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20. EOCENE–MIOCENE MAGNETOSTRATIGRAPHY OF THE SOUTHEAST GREENLAND MARGIN AND WESTERN IRMINGER BASIN[1]

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ABSTRACT

Shore-based paleomagnetic investigations were conducted on Eocene–Miocene sediments recovered during Ocean Drilling Program Leg 152 drilling of the southeast Greenland Margin and the western Irminger Basin. A total of 147 specimens was analyzed. In general, the magnetostratigraphy obtained from the shipboard whole-core magnetometer studies (spot demagnetization at 25 mT) has been confirmed. However, a number of specimens yielded polarities different from those obtained by the shipboard magnetometer, calling for some caution in the interpretation of the magnetostratigraphy. During Leg 152, it proved difficult to correlate the polarity records with the geomagnetic polarity time scale because of core recovery and the limited biostratigraphic information available at the time. Since then, the shore-based biostratigraphic studies have yielded many datum points useful for correlating the refined magnetozone sequences to the polarity time scale. In terms of seaward dipping reflector formation, the new data are particularly valuable in determining their subsidence history. At Sites 915 and 917, close to the southeast Greenland ocean/continent transition, intervals of 13 m.y. and 4 m.y., respectively, elapsed before marine sedimentation commenced. Sedimentation at Site 918, in the western part of the Irminger Basin, commenced almost immediately after seaward dipping reflector formation at about 54 Ma.

INTRODUCTION

In this paper, we present the results of shore-based magnetostratigraphic studies of Eocene–Miocene sediments from Ocean Drilling Program (ODP) Leg 152. To varying degrees, our results are relevant to all of the cruise objectives: formation of the southeast Greenland seaward dipping reflector sequences (SDRS) during Paleocene–earliest Eocene times, Northern Hemisphere glaciation (late Miocene–Holocene), Neogene Arctic–Atlantic paleoceanography and North Atlantic Eocene–Oligocene chronostratigraphy. The drilling at all six of the sites (914–919) penetrated Cenozoic sediments overlying volcanic basement (SDRS) of presumed C24r age (except Site 919, C24n.3n age); see also Larsen and Saunders (this volume).

LABORATORY PROCEDURES

A full account of the shipboard paleomagnetic laboratory procedures is provided in Larsen, Saunders, Clift, et al. (1994). In summary, 1.5-m-long archive-half sections were analyzed for their paleomagnetism using a 2G Enterprises cryogenic magnetometer with an in-line, three-axis alternating field (AF) demagnetization system. The AF system is capable of generating fields of up to 35 mT. Prior to AF cleaning, the initial remanent magnetization of the cores was measured at 10-cm intervals along each section. Unfortunately, because of the large volumes of material that had to be analyzed aboard ship, only one demagnetization (25 mT) and one measurement cycle could be performed on each section. This limited us in fully investigating the nature and origin of the natural remanent magnetization (NRM) within the rocks examined.

To enhance the reliability of the polarity record defined from shipboard measurements, detailed post-cruise shore-based studies were performed. Typically, one sample per core section was taken for these studies. Samples were measured using a 2G Enterprises cryogenic magnetometer, with an in-line AF demagnetizing system capable of generating fields of up to 40 mT. After initial measurement of the NRM, samples were demagnetized at 5-mT step increments up to 40 mT to isolate the primary remanence. Samples requiring additional demagnetization were processed to 50–70 mT using a Molspin tumbling AF system. In practically all cases, the magnetization comprises a single low-coercivity component (which generally is indicative of a simple magnetization history). Examples of the responses of samples to AF demagnetization are shown in Figure 1.

BIOSTRATIGRAPHIC CONSTRAINTS AND GEOMAGNETIC POLARITY TIME SCALE

During Leg 152 and in our report in Larsen, Saunders, Clift, et al. (1994), we used the Cande and Kent (1992) geomagnetic polarity time scale. In this paper, we use the Cande and Kent (1995) time scale.

The magnetostratigraphy obtained on *JOIDES Resolution* provided an apparently clear pattern of normal and reverse polarity magnetozones within the Eocene–Miocene succession. However, correlating this record with the geomagnetic polarity time scale (GPTS) proved somewhat difficult because of the limited recovery in certain intervals and because of the lack of age-diagnostic microfaunas at many levels. As far as Leg 152 is concerned, the nannoplankton are the most useful fossil group with which to link the obtained polarity record to the GPTS. A refined nannofossil stratigraphy has been provided by Wei (this volume). Additional information is provided by Jolley (this volume) on the Eocene palynomorphs.

SITE 914

At Site 914, only Cores 152-914B-l5R through 17R recovered Eocene–Miocene sediments. Shipboard biostratigraphic studies assigned these three cores to Zones CP16–CP18, indicating an early Oligocene age. The magnetic polarity sequence obtained from the

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Prior Chapter Contents Next Chapter

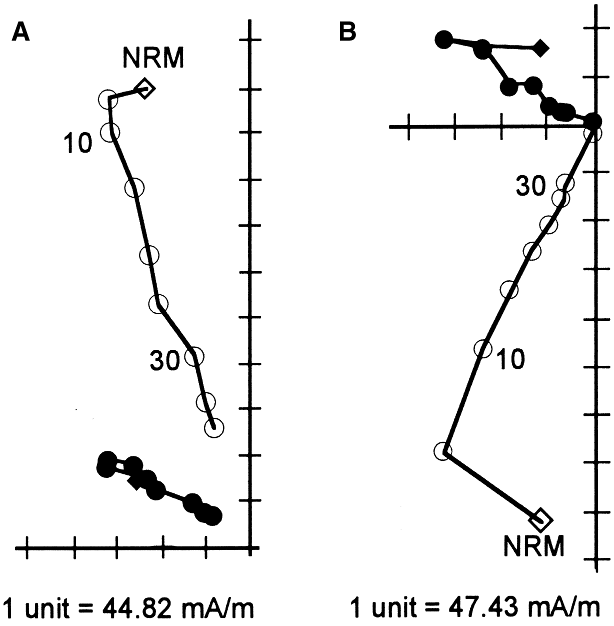

Figure 1. Examples of responses to AF demagnetization. Data plotted on Zijderveld (1967) diagrams. Closed symbols represent the vectors plotted on the horizontal plane and open symbols represent the vectors plotted on a vertical plane. Numbers alongside both vertical plane plots indicate the applied demagnetization field (mT). **A.** Sample 152-918D-25R-3, 14 cm. **B.** Sample 152-918D-36R-1, 114 cm.

cores was correlated with geomagnetic Chrons C13n–C12r although a number of other, theoretically plausible, correlations are possible. Shore-based paleomagnetic studies were not performed on material from this site. New biostratigraphic information indicates a narrower age range for the three cores (CP16) in support of the C13n–12r magnetostratigraphic correlation. Accordingly, the age of these cores is around 33 Ma (Cande and Kent, 1995).

SITE 915

At Site 915, only Cores 152-915A-11R through 23R recovered middle through upper Eocene sediments; no Oligocene–Miocene sediments were cored. Shipboard measurements were taken only on Cores 152-915A-16R and 18R through 22R, where the sediments were undisturbed. The polarity sequence obtained shipboard is relatively simple, with Core 152-915A-16R carrying a normal polarity and Cores 152-915A-18R through 22R carrying a reverse polarity. Only slight modifications to the magnetostratigraphy are needed following shore-based work (Table 1). Sample 152-915A-16R-1, 102 cm, carries a reverse polarity magnetization, contrary to the normal polarity previously identified at this level. Samples 152-915A-18R-1, 61 cm, 21R-1, 126 cm, and 21R-2, 10 cm, carry unstable magnetizations, and the reverse polarity record at these levels must be regarded as suspect. Reliable polarity data have also been obtained from three levels that were not investigated on the ship (Table 1). This new information confirms the record of a dominantly reverse polarity magnetization in Cores 152-915A-18R through 22R, which, according to the sparse biostratigraphic data, suggests a correlation with Chron C18r (middle Eocene) that is considerably younger than the volcanic basement.

Table 1. Summary of discrete specimen paleomagnetic data from Holes 915A, 916A, and 917A.

Core, section, interval (cm)	Depth (mbsf)	Inc	Polarity	
			Lab	Ship
152-915A-				
16R-1, 102	131.32	–44.5	R	N
17R-CC, 3	139.51	73.0	R	ND
18R-1, 61	149.21	?	R	R
18R-2, 33	150.43	–28.3	R	R
18R-3, 23	151.83	–32.6	R	R
18R-4, 26	151.86	–30.5	R	R
18R-CC, 23	153.40	–29.2	R	ND
19R-1, 22	158.32	–25.3	R	R
19R-2, 102	160.62	–45.0	R	R
19R-3, 85	161.95	–38.6	R	R
19R-4, 40	163.00	–51.8	R	R
20R-1, 19	163.09	–49.3	R	R
20R-2, 79	165.19	–71.0	R	ND
21R-1, 126	169.16	?	?	R
21R-2, 10	169.50	?	?	R
21R-3, 73	171.63	–22.0	R	R
21R-4, 75	173.15	–35.6	R	R
21R-5, 34	174.24	–33.6	R	R
22R-1, 29	177.79	–45.7	R	R
22R-2, 1	179.01	–23.0	R	R
22R-3, 13	180.63	–24.3	R	R
152-916A-				
13R-1, 78	79.38	75.8	N	N
13R-2, 23	80.33	80.5	N	N
13R-2, 55	80.65	79.4	N	N
152-917A-				
4R-1, 103	29.73	?	?	R
4R-2, 91	31.11	–18.6	R	R

Notes: Inc = characteristic remanent magnetization inclination. In Inc column, ? = no characteristic direction. Lab/Ship = polarity of equivalent levels from discrete samples analyzed onshore and shipboard whole-core determinations; N = normal, R = reverse, ? = indeterminate, and ND = no data.

SITE 916

Normal polarity data from sediments assumed from seismic stratigraphy to be of Eocene–Oligocene age were obtained from Cores 152-916A-13R and 14R, immediately above basement (Table 1). Unfortunately, shore-based biostratigraphic studies (Wei, this volume) have not yielded any fossil markers from this interval. Thus, it is not possible to correlate the magnetostratigraphy with the GPTS.

SITE 917

A single hole (917A) was drilled at this site through a 41.9-m-thick, post-SDRS sedimentary cover. In the sediments, magnetic polarity data were obtained only from Core 152-917A-4R (reversely magnetized). Subsequent shore-based studies yielded a CP14a (middle Eocene) nannoplankton date for this core (Wei, this volume). Shore-based paleomagnetic studies were performed on two specimens (Table 1). Sample 152-917A-4R-1, 103 cm, yielded an indeterminate polarity. Sample 152-917A-4R-2, 91 cm, confirms the presence of a reverse polarity magnetization in this core. Linkage to Chron C21r is the only feasible correlation for this magnetozone.

SITE 918

At Site 918, 120 specimens were analyzed from the ~690-m-thick, Eocene–Miocene sequence drilled in Hole 918D. On the whole, there is good agreement between ship and shore-based polarity determinations, except at levels within Cores 152-918D-42R and

Table 2. Summary of discrete specimen paleomagnetic data from Hole 918D.

Core, section, interval (cm)	Depth (mbsf)	Inc	Polarity		Core, section, interval (cm)	Depth (mbsf)	Inc	Polarity	
			Lab	Ship				Lab	Ship
152-918D-									
24R-1, 35	503.54	54.2	N	N	42R-3, 105	680.84	24.6	R	N
24R-2, 27	504.96	−62.7	R	R	42R-3, 144	681.23	−38.4	R	?
24R-3, 21	506.21	−50.8	R	R	42R-4, 52	681.82	−47.0	R	R
25R-1, 81	513.60	−66.6	R	R	42R-4, 131	682.60	−53.6	R	R
25R-2, 24	514.03	−46.7	R	R	42R-5, 113	683.92	−64.1	R	R
25R-3, 14	514.50	−67.0	R	R	44R-1, 47	697.56	62.3	N	N
25R-5, 19	517.12	64.8	N	N	44R-3, 143	700.52	62.9	N	N
27R-1, 30	532.39	−63.8	R	R	44R-4, 52	701.12	75.2	N	N
27R-2, 17	533.76	−63.6	R	R	44R-5, 4	702.50	55.0	N	N
27R-3, 30	535.39	−62.8	R	R	47R-2, 55	725.74	−30.7	R	R
28R-1, 48	542.27	−63.7	R	R	47R-2, 86	726.05	−70.9	R	N
28R-2, 81	544.10	70.4	N	N	51R-1, 83	764.02	−36.7	R	N
28R-3, 37	545.16	70.3	N	N	51R-2, 128	765.97	−42.1	R	R
2BR-4, 35	546.64	67.4	N	N	51R-4, 25	767.95	72.5	N	N
29R-1, 58	551.97	72.9	N	N	51R-5, 145	770.64	53.4	N	N
29R-2, 36	553.25	67.0	N	N	52R-1, 122	774.11	53.4	N	N
29R-CC, 13	554.16	−71.7	R	ND	52R-3, 58	776.47	60.9	N	N
31R-1, 86	571.55	−57.1	R	R	52R-4, 32	777.71	65.2	N	N
32R-1, 98	581.27	71.6	N	N	52R–5, 80	779.70	−53.5	R	R
33R-CC, 10	591.49	72.4	N	ND	53R-1, 35	782.84	70.0	N	N
34R-1, 20	599.79	−52.0	R	R	53R-1, 62	783.11	68.4	N	N
34R-1, 106	600.65	57.8	R	N	53R-1, 116	783.65	76.8	N	N
34R-2, 5	601.14	−52.1	R	R	53R-2, 22	784.21	−31.8	R	R
35R-1, 18	609.38	3.3	?	?	53R-2, 134	785.33	55.0	N	N
36R-1, 114	620.03	60.4	N	N	53R-3, 19	785.68	−43.9	R	R
36R-CC, 3	622.83	−66.0	R	R	53R-3, 8	785.87	−42.4	R	R
37R-1, 132	629.91	−55.6	R	R	53R-3, 10	786.45	−61.4	R	R
37R-2, 79	630.88	−50.9	R	R	53R-5, 16	789.48	−48.4	R	R
37R-2, 121	631.30	80.2	N	R	53R-6, 41	790.92	−49.1	R	R
37R-3, 8	631.67	−43.5	R	R	55R-1, 35	802.14	67.5	N	N
37R-3, 54	632.13	74.6	N	N	55R-3, 38	805.17	76.4	N	N
37R-4, 23	633.32	62.2	N	N	55R-5, 16	807.67	65.8	N	R
38R-2, 127	640.97	54.1	N	N	55R-6, 41	809.42	67.2	R	R
38R-4, 74	643.43	80.7	N	N	57R-1, 112	822.11	−55.1	R	R
38R-6, 19	645.88	68.9	N	N	57R-2, 134	823.83	?	R	R
39R-1, 27	648.16	?	?	N	57R-3, 144	825.43	−26.3	R	R
39R-1, 52	648.41	84.0	N	N	57R-4, 36	825.85	69.1	N	N
39R-1, 96	648.86	?	?	N	62R-1, 7	869.37	?	?	?
39R-1, 137	649.26	62.9	N	N	62R-2, 30	871.11	68.5	N	N
39R-2, 18	649.57	−44.6	R	R	63R-1, 87	879.76	−19.4	R	N
39R-2, 123	650.62	−61.6	R	R	63R-2, 32	880.71	−53.4	R	R
39R-3, 11	651.00	70.1	N	N	74R-1, 24	982.93	69.1	N	N
39R-3, 21	651.10	?	?	N	75R-1, 39	992.68	−43.7	R	N
39R-3, 114	652.03	?	?	?	75R-2, 52	994.31	58.9	N	N
39R-5, 14	654.03	−61.2	R	R	75R-3, 71	996.00	47.3	N	N
39R-6, 64	656.03	−62.7	R	R	75R-4, 26	996.55	48.7	N	N
40R-1, 46	657.95	−52.5	R	R	76R-1, 51	1002.50	−36.7	R	N
40R-2, 128	660.27	52.1	R	R	77R-1, 20	1011.79	4.2	?	N
40R-4, 91	662.80	56.7	N	N	78R-1, 21	1021.40	65.0	N	N
40R-6, 11	664.60	65.1	N	N	79R-1, 9	1030.98	77.1	N	N
41R-1, 92	668.11	−45.1	N	N	80R-1, 27	1040.86	38.5	R	N
41R-3, 146	671.65	64.4	N	N	89R-1, 15	1127.54	46.9	N	N
41R-5, 127	674.47	59.8	N	ND	89R-4, 31	1131.70	59.1	R	R
41R-CC, 24	674.94	73.7	N	N	90R-3, 82	1139.75	−67.0	N	N
42R-1, 72	677.51	73.9	N	N	93R-1, 24	1165.99	44.7	N	N
42R-2, 12	678.41	−25.3	R	N	93R-1, 135	1167.14	69.0	N	N
42R-2, 74	679.04	29.0	N	N	95R-1, 18	1180.57	−63.9	R	N
42R-2, 141	679.70	44.0	R	R	95R-2, 20	1181.00	−72.8	R	N
42R-3, 39	680.18	−35.9	R	?	95R-3, 74	1183.03	39.3	N	R
42R-3, 70	680.49	43.0	R	?	96R-1, 33	1185.42	−25.8	R	R

Notes: Inc = characteristic remanent magnetization inclination. In Inc column, ? = no characteristic direction. Lab/Ship = polarity of equivalent levels from discrete samples analyzed onshore and shipboard whole-core determinations; N = normal, R = reverse, ? = indeterminate, and ND = no data.

95R. (Table 2). Although core recovery averaged ~35%, two major intervals (703–763 meters below seafloor [mbsf] and 825–1127 mbsf) had almost negligible recovery, making correlation between magnetozones and the GPTS difficult (Fig. 2).

Nannoplankton studies have been conducted on more than 170 Eocene–Miocene specimens (Wei, this volume). Additionally, 25 samples from the Eocene succession have been examined for palynomorphs (Jolley, this volume).

The most reliable magnetobiostratigraphic information comes from the lower part of the sequence, between about 1118 and 1189 mbsf, where the biostratigraphic data permit reasonably sound correlations. The proposed correlations are: end C24r at 1185 mbsf, C24n.3n at 1185–1180 mbsf, C24n.1n at 1168–1166 mbsf, C23n at 1158–1156 mbsf, C22n–C20n at 1148–1127 mbsf, and C19n at 1119–1118 mbsf. Other possible correlations higher in the sequence are: Chrons C6n at 807–802 mbsf, C5Dr–5Cn at 792–766 mbsf, C5AC/5AD or C5AC–AD at 703–696 mbsf, C5r at 658–651 mbsf, and C3r at 516–505 mbsf.

Basement at Site 918 almost certainly formed during Chron C24r (Larsen and Saunders, this volume). Therefore, there is only a minimal time lag between SDRS formation and subsidence to a depth at which marine sedimentation commenced (Chron C24r).

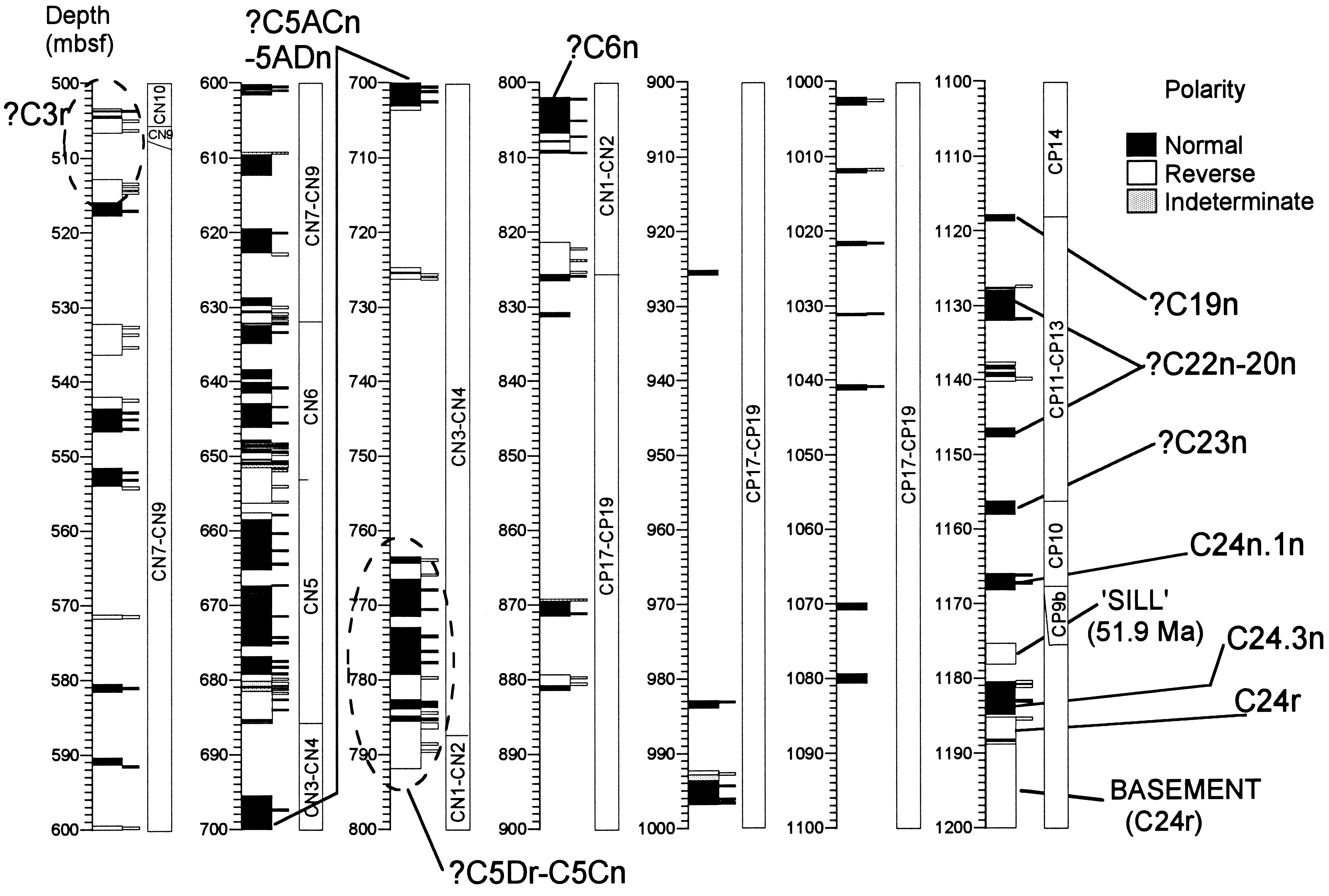

Figure 2. Magnetostratigraphy of Hole 918D, western Irminger Basin. Polarity bars adjacent to the depth scale represent shipboard whole-core determinations. Thin bars to the right of these represent the polarities of discrete specimens. Nannofossil biostratigraphy (CP9b–CN10) based on Wei (this volume). Palynology based on Jolley (this volume). Although all the correlated magnetozones have queries associated with them, those spanning Chrons C24r through C19n are considered reliable.

SITE 919

No Eocene–Miocene sediments were drilled at Site 919.

SUMMARY AND CONCLUSIONS

Sites 914, 916, 917, and 918, drilled on the southeast Greenland Margin and in the western Irminger Basin, recovered Eocene–Miocene sediments suitable for magnetostratigraphic studies. Whole-core and discrete specimen data have been integrated with biostratigraphic data, and attempts have been made to link the records to the GPTS. Incomplete recovery and limited biostratigraphic information at a number of levels have made this task difficult. Probably the most useful information is provided by Hole 918D, where the magnetobiostratigraphic record from sediments immediately above basement record the early history of the western Irminger Basin (early to middle Eocene). Sedimentation at Site 918, central in the SDRS, commenced very shortly after SDRS formation at ~54–53.5 Ma. Sedimentation across the landward edge of the SDRS at the southeast Greenland ocean/continent transition appears to have started much later (13 m.y. for Site 915 and 4 m.y. for Site 917). This prolonged sedimentation time lag between Sites 917 and 915, only ~3 km apart, probably reflects the complexities of the local basement structure induced during rupture at the ocean/continent transition.

Magnetobiostratigraphic correlations for the younger part of the sequence in Hole 918D place some constraints on Arctic–North Atlantic overflow (11–12 Ma) and southeast Greenland glaciation (at least pre Chron C3r, 5.89 Ma). Unfortunately, our objective of linking more closely North Atlantic faunal and magnetic polarity records has been unsuccessful because of the poor recovery in the lower part of Hole 918D.

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Prior Chapter Contents Next Chapter