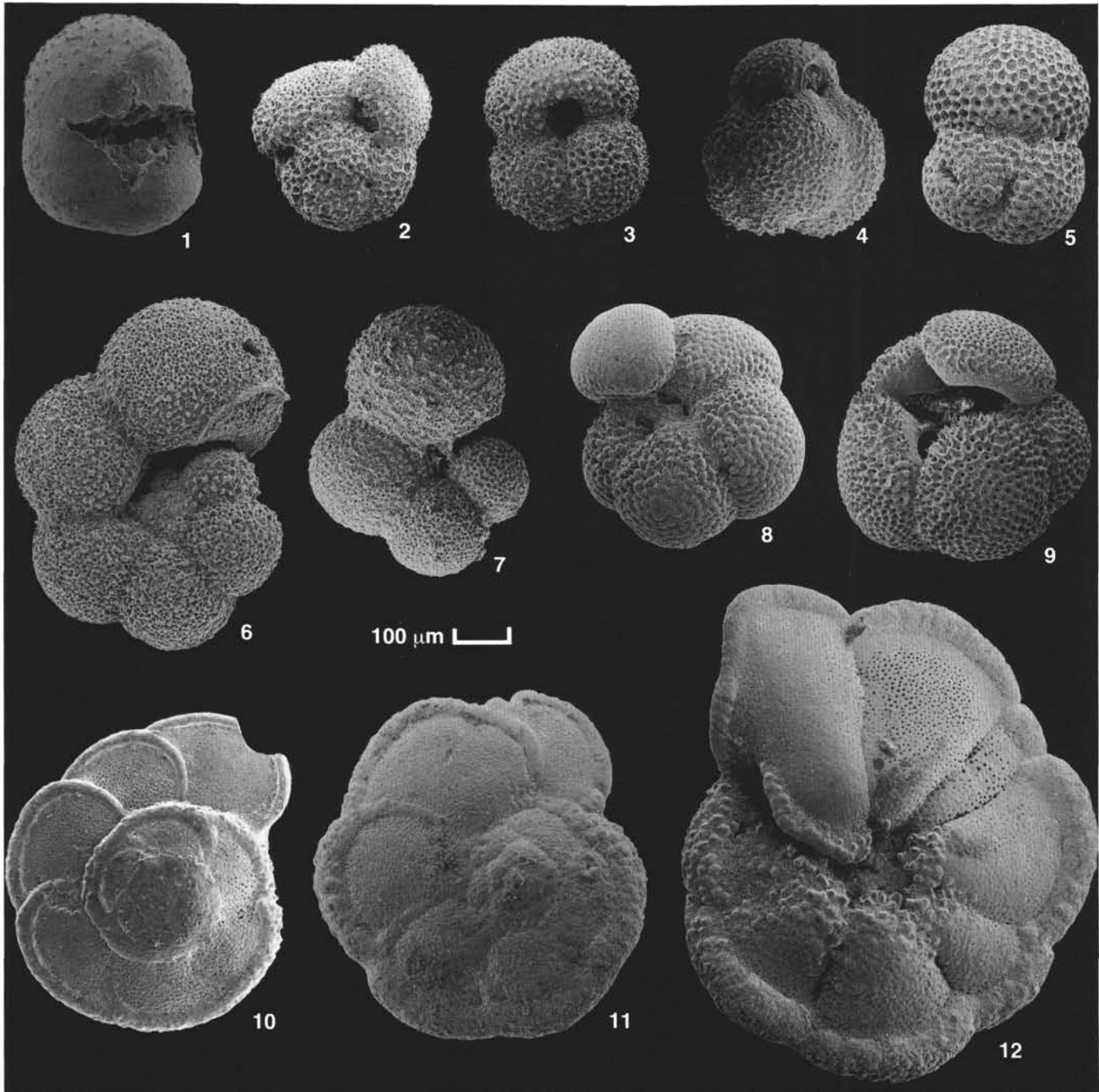


Plate 2. Subtropical upper Pliocene planktonic foraminifera at Site 910. **1.** *Sphaeroidinellopsis* sp. juv., aff. *S. paenedehiscens* (Blow), Sample 151-910D-10X-3, 74–76 cm. **2.** *Globigerinoides obliquus extremus* Bolli and Bermudez, Sample 151-910D-16X-2, 74–76 cm. **3–4.** *Globigerinoides ruber* (Orbigny), 3, Sample 151-910D-16X-2, 74–76 cm, 4, Sample 151-910D-15X-3, 74–76 cm. **5.** *Globigerinoides trilobus* (Reuss), Sample 151-910D-10X-3, 74–76 cm. **6.** *Globigerinella aequilateralis* (Brady), Sample 151-910D-13X-2, 74–76 cm. **7.** *Globigerinella siphonifera* (Orbigny), Sample 151-910D-14X-2, 74–76 cm. **8.** *Neoglobobadrina dutertrei* (Orbigny), Sample 151-910D-15X-3, 74–76 cm. **9.** *Dentoglobigerina altispira* (Cushman and Jarvis), Sample 151-910D-16X-2, 74–76 cm. **10.** *Menardella limbata* (Fornasini), Sample 151-910D-15X-3, 74–76 cm. **11–12.** *Menardella menardii* (Parker, Jones, and Brady), 11, Sample 151-910D-15X-3, 74–76 cm. 12, Sample 151-910D-16X-2, 74–76 cm.