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11. *DATA REPORT:* PALEOMAGNETISM OF CARBONATE SEDIMENTS FROM HOLE 1006A, BAHAMAS TRANSECT, LEG 166[1]

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ABSTRACT

Paleomagnetic analyses from discrete samples of carbonate sediment from Hole 1006A were completed to assess the nature of magnetic remanence and to evaluate the use of directional data for a magnetic reversal stratigraphy.

Magnetic remanence in these carbonates was moderate to weak but was stable enough to reliably identify polarity in 26.7% of the samples. The remaining 73.3% samples were judged either too weak or unstable, or else they exhibited a very steep inclination interpreted to be the result of some type of drilling overprint. Thus, magnetic polarity data from Hole 1006A should be used with caution. The nature of magnetic remanence and some reconnaissance acquisition tests suggest that single-domain magnetite (with some possible alteration to maghemite) is the dominant source of the remanent magnetization.

INTRODUCTION

Paleomagnetic measurements were conducted on discrete samples taken from advanced hydraulic piston corer (APC) and extended core barrel cores of Hole 1006A, part of the Bahamas Transect (Leg 166) of the Ocean Drilling Program (ODP). The Bahamas Transect consists of five ODP sites, moving from the basin (Site 1006) to the toe-of-slope (Site 1007) and up the lower slope (Sites 1003, 1004, and 1005) (Shipboard Scientific Party, 1997b). The purpose of the Hole 1006A paleomagnetic samples was to attempt to construct a magnetic reversal stratigraphy for sediments that comprise part of a deep-water current drift deposit. Shipboard measurements during Leg 166 (February–April 1996) were unable to determine a reversal stratigraphy for a number of reasons, including instrumentation problems, a possible radial overprint from the coring process, and the relatively weak nature of the magnetic remanence inherent in these types of sediments (see "Cautionary Note Regarding Cryogenic Magnetometer Data," in Shipboard Scientific Party, 1997a). We hoped that shore-based measurement of the discrete samples would overcome the instrument concerns and the severity of the suspected radial overprint remagnetization. To assess the nature of the magnetic remanence and determine if a reversal stratigraphy could be gleaned from the sediment record, we analyzed 778 discrete samples. The results are presented in this data report.

LABORATORY METHODS AND SAMPLE RANKING

Paleomagnetic Measurement and Analysis

Paleomagnetic measurements were conducted using a 2G Enterprises model 755 rock magnetometer housed in a magnetically shielded room at the Rosenstiel School, University of Miami. All samples were collected on board the *JOIDES Resolution* in standard plastic cubes, ~6 cm^3 in size. After measurement of natural remanent magnetization (NRM), samples were demagnetized at progressively higher alternating fields (AF), usually at 2- to 3-mT steps, depending on the magnitude of intensity reduction. The maximum AF field depended on the intensity of the sample and was concluded either when the sample became magnetically unstable or when it became too weak for consistent, repeatable measurement. Paleomagnetic data were analyzed using a least-squares method (Kirschvink, 1980) to determine sample inclination and declination. Inclination values were used in the unoriented cores to assign a polarity. In some cases where the APC was oriented, both the inclination and the declination values could be used to assess polarity. Twenty-seven of the hydraulic piston cores were oriented during collection using the Tensor orientation tool (see Shipboard Scientific Party, 1997a). A maximum angular deviation (MAD) value was calculated as part of the least-squares technique in order to assess the relative quality of the paleomagnetic orientation data.

Isothermal Remanent Magnetization Test

Saturation experiments were conducted on discrete samples using an ASC Scientific model IM-10 impulse magnetizer to produce an applied field. Isothermal remanent magnetization (IRM) associated with progressively stronger applied fields (to saturation) was measured at each step with the cryogenic magnetometer. Additional IRM results for carbonate sediments are given in the Leg 166 *Initial Reports* volume (Shipboard Scientific Party, 1997c).

Sample Ranking Criteria

The discrete samples were classified in three categories (A, B, or C) based on their relative quality. Class A samples usually exhibited a stronger NRM remanence (>1 × 10^{-7} Am^2/kg), near-linear decay during demagnetization, a MAD value <15°, and the absence of very steep (>70°) NRM inclination. Class B samples typically had slightly lower intensities and MAD values between 15° and 20°, reflecting less linear decay and a decay component only partially stable (although all the demagnetization steps maintained the same polarity). Class C samples exhibited complete or almost complete instability during the initial AF demagnetization steps and had measurements that could not be immediately replicated. Principal component analysis that resulted in MAD values >20° were also grouped with the Class C samples. Most of these samples were not even analyzed because of their inherent instability.

Class A samples are likely reliable for magnetostratigraphic purposes, despite the unusually liberal (as much as 15° MAD limit) classification criteria for these samples. Class B samples should be viewed with caution in developing a magnetostratigraphy. These samples may be reliable if they form part of a sequence containing

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adjacent Class A samples of similar polarity. Class C sample data were discarded and are not suitable for polarity determination.

Magnetic Susceptibility

Low-field magnetic susceptibility was measured for each discrete sample using a Bartington MS2 susceptibility meter with a single-sample sensor. Data are reported in (10^{-6}) cgs units. No volume correction has been applied to convert cgs units to SI units.

DATA RESULTS

Susceptibility

Magnetic susceptibility measured in discrete samples from Hole 1006A indicated a combination of weak positive susceptibility and diamagnetism (Fig. 1; Table 1). The core susceptibility profile clearly shows several cycles of variation. Mixed positive and diamagnetic responses characterize the upper ~100 m, from mostly diamagnetic between ~100 and ~300 meters below seafloor (mbsf) to two positive intervals and one diamagnetic interval in the bottom 300 m (~300–600 mbsf) of the core. The interval between ~540 and ~560 mbsf is marked by the highest positive susceptibilities (up to +2), besides the upper few meters of the core (Fig. 1).

Magnetic Remanence and Sample Reliability

Shore-based discrete sample analyses indicate that the carbonate sediments in Hole 1006A exhibit weak to moderate magnetic moments (Fig. 2; Table 2). Mean intensity for the 778 samples is 9.47×10^{-8} Am^2/kg (median = 6.04×10^{-8} Am^2/kg). Similar to the susceptibility profile, magnetic intensity at the NRM level exhibits distinct intervals of variation, including considerable difference between adjacent samples (Fig. 2). These variations in magnetic intensity are evident in both the scatter plot and the three-point smoothing (Fig. 2). The weakest remanent magnetization (~5×10^{-8} Am^2/kg) is found in the interval between ~50 to ~200 mbsf. Below ~200 mbsf, the intensity is generally around 1×10^{-7} Am^2/kg with two slightly stronger intervals (Fig. 2). A histogram of intensity distribution within the range of 1×10^{-8} and 1×10^{-7} Am^2/kg shows a widely scattered distribution (Fig. 3A). The distribution of samples between 1×10^{-7} and 1×10^{-6} Am^2/kg shows a rapid decline in the number of samples in the stronger intensity classes (Fig. 3B). Samples with NRM intensity of <5×10^{-8} Am^2/kg were usually deemed either Class B or Class C samples. Class A (N = 106, 13.6%) and Class B (N = 102, 13.1%) samples comprised 27.7% of the 778 total samples and are tentatively judged as reliable.

AF demagnetization was responsible for the almost complete decay of magnetic remanence. Usually only 10% of the original remanence remained after AF fields of 25 to 30 mT (Fig. 4). Median destructive field for most samples was in the range of 5–15 mT. This relatively "soft" remanence is often characteristic of magnetite with comparatively low magnetostatic interaction and/or magnetite that has undergone partial oxidation to maghemite (McNeill, 1997).

A significantly steep (>70°) inclination angle was measured at the NRM level in many samples below ~200 mbsf. This steep inclination greatly exceeds the axial dipole value (43°) expected for the site latitude of ~25°N. We interpret this steep inclination as some type of drilling/coring overprint or remagnetization(?), as the drill pipe can produce a magnetic field with very steep inclination. AF demagnetization was not able to effectively remove the steep angles in many of the samples; as a result, they were classified as the Class C type because of the uncertainty in reliability. Although not quantified, many of the samples with higher intensities did not exhibit the steep inclination found in the more moderate to weak samples.

Rock Magnetics

Isothermal remanent magnetization acquisition was performed on selected samples from Hole 1006A (Fig. 5). Most of the samples show acquisition patterns and characteristics (Fig. 5A) similar to those of single-domain magnetite. Of the seven IRM samples, most reached saturation before or near 100 mT (Fig. 5A) and have ratios from IRM acquisition of near 1 (within the single-domain magnetite field on Fig. 5B).

CONCLUSIONS REGARDING THE DATA SET

This survey of magnetization in sediments from Hole 1006A indicates that a continuous reversal stratigraphy is probably unobtainable because of the weak nature of the magnetic remanence and the related problems of drilling/coring overprints (or remagnetization). A reliable polarity determination may be available in some isolated interval of the cored section (although these should be used with due caution).

The reason for a general increase in NRM intensity with depth in Hole 1006A (Fig. 2) is unknown at this time, but it may be linked to

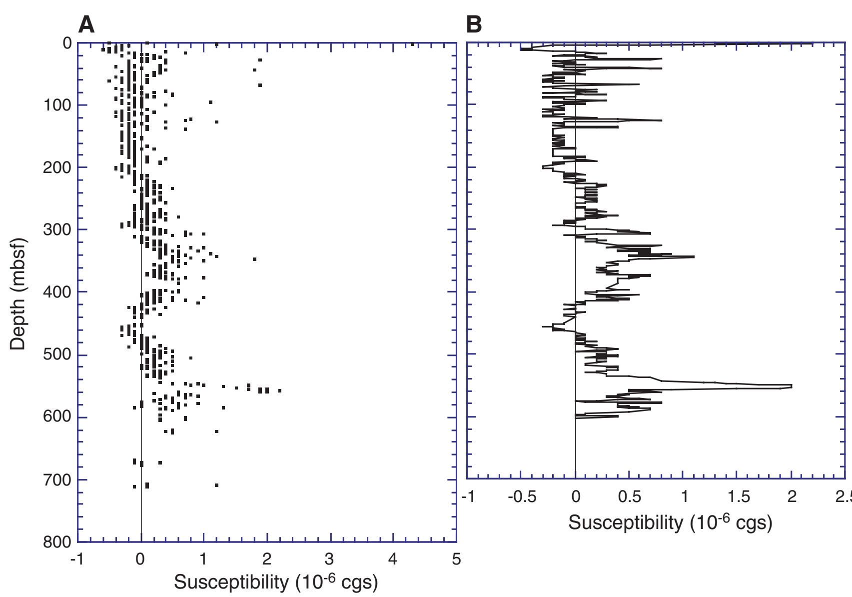

Figure 1. Magnetic susceptibility of discrete samples from Hole 1006A. Susceptibility is mostly diamagnetic as a result of the high carbonate content. Several zones of positive susceptibility appear in the middle and lower parts of the cored section. **A.** Susceptibility values for discrete samples. **B.** Three-point smoothing of susceptibility values.

the input of detrital (noncarbonate) sediments. Hole 1006A penetrated a thick pile of upper Miocene and lower Pliocene sediments thought to represent current drift deposits. These intervals may include subtle increases in detrital sediments partially responsible for providing the downcore increase in remanence. Geochemical logging at Hole 1006A has been interpreted to reflect an increase in detrital minerals at two intervals (~350-450 mbsf and ~500–650 mbsf) (Shipboard Scientific Party, 1997c). Spectral gamma-ray results indicate a nearly twofold increase in percent potassium, perhaps related to increased abundance of K-feldspars, micas, glauconite, or clay minerals. If this geochemical log signal is responding to a greater detrital component, it would be expected to also contain grains having a stable magnetic remanence. The influence of detrital grains on the magnetic remanence is consistent with positive susceptibilities measured in these two intervals (Fig. 1). Likewise, the detrital intervals in the upper 125 m of Hole 1006A reveal positive susceptibilities and greater whole-core remanence intensities (Shipboard Scientific Party, 1997c) relative to the background carbonate intervals.

The weak remanence documented here does, however, yield some initial insight into the nature and preservation of carbonate sediment magnetization along the platform-to-basin transect. The middle and lower slope deposits comprising the western margin of Great Bahama Bank are weakly magnetized and often magnetically unstable. At Hole 1006A, ~27% of the samples were judged stable (this is likely a minimum percentage because of the drilling overprint problem), whereas cores (Bahamas Drilling Project cores Clino and Unda; Eberli et al., 1997) from the margin of the platform top had percentages of samples with stable remanence of more than 80% (McNeill, 1997). If this difference in magnetic remanence is real and can be confirmed, factors involving preservation of the ultrafine-grained single-domain magnetite and the detrital component need to be explored, especially in the geochemical and diagenetic realm.

Table 1. Paleomagnetic data for discrete samples from Hole 1006A, including the remanence intensity at the natural remanent magnetization (NRM) level, the maximum alternating-field (AF) demagnetization step, and the magnetic susceptibility.

Core	Section	Interval (cm)	Depth (mbsf)	NRM (emu)	NRM (Am^2/kg)	Max AF (mT)	Susceptibility (10^{-6} cgs)
1H	1	45-47	0.45	5.18E–07	6.48E–08	30	0.1
1H	1	109-111	1.09	5.86E–07	7.33E–08	30	–0.5
1H	2	45-47	1.95	2.40E–05	3.00E–06	30	4.3
1H	2	109-111	2.59	4.43E–06	5.54E–07	30	1.2
1H	3	45-47	3.45	1.09E–05	1.36E–06	30	1.2
1H	3	109-111	4.09	7.23E–07	9.04E–08	30	–0.2
1H	4	45-47	4.95	1.93E–07	2.41E–08	30	–0.3
1H	4	105-107	5.55	2.66E–07	3.33E–08	30	–0.2
1H	5	45-47	6.45	2.28E–07	2.85E–08	30	–0.3
2H	1	44-46	7.54	2.61E–07	3.26E–08	30	–0.4

This is a sample of the table that appears on the volume CD-ROM.

ACKNOWLEDGMENTS

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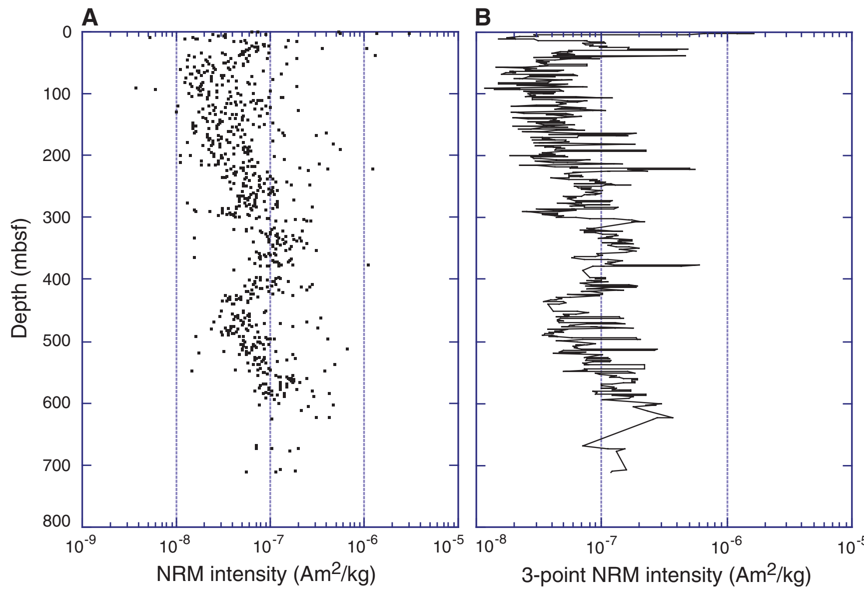

Figure 2. Magnetic intensity at the natural remanent magnetization (NRM) level for Hole 1006A discrete samples. **A.** Individual data points from discrete samples with a best-fit curve. Variations in NRM intensity are apparent in several intervals of the cored section. **B.** Three-point smoothing of the magnetic intensity data shown in A.

Table 2. Summary of orientation data, maximum angular deviation (MAD) value, sample ranking, and polarity designation (where possible), Hole 1006A.

Core	Section	Interval (cm)	Depth (mbsf)	Declination (°)	Inclination (°)	MAD (°)	No. points	Category	Polarity
1H	1	45-47	0.45	301	27	4.1	12	A	N
1H	2	109-111	1.09	351	25	3.4	11	A	N
1H	2	45-47	1.95	312	28	6.9	11	A	N
1H	3	109-111	2.59	216	9	11.1	10	A	N
1H	3	45-47	3.45	231	7	2.6	11	A	N
1H	4	109-111	4.09	320	28	13.7	9	A	N
1H	4	45-47	4.95					C	
1H	5	105-107	5.55	60	31	17.9	6	B	N?
1H	1	45-47	6.45	44	47			B	N?
2H	1	44-46	7.54	278	6	15.7	10	B	?

Note: See text for sample ranking criteria.

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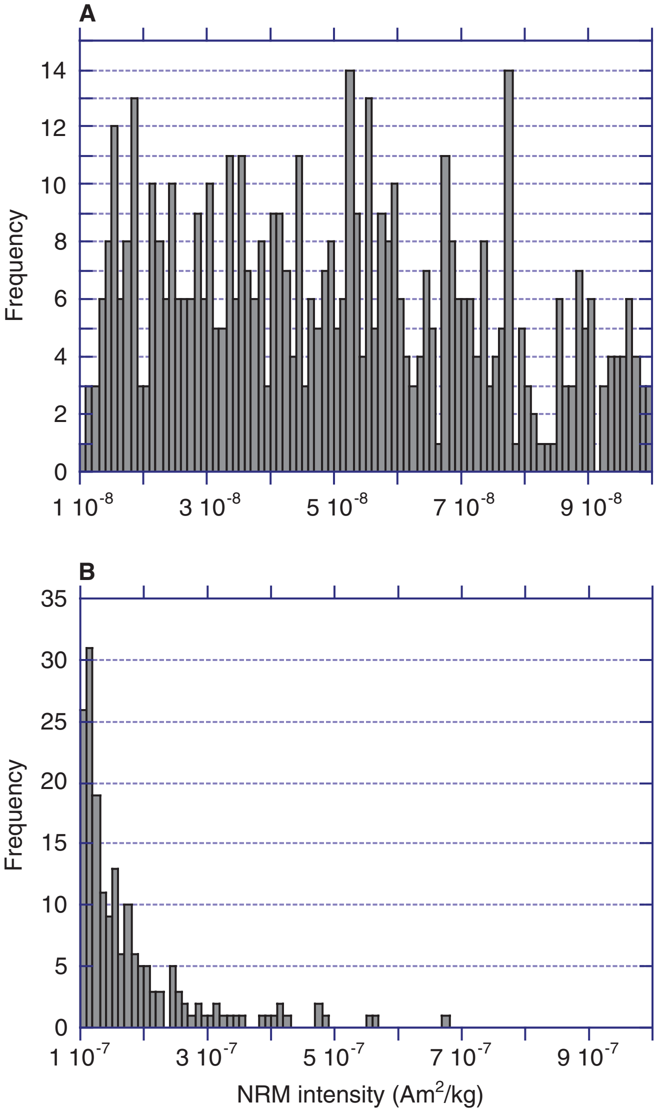

Figure 3. Histogram of natural remanent magnetization (NRM) intensity values for discrete samples. **A.** Distribution of intensity values between 1×10^{-8} and 1×10^{-7} Am^2/kg. **B.** Distribution of intensity values between 1×10^{-7} and 1×10^{-6} Am^2/kg. Distribution of samples $>1 \times 10^{-7}$ Am^2/kg decreases rapidly. Note change in frequency scale between the two histograms.

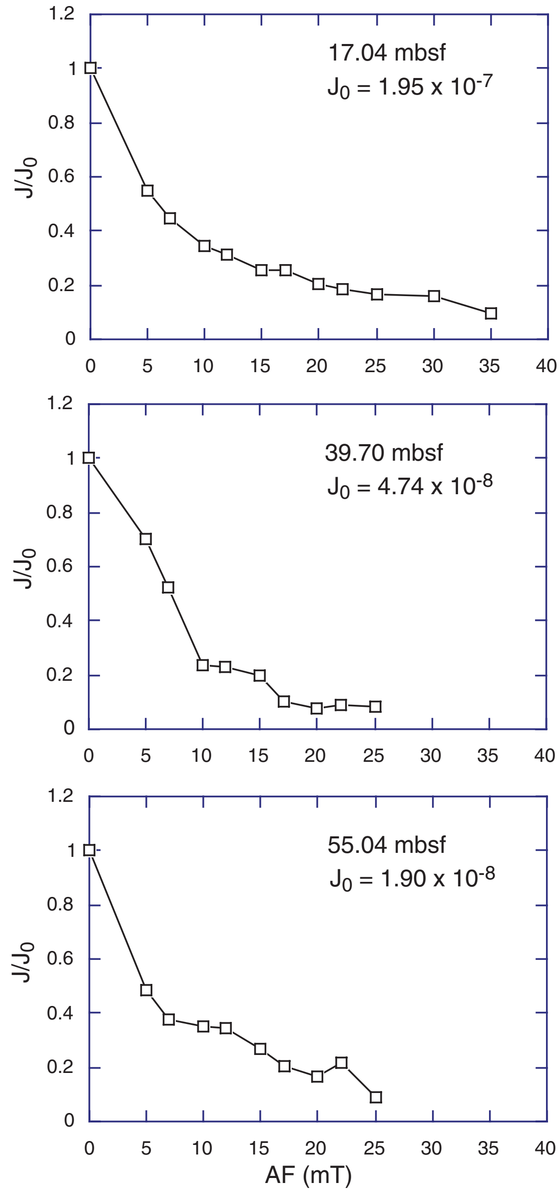

Figure 4. Typical J/J_0 plots of carbonate samples from Hole 1006A. Samples responded to AF demagnetization as the remanence decayed quickly at fields of only 10–15 mT. Sample number is depth in core (in mbsf). J_0 intensity is in Am^2/kg.

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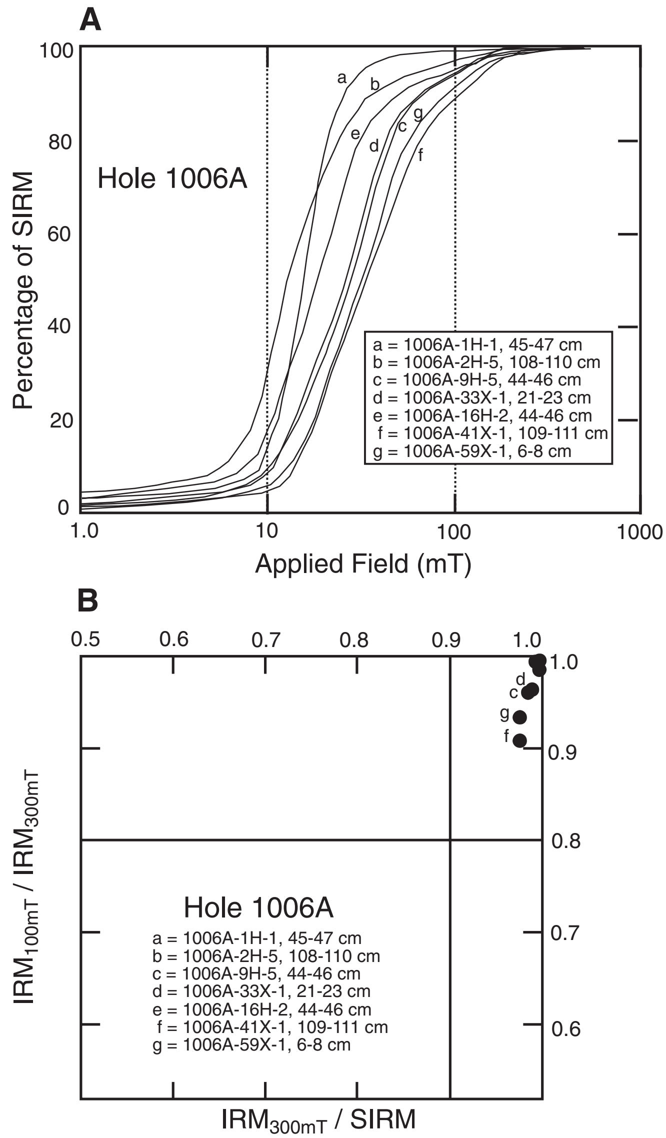

Figure 5. **A.** Isothermal remanent magnetization acquisition curves for several samples from Hole 1006A. The acquisition patterns are similar to those of single-domain magnetite (samples a, b, and e) or magnetite partially oxidized to maghemite (samples c, d, f, and g), as most samples reach saturation near an applied field of 100 mT. **B.** Comparison of ratios from the isothermal remanent magnetization (IRM) acquisition data. SIRM = saturation isothermal remanent magnetization. All the samples fall in the upper right portion of the plot—ratios characteristic of single-domain magnetite.