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21. Paleomagnetism of Early Cretaceous (Berriasian) Sedimentary Rocks, Hole 1213B, Shatsky Rise[1]

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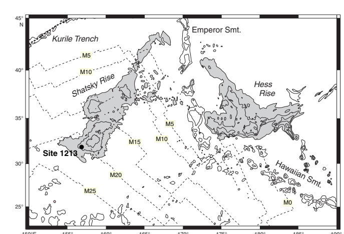
ABSTRACT

Coring in Hole 1213B on the south flank of Shatsky Rise recovered sedimentary rocks (chalk and claystone) of earliest Cretaceous (Berriasian) age. Because few samples of this age are available for the Pacific plate, this recovery provides an opportunity to use paleomagnetism to determine a value for the paleolatitude of the site and of the Pacific plate for Berriasian time. A total of 22 vertically oriented samples were measured, yielding consistent alternating-field demagnetization results and low paleoinclination values consistent with magnetization near the equator. Samples can be grouped by inclination sign to produce a magnetic stratigraphy. If negative inclinations are assumed to represent reversed polarity (i.e., the site was magnetized north of the equator), the result is consistent with the Berriasian reversal timescale, which contains more reversed polarity (Chrons M16r–M18r) than normal polarity. Likewise, the assumption of a Northern Hemisphere magnetization produces a paleoinclination (9.1° + 13.6°/–14.2°; N = 17) and paleolatitude (4.6° + 7.2°/–6.9°) that is consistent with independent Pacific paleomagnetic data of Late Jurassic and Early Cretaceous age. This paleolatitude implies that the Pacific Apparent Polar Wander Path trends southward from this time until the mid-Cretaceous.

INTRODUCTION

Coring in Hole 1213B (31°34.6402′N, 157°17.8605′E) (Fig. F1), on the south flank of southern Shatsky Rise, penetrated 447.8 m of sediment

F1. Site 1213 location, p. 9.



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and sedimentary rock before striking basaltic sills presumed to be the top of the volcanic edifice. Much of the sedimentary section was deposited during Early Cretaceous time, and the oldest sediments, from the base of Subunit IIID and IIIE, are Berriasian in age (Shipboard Scientific Party, 2002a; **Bown**, this volume). Although recovery in the Early Cretaceous section was low because of ubiquitous chert and porcellanite, a number of large oriented sedimentary rock pieces were recovered from the lower reaches of the sedimentary section. The samples include moderately to highly bioturbated nannofossil chalk, clayey nannofossil chalk, and claystone with nannofossils (Shipboard Scientific Party, 2002b). Despite more than three decades of Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP) coring in the Pacific, samples of such antiquity are rare and therefore provide an important opportunity for paleomagnetic measurements to determine the paleolatitude of southern Shatsky Rise and the Pacific plate during the earliest Cretaceous.

Few paleomagnetic data from Early Cretaceous and Jurassic age exist from the Pacific plate, and as a consequence there is uncertainty about pole locations of that age. Many investigators accept the idea that Early to mid-Cretaceous paleomagnetic poles are located in the North Atlantic at ~60°N, 340°E and that the Apparent Polar Wander Path trends first northeast and then north from that location with decreasing age (e.g., Sager and Pringle, 1988; Petronotis and Gordon, 1999; Sager and Koppers, 2000), reflecting northward motion of the Pacific plate. Based on Jurassic basalt samples from only a few lava flows cored at DSDP Site 307, Cox and Gordon (1984) argued that the Jurassic pole position is significantly north of Early Cretaceous poles, indicating southward polar motion and southward drift of the Pacific plate during Jurassic time. Sedimentary rock paleomagnetic measurements from Site 801, located ~15° south of Site 1213, show paleolatitude trends consistent with this reversal in drift (Steiner and Wallick, 1992; Larson et al., 1992). Similarly, paleomagnetic poles calculated from magnetic lineation skewness show southward polar motion from Jurassic to mid-Cretaceous time despite an uncertainty in longitude that results from anomalous skewness assumptions (Larson and Sager, 1992). Together, these data sets imply that the polar path reversal, from southward to northward drift, happened during mid-Cretaceous time.

Because Early Cretaceous and older locations of the Pacific paleomagnetic pole are uncertain, we made paleomagnetic measurements of Berriasian-age chalk and claystone samples from Hole 1213B. Based on published paleomagnetic data, our working hypothesis was that these samples should yield a low paleolatitude because of the ~20°–30° northward drift of the Pacific plate since Cretaceous time. If interpretations of southward polar motion during the Early Cretaceous are correct, the Site 1213 sediments should have acquired a magnetization ~10° north of the equator.

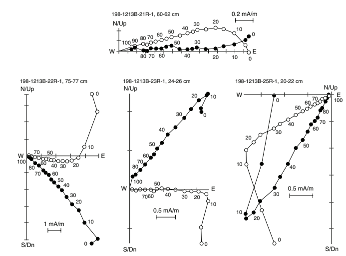
METHODS

Paleomagnetic samples from the lower sedimentary section of Hole 1213B were drilled from virtually every cylindrical sedimentary rock core piece large enough to have apparently remained oriented vertically during coring and recovery. This resulted in 22 samples from Cores 198-1213B-19R to 25R covering depths from 363 to 420 meters below seafloor (mbsf) (Table **T1**) and representing the lower part of Subunit IIID

T1. Sediment paleomagnetic data, p. 14.

and most of Subunit IIIE. The samples were taken as 2.5-cm (1 in) diameter minicores drilled perpendicular to the split face of the core.

Samples were measured with a 2G model 755 direct-current superconducting quantum interference device cryogenic magnetometer in a shielded room at the University of Florida paleomagnetic laboratory. After measuring the natural remanent magnetization (NRM), all samples were treated using alternating-field (AF) demagnetization using a D-Tech D2000 AF demagnetizer to remove overprints and isolate a characteristic remanent magnetization direction. The alternating field was increased in 5-mT steps up to 60–80 mT and continued with 10-mT steps to 100 mT. As a result, most samples were measured at 16–20 different demagnetization steps. Because the results from AF demagnetization appeared remarkably consistent (Fig. F2), we did not use thermal demagnetization.



F2. Sample orthogonal vector plots, p. 10.

Characteristic remanent magnetization directions were calculated using principal component analysis (PCA) (Kirschvink, 1980) with the best-line fit anchored at the origin. The observation that most samples show linear decay toward the origin indicates that the anchored origin assumption should not bias the calculated magnetization vector. Because overprints were not often large and the samples gave consistent demagnetization results, it was possible to use >10 demagnetization steps in almost all mean magnetization calculations (Table T1).

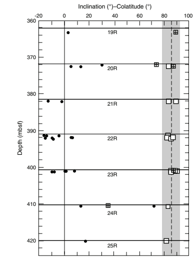
We used the methods of Cox and Gordon (1984) to determine a mean paleoinclination, error estimates, and corrections for bias resulting from averaging inclination-only data. This technique gives similar results to other routines developed for the same purpose but includes in the error estimates the contributions from paleosecular variation and possible systematic error owing to borehole tilt. Adding these contributions to the error budget does not change the mean paleoinclination but increases the error-bound estimates slightly. Because the samples cover a large span of time (much of the Berriasian stage) each was treated as an independent measurement of the field direction. Following Cox and Gordon (1984), we assumed a systematic error of 2° to represent possible off-vertical tilt of the borehole. Even though measurements of tilt were not made in Hole 1213B, this is likely to be a conservatively large estimate given measurements in other holes (Cox and Gordon, 1984).

RESULTS

Early Cretaceous sediment samples from Hole 1213B have NRM magnetizations ranging over two orders of magnitude, from 1.9×10^{-6} to 2.2×10^{-4} A/m (Table T1). AF demagnetization results were generally highly consistent, with most samples displaying linear univectorial decay of magnetization toward the origin of orthogonal vector plots (Fig. F2). A notable character of these samples is that their NRMs are not overwhelmed by an upward- or downward-directed overprint, thought to result from exposure to high drill string magnetic fields, as are many ODP samples (Acton et al., 2002). Although such an overprint is indeed present in many samples, as shown by orthogonal vector plots (Fig. F2), in many samples the overprint is small in magnitude. In most samples, this overprint is removed by AF demagnetization to ~20 mT. At higher demagnetization steps, directions are consistent, usually in AF fields as high as 70–100 mT. As a result, most samples have a well-determined characteristic remanence vector calculated from >10 steps and characterized by a small maximum angle of deflection (MAD; a measurement of intrastep scatter [Kirschvink, 1980]). Only one sample has a MAD >10° and 17 have a MAD <5° (Table T1). Median destructive field values (MDF; a measure of bulk sample coercivity) values range from 8 to 49 mT (Table T1), with an average of 26 mT. Many MDF values are relatively low, as would be expected from samples containing magnetite (e.g., McElhinny, 1973).

Most sample characteristic remanence inclinations are either low positive or negative values (Fig. F3; Table T1) consistent with magnetization near the equator. Only two samples have inclinations with magnitudes >17°. The other samples have an average inclination absolute value of 8.7° with a standard deviation of 5.0°. Inclination polarity is consistent, with adjacent samples usually having the same sign and a small number of changes in sign, implying the samples faithfully record intervals of opposite magnetic polarities (Table T1). For the purpose of averaging inclinations, we used only the most reliable samples, those with MAD <7° and with magnetization directions determined from $N \geq 10$ demagnetization measurements (Table T1). This step eliminated two samples with large inclination values that appear to be outliers of the population. By averaging and correcting for bias inherent in using inclination-only data (Cox and Gordon, 1984), a mean paleoinclination of 9.1° + 13.6°/–14.2° (confidence interval [CI] = 95%) was calculated from $N = 17$ samples using the absolute value of the inclination. If we assume the magnetization was acquired north of the equator, this value implies a paleolatitude of 4.6° + 7.2°/–6.9° (CI = 95%).

F3. Sample inclination and colatitudes, p. 11.

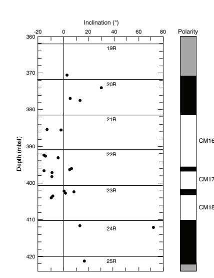


DISCUSSION

Because of the low paleolatitude of Hole 1213B samples, polarity interpretation is not straightforward. To determine whether positive or negative inclination values represent normal polarity, one needs to know in which hemisphere, north or south, the samples acquired their magnetization. Furthermore, because the mean inclination is about half that of typical changes in inclination arising from secular variation (e.g., McElhinny, 1973), differences in inclination sign can occur as a result of secular variation as well as polarity reversals. We can, however, construct a plausible and consistent scenario using constraints from stratigraphic and independent paleomagnetic data to place Hole 1213B in the Northern Hemisphere during Berriasian time.

The simplest polarity interpretation (Fig. F4) shows a long reversed section interrupted by two short normal polarity zones and bracketed on top and bottom by normal polarity zones. This interpretation assumes that the cores were magnetized in the Northern Hemisphere (i.e., positive inclinations denote normal polarity) and that all zones of positive inclination represent periods of normal polarity. Some reversals could result from secular variation, but without additional orientation information (e.g., paleodeclination) we cannot be certain which zones represent true reversals. We think it unlikely for the sediments to record extreme inclination values because secular variation is often partly averaged within single samples, lessening the overall variation. It is also possible to have short apparent reversals caused by accidental sample inversion, but this seems unlikely because all of the polarity zones are delineated by two or more samples. If our assumption of Northern Hemisphere magnetization is incorrect, the polarity signature would be opposite (i.e., normal would be reversed and vice versa).

F4. Sample magnetic polarity interpretation, p. 12.



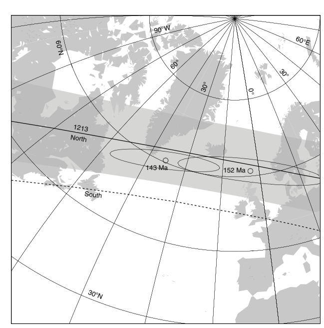
Correlation of the polarity record with established timescales is complicated by low recovery, which limits the reliability of the biostratigraphy and distorts the appearance of polarity chronozones in the paleomagnetic record. Nevertheless, biostratigraphic constraints on the sampled cores appear sufficiently tight to limit the interpretation to only a few polarity chrons. According to **Bown** (this volume), Hole 1213B sampled a relatively continuous Berriasian section. He places Cores 198-1213B-16R through 26R, corresponding to the entire section analyzed, within nannofossil Subzone NK2A. In the Bralower et al. (1995) timescale, this zone is narrow and contains only Chron M16. Other important time marker nannofossils found in the cores are *Percivalia fenestrata* near the top of Core 198-1213B-18R and *Lithraphidites carniolensis* in Core 198-1213B-27R (**Bown**, this volume). The former is a marker for Subzone NK2B, which includes Chron M15 (Bralower et al., 1995), and the latter corresponds to Chrons M19–M20 (Channell et al., 1995).

If we take Bown's assignment of the entire measured section to Subzone NK2A, all of the reversed intervals may represent Chron M16. In that case, we must assume that the normal samples that interrupt the reversed section are either inverted samples (seemingly unlikely) or that the normal inclinations represent periods when secular variation or excursions caused the geomagnetic field inclination to change sign. If that was true, the mean paleoinclination would have been better determined without reversing the sign of these samples. If the inclination values of the short normal sections within the reversed zone are not inverted, the mean paleoinclination is decreased slightly to 6.5° ± 22.3° (CI = 95%).

Alternatively, if we assume that the measured section spanned much of the Berriasian, as could be inferred from the occurrence of *P. fenestrata* above the section and *L. carniolensis* below, the three observed reversed sections likely correspond to three of four reversed polarity chrons (Chrons M15–M18) within this stage. We prefer this interpretation because it accounts for both normal and reversed polarity sections, as observed, without resorting to special circumstances (i.e., extremely rapid sedimentation plus anomalous paleoinclinations). The uppermost reversed polarity chron is interpreted as Chron M16 because Chron M15 should correspond to the occurrence of *P. fenestrata*, which is first found above the measured section. The two reversed polarity zones below (Fig. **F4**) may be Chrons M17 and M18. This interpretation is also consistent with the finding of *L. carniolensis*, which is correlated with Chron M19, in cores directly below the measured section. With that said, we note that our polarity chron identification is highly dependent on the uncertain biostratigraphic results (**Bown**, this volume), especially because the low recovery does not produce a reliable record of polarity chron spacing and duration. If there has been a misinterpretation of the fossil record, it means the same for the polarity record. Our findings are consistent with the biostratigraphy but are not unique or robust.

The Northern Hemisphere interpretation is also most consistent with existing Pacific paleomagnetic data of similar age. The 4.6°N paleolatitude implies ~27° of northward movement of Hole 1213B since Berriasian time. This paleolatitude predicts pole positions consistent with 143- and 152-Ma paleomagnetic poles calculated from magnetic lineation skewness (Fig. **F5**). Alternatively, if a Southern Hemisphere formation is assumed, the northward drift is 36°, which is on the high end of

F5. Colatitude arcs, p. 13.



estimates of drift and consistent with younger Cretaceous poles (Fig. F5).

The absolute age of the Hole 1213B paleomagnetic samples is slightly uncertain because one timescale (Bralower et al., 1995) gives the ages of Chrons M16–M18 as 143–146 Ma, whereas another (Channell et al., 1995) lists the same chrons as 138–141 Ma. The difference comes about from different calibrations of the polarity chrons, and resolution of this discrepancy is beyond the scope of this article. It is sufficient to note that the absolute age of the section is ~140 Ma, implying that comparison with the 143-Ma skewness pole (Larson and Sager, 1992) is appropriate.

A potential problem with using sedimentary paleomagnetic data to determine paleolatitude is systematic error resulting from compaction (i.e., inclination shallowing) (e.g., Anson and Kodama, 1987). In particular, two studies of DSDP sediment core data from the Pacific plate concluded that such data are highly biased (Tarduno, 1990; Gordon, 1990); however, these conclusions may be biased themselves by comparison of sedimentary data to independent paleomagnetic data that are suspect. A number of studies have found that the inclination shallowing is a fraction of the tangent of the applied field (King, 1955; Tauxe and Kent, 1984). As a result, the bias is maximum at inclinations near 45° and negligible near the equator and poles. Because Hole 1213B sediments were magnetized near the equator, inclination shallowing should be minimal. Indeed, the good agreement of the Hole 1213B paleolatitude with independent paleomagnetic data (Fig. F5) suggests the same.

CONCLUSIONS

A total of 22 sedimentary rock core samples from the Berriasian section of Hole 1213B were measured to determine paleoinclination and paleolatitude. Most samples yielded consistent demagnetization results and low inclination values. The occurrence of both positive and negative inclinations implies polarity reversals, especially because the signs are consistent in adjacent samples and imply a small number of reversals consistent with expected Berriasian polarity chronozones. For consistency with independent paleolatitude data and with the expected Berriasian reversal sequence, negative inclinations were assumed to represent reversed polarity. The observed Hole 1213B polarity sequence appears to correlate with Chrons M16, M17, and M18. The mean normal polarity paleoinclination for the site, corrected for bias caused by averaging inclination-only data, is 9.1° + 13.6°/–14.2°, which implies a paleolatitude of 4.6° + 7.2°/–6.9°. This paleolatitude is consistent with independent Pacific paleomagnetic data of Late Jurassic–Early Cretaceous age and the hypothesis that Early Cretaceous paleopoles were located at a higher latitude than mid-Cretaceous poles.

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REFERENCES

Acton, G.D., Okada, M., Clement, B.M., Lund, S.P., and Williams, T., 2002. Paleomagnetic overprints in ocean sediment cores and their relationship to shear deformation caused by piston coring. *J. Geophys. Res.,* 107. doi:10.1029/2001JB000518

Anson, G.L., and Kodama, K.P., 1987. Compaction-induced shallowing of the post-depositional remanent magnetization in a synthetic sediment. *Geophys. J. R. Astron. Soc.,* 88:673–692.

Bralower, T.J., Leckie, R.M., Sliter, W.V., and Thierstein, H.R., 1995. An integrated Cretaceous microfossil biostratigraphy. *In* Berggren, W.A., Kent, D.V., Aubry, M.-P., and Hardenbol, J. (Eds.), *Geochronology, Time Scales, and Global Stratigraphic Correlation.* Spec. Publ.—SEPM (Soc. Sediment. Geol.), 54:65–79.

Channell, J.E.T., Erba, E., Nakanishi, M., and Tamaki, K., 1995. Late Jurassic–Early Cretaceous time scales and oceanic magnetic anomaly block models. *In* Berggren, W.A., Kent, D.V., Aubry, M.-P., and Hardenbol, J. (Eds.), *Geochronology, Time Scales, and Global Stratigraphic Correlation.* Spec. Publ.—SEPM (Soc. Sediment. Geol.), 54:51–63.

Cox, A., and Gordon, R.G., 1984. Paleolatitudes determined from paleomagnetic data from vertical cores. *Rev. Geophys. Space Phys.,* 22:47–72.

Gordon, R.G., 1990. Test for bias in paleomagnetically determined paleolatitudes from Pacific plate Deep Sea Drilling Project sediments. *J. Geophys. Res.,* 95:8397–8404.

King, R.F., 1955. The remanent magnetism of artificially deposited sediments. *Mon. Not. R. Astron. Soc., Geophys. Suppl.,* 7:115–134.

Kirschvink, J.L., 1980. The least-squares line and plane and the analysis of palaeomagnetic data. *Geophys. J. R. Astron. Soc.,* 62(3):699–718.

Larson, R.L., and Sager, W.W., 1992. Skewness of magnetic Anomalies M0 to M29 in the northwestern Pacific. *In* Larson, R.L., Lancelot, Y., et al., *Proc. ODP, Sci. Results,* 129: College Station, TX (Ocean Drilling Program), 471–481.

Larson, R.L., Steiner, M.B., Erba, E., and Lancelot, Y., 1992. Paleolatitudes and tectonic reconstructions of the oldest portion of the Pacific plate: a comparative study. *In* Larson, R.L., Lancelot, Y., et al., *Proc. ODP, Sci. Results,* 129: College Station, TX (Ocean Drilling Program), 615–631.

McElhinny, M.W., 1973. *Palaeomagnetism and Plate Tectonics:* Cambridge (Cambridge Univ. Press).

Petronotis, K.E., and Gordon, R.G., 1999. A Maastrichtian palaeomagnetic pole for the Pacific plate from a skewness analysis of marine magnetic Anomaly 32. *Geophys. J. Int.,* 139:227–247.

Sager, W.W., and Koppers, A.A.P., 2000. Late Cretaceous polar wander of the Pacific plate: evidence of a true polar wander event. *Science,* 287:455–459.

Sager, W.W., and Pringle, M.S., 1988. Mid-Cretaceous to early Tertiary Apparent Polar Wander Path of the Pacific plate. *J. Geophys. Res.,* 93(10):11753–11771.

Shipboard Scientific Party, 2002a. Explanatory notes. *In* Bralower, T.J., Premoli Silva, I., Malone, M.J., et al., *Proc. ODP, Init. Repts.,* 198, 1–63 [CD-ROM]. Available from: Ocean Drilling Program, Texas A&M University, College Station TX 77845-9547, USA.

Shipboard Scientific Party, 2002b. Site 1213. *In* Bralower, T.J., Premoli Silva, I., Malone, M.J., et al., *Proc. ODP, Init. Repts.,* 198, 1–110 [CD-ROM]. Available from: Ocean Drilling Program, Texas A&M University, College Station TX 77845-9547, USA.

Steiner, M.B., and Wallick, B.P., 1992. Jurassic to Paleocene paleolatitudes of the Pacific plate derived from the paleomagnetism of the sedimentary sequences at Sites 800, 801, and 802. *In* Larson, R.L., Lancelot, Y., et al., *Proc. ODP, Sci. Results,* 129: College Station, TX (Ocean Drilling Program), 431–446.

Tarduno, J.A., 1990. Absolute inclination values from deep sea sediments: a reexamination of the Cretaceous Pacific record. *Geophys. Res. Lett.,* 17:101–104.

Tauxe, L., and Kent, D.V., 1984. Properties of a detrital remanence carried by hematite from study of modern river deposits and laboratory redeposition experiments. *Geophys. J. R. Astron. Soc.,* 77:543–561.

Figure F1. Location of ODP Site 1213 on Shatsky Rise and major bathymetric features of the northwest Pacific. Dashed lines denote selected magnetic isochrons labeled by anomaly number. Heavy dashed line shows Kurile Trench Axis.

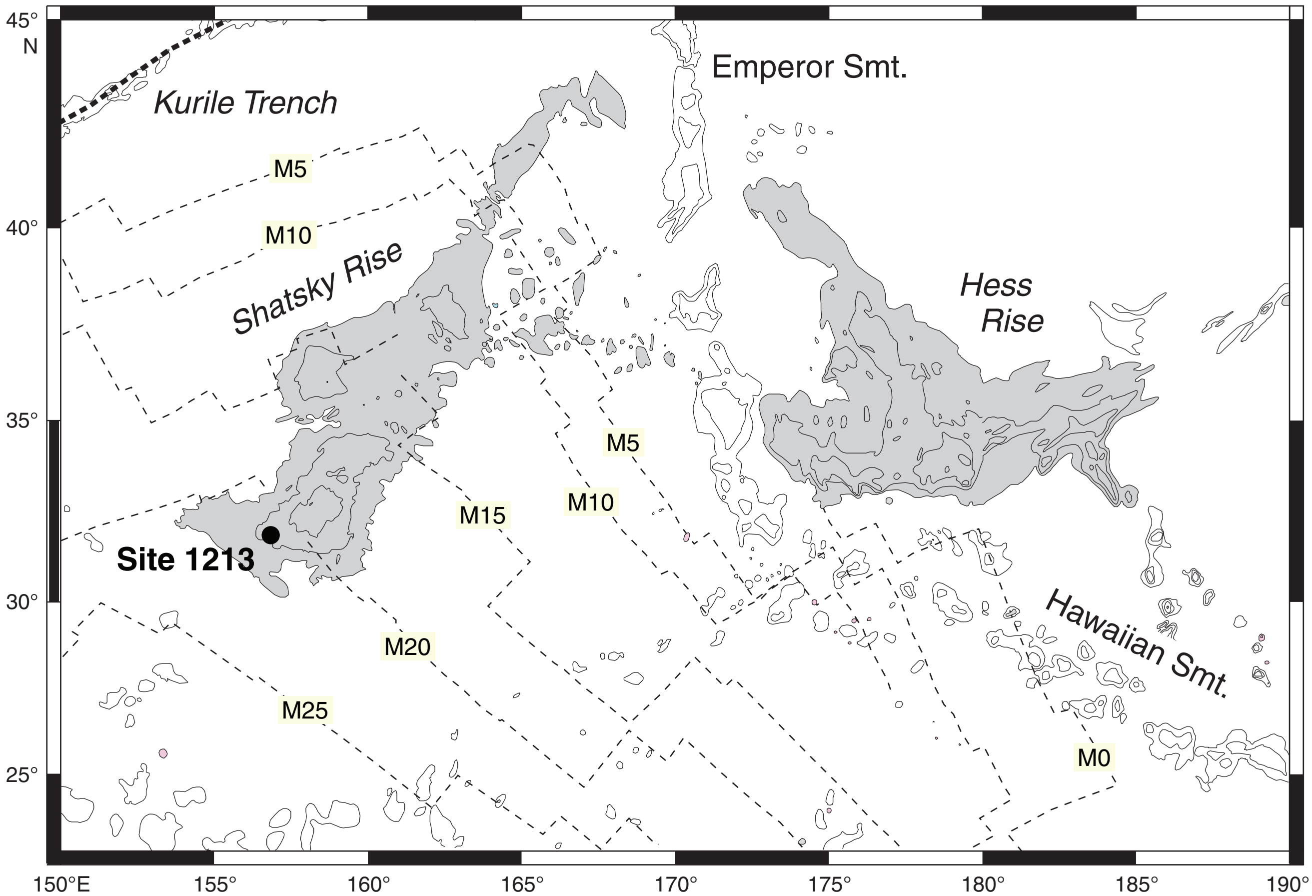

Figure F2. Example orthogonal vector (Zijderfeld) plots of four Early Cretaceous sediment samples from Hole 1213B undergoing alternating-field demagnetization. Each plot shows the projection of the magnetization vector endpoint on two perpendicular planes, one in the horizontal plane (solid symbols) and one vertical (open symbols). In all cases, the vertical plane is oriented east-west in sample coordinates (i.e., across the core and perpendicular to the split face) and the horizontal plane is oriented up and down (i.e., parallel to the split face). Numbers give strength of the demagnetizing field in milliTeslas. Scale bars represent magnetization strength.

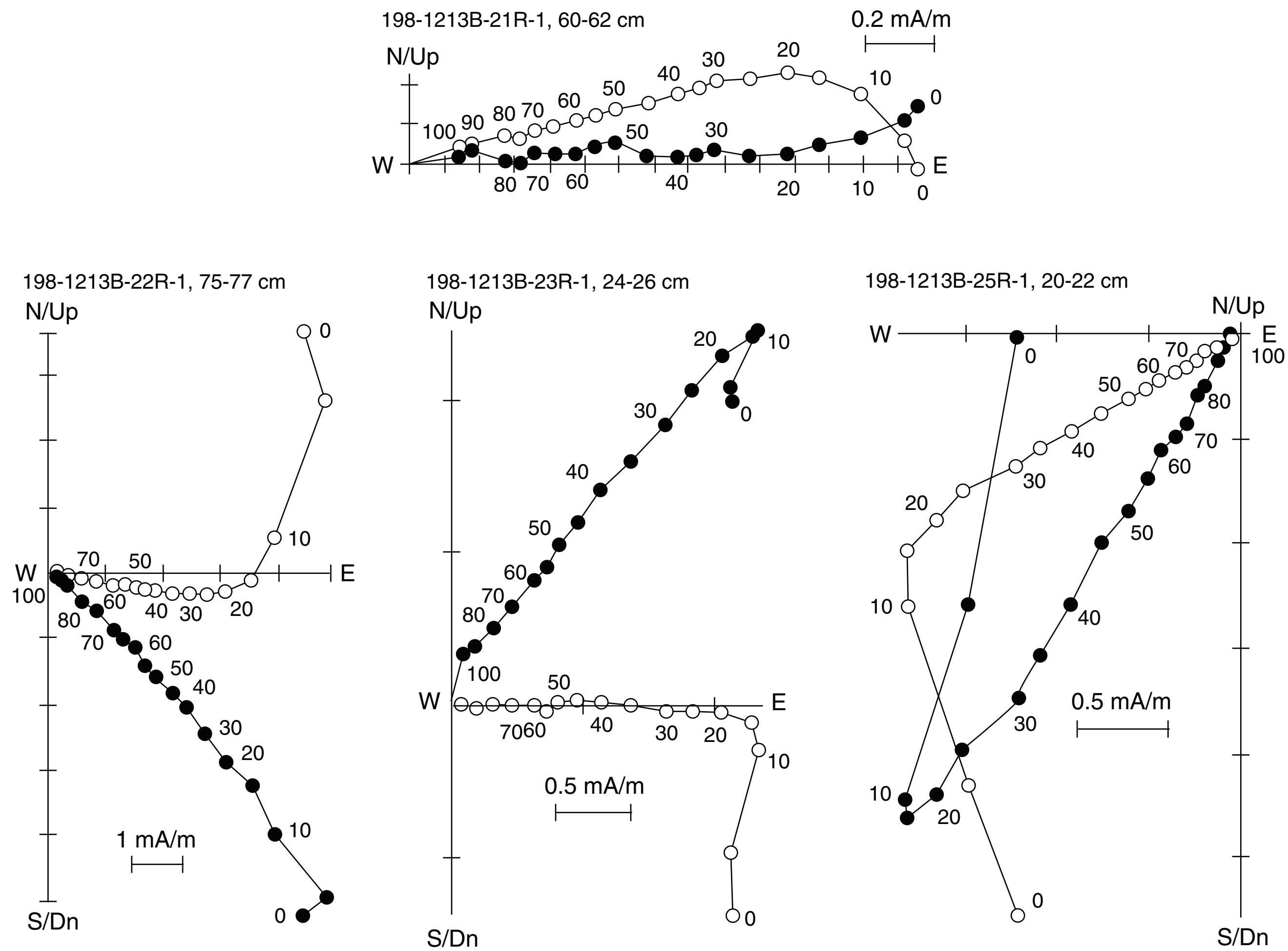

Figure F3. Inclination and colatitude of Hole 1213B sediment samples. Solid circles = inclination values, open squares = colatitudes calculated from inclinations assuming samples were magnetized in the Northern Hemisphere, colatitude symbols with crosses = samples not used in calculation of mean colatitude (dashed line), thin horizontal lines = boundaries between cores.

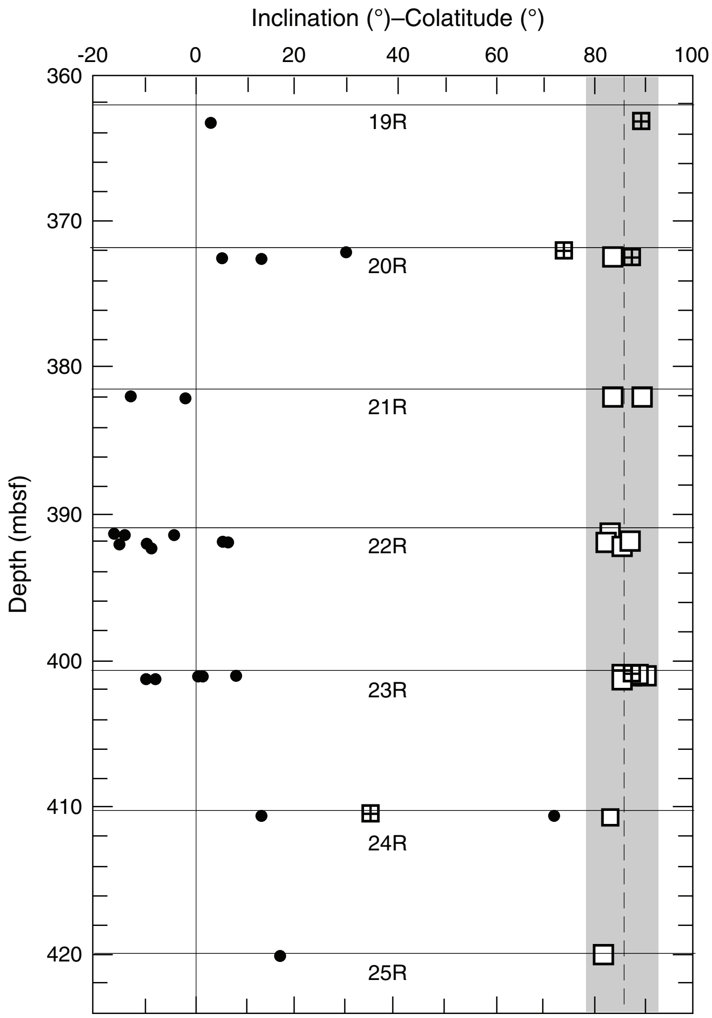

Figure F4. Magnetic polarity interpretation of Hole 1213B Early Cretaceous sediment samples. Solid circles = inclination values for samples (see Fig. F3, p. 11). Subbottom depth has been recalculated to expand recovered core to fill the cored intervals. Polarity interpretation is shown at right. Black = normal polarity, white = reversed polarity, gray = uncertain polarity.

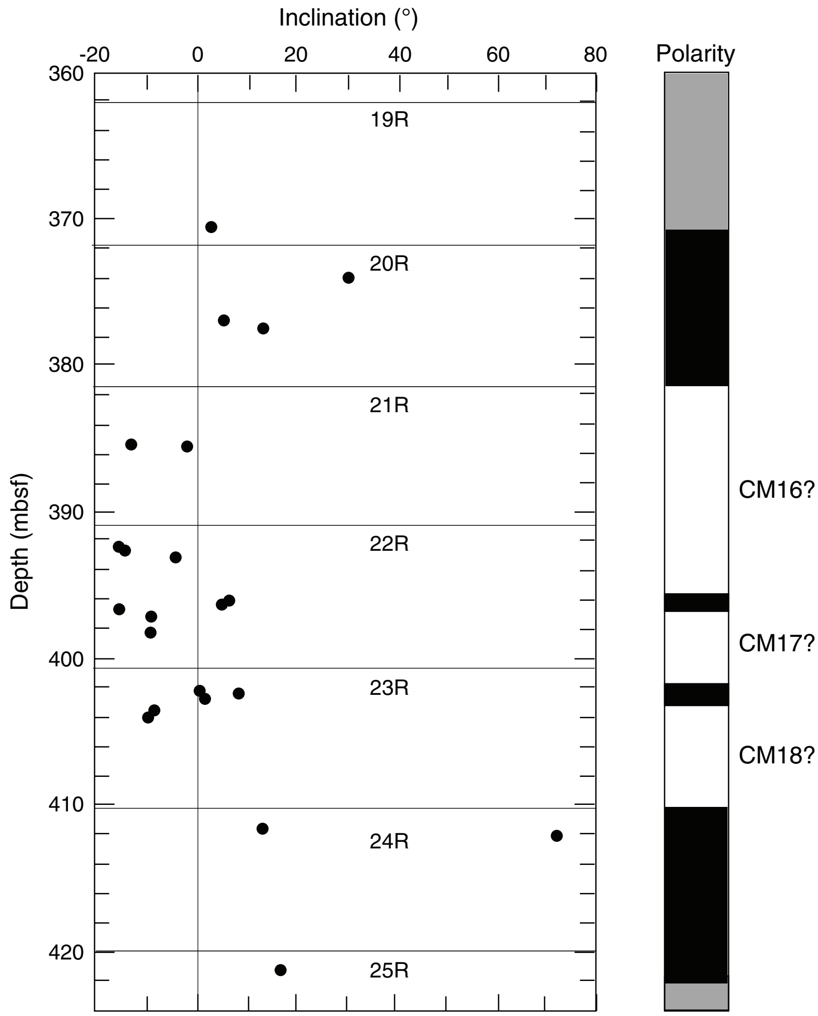

Figure F5. Colatitude arcs determined from Hole 1213B Early Cretaceous sediment sample paleoinclination data. Heavy arc shows locus of paleomagnetic poles inferred from the mean colatitude assuming the magnetization was acquired north of the equator, whereas the dashed line is the same with the magnetization assumed from south of the equator. Gray band shows 95% confidence limits on northern colatitude arc. Open circles are nearly coeval paleomagnetic poles calculated from magnetic lineation skewness (Larson and Sager, 1992) and are surrounded by 95% confidence ellipses and labeled with age in Ma. Northern Hemisphere magnetization of the Hole 1213B sediments is most consistent with these independent paleomagnetic data.

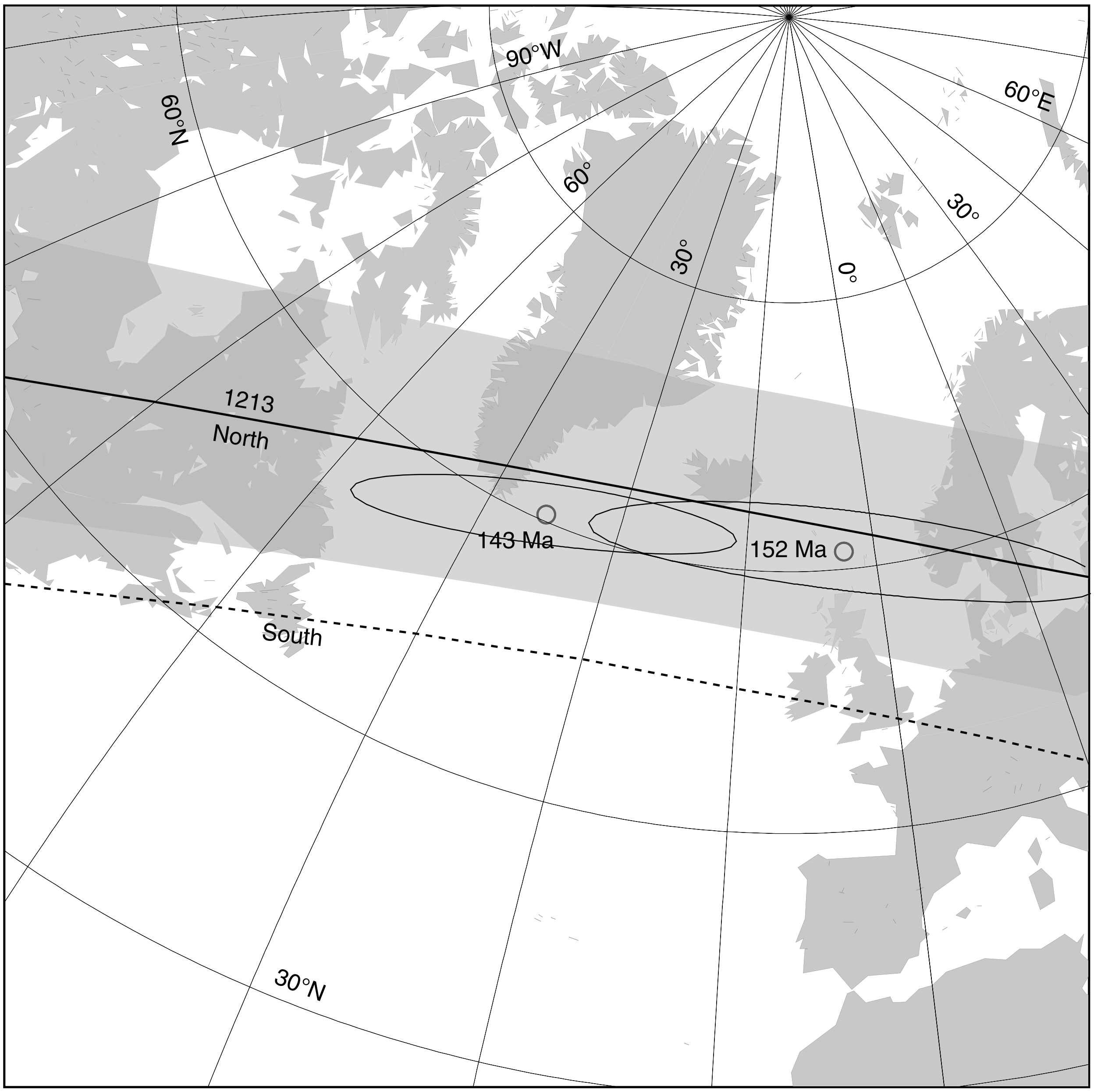

Table T1. Sediment paleomagnetic data.

Core, section, interval (cm)	Depth (mbsf)	Inclination (°)	Polarity	Steps (mT)	*N*	MAD (°)	*J* (10^{-4} A/m)	MDF (mT)
198-1213B-								
19R-1, 107	363.27	3.0*	N	0–15	4	5.5	0.019	8.0
20R-1, 27	372.07	30.4*	N	20–100	17	8.9	0.558	13.2
20R-1, 64	372.44	5.6*	N	95–100	2	3.0	0.033	17.9
20R-1, 72	372.52	13.1	N	20–100	13	2.2	0.080	31.1
21R-1, 60	382.00	–12.7	R	25–100	14	1.5	0.146	43.5
21R-1, 65	382.05	–1.8	R	25–90	13	0.7	0.204	45.0
22R-1, 17	391.27	–15.5	R	25–100	12	2.3	0.364	21.2
22R-1, 22	391.32	–14.1	R	30–100	11	1.5	0.349	25.7
22R-1, 30	391.39	–4.1	R	20–100	17	3.1	1.357	18.9
22R-1, 75	391.85	6.4	N	30–100	11	1.9	0.778	23.5
22R-1, 78	391.88	5.5	N	35–100	10	2.0	1.094	18.2
22R-1, 85	391.95	–15.2	R	30–100	11	2.3	0.554	33.2
22R-1, 90	392.00	–9.2	R	30–100	11	1.7	0.866	25.9
22R-1, 110	392.20	–8.7	R	25–100	14	6.6	2.272	24.9
23R-1, 24	400.94	0.7	N	20–100	13	2.3	0.325	43.4
23R-1, 28	400.98	8.5	N	25–100	14	1.7	0.389	38.5
23R-1, 32	401.02	1.8	N	10–100	19	1.2	0.703	48.8
23R-1, 50	401.20	–8.1	R	35–100	12	4.2	0.563	23.4
23R-1, 56	401.26	–9.6	R	25–100	14	2.8	1.072	14.2
24R-1, 18	410.48	13.4*	N	55–90	7	11.7	0.449	9.9
24R-1, 25	410.55	71.9*	N	25–60	7	6.1	0.358	8.4
25R-1, 20	420.10	16.9	N	20–100	15	1.3	0.303	42.0

Notes: Inclination = inclination of characteristic remanent magnetization direction calculated from principal component analysis, Steps = demagnetization steps used in determination of mean magnetization direction, *N* = number of demagnetization steps used for magnetization calculation, MAD = maximum angle of deviation, *J* = natural remanent magnetization. MDF = median destructive field. * = results not included in averaging inclinations ($N < 10$ or MAD > 7°), N = normal, R = reversed.