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8. MAGNETIC STUDIES OF SELECTED SEDIMENTS[1]

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ABSTRACT

The results of two separate magnetic investigations are discussed in this paper. The first study produced a magnetostratigraphy from the K/T boundary interval of Hole 1001A from the lower Nicaraguan Rise. The second investigation produced a high-resolution Brunhes age paleomagnetic and rock-magnetic record from Hole 1002C in the Cariaco Basin.

INTRODUCTION

Paleomagnetic and rock-magnetic measurements are routinely used to provide chronological control for stratigraphic studies of Ocean Drilling Program (ODP) sediments. In addition, rock-magnetic studies of ODP sediments are often used to provide core correlation, resolve glacial-interglacial cycles, and detect other types of paleoenvironmental changes (see reviews in King and Channell, 1991; Reynolds and King, 1995).

Shipboard paleomagnetic studies of Leg 165 sediments were severely hampered by drilling-induced overprints that could not be removed by the available shipboard alternating field (AF) demagnetization capabilities (Sigurdsson et al., 1997). Shore-based paleomagnetic studies with demagnetization equipment capable of AF demagnetization at high peak fields were undertaken to improve the magnetostratigraphy of selected Leg 165 sediments. In addition, rock-magnetic studies of selected Leg 165 sediments were undertaken to detect glacial-interglacial cycles and other types of paleoenvironmental changes.

The results of two separate magnetic investigations are discussed in this paper. The first is a high-resolution paleomagnetic study of the interval adjacent to the K/T boundary in Hole 1001A from the lower Nicaraguan Rise. The second is a low-resolution paleomagnetic and rock-magnetic study of sediments from Hole 1002C from the Cariaco Basin.

METHODS

Sampling

Samples from Holes 1002A and 1002C were obtained by pushing an oriented square-section stainless steel tube into the split core face. The resulting minicore was withdrawn and extruded into a 5-cm^3 plastic box. Samples from Hole 1001A were obtained postcruise by cutting ~2-cm-long quarter-round samples from the working half using a nonmagnetic ceramic blade in a rock saw. The relatively large quarter-round samples were subsequently trimmed by hand with a titanium carving knife to fit into an AF demagnetizer.

Magnetic Measurements

Sample processing for magnetic measurements consisted of the following steps:

1. Measurements of the natural remanent magnetization (NRM) of all samples using a two-axis, 2G Enterprises cryogenic magnetometer.
2. Stepwise AF demagnetization with a DTECH demagnetizer and subsequent remeasurement of samples with the magnetometer.
3. Measurement of low field (0.1 mT) volume magnetic susceptibility (K) at a driving field frequency of 0.47 kHz with a Bartington Instruments susceptibility meter and MS1B dual-frequency sensor.
4. Demagnetization of all samples at 90 mT to remove the NRM followed by the acquisition of anhysteretic remanent magnetization (ARM) by subjecting samples to a gradually decreasing peak AF of 100 mT in the presence of a 0.1-mT direct current (DC) field. The ARM was measured using the cryogenic magnetometer. The ARMs are expressed as an anhysteretic susceptibility (K_{ARM}), obtained by dividing by the strength of the DC field.
5. All samples were given a saturation isothermal remanent magnetization (SIRM) in a 1-T DC field, measured with the cryogenic magnetometer, subjected to a reversed DC field of 0.3 T, and then remeasured. The two measurements were used to calculate HIRM ("hard" IRM), which is defined as ($IRM_{-0.3\ T}$ + SIRM)/2, and S, which is defined as -$IRM_{-0.3\ T}$/SIRM.

In the following we briefly outline the rock-magnetic significance of these parameters. The K, SIRM, K_{ARM}, and NRM usually reflect variations in the concentration of ferrimagnetic minerals (i.e., members of the magnetite-ulvospinel and magnetite-maghemite solid solution series, henceforth described as "magnetite"). However, K and SIRM are biased toward coarser grained magnetite and K_{ARM} and NRM toward finer grained magnetite. The NRM also partly reflects the intensity of the ambient geomagnetic field at around the time of sediment deposition. The HIRM is proportional to the concentration of such coercivity, antiferromagnetic minerals as goethite and hematite.

For magnetic mineral assemblages dominated by magnetite, the ratio K_{ARM}/K is indicative of magnetite grain size within the magnetically stable fraction; that is, grains that span the range of stable single-domain through multidomain behavior (e.g., Hartstra, 1982a, 1982b; King et al., 1982; Ozdemir and Banerjee, 1982). The S values reflect the ratio of goethite/hematite to magnetite, with lower values indicating an increase in this ratio.

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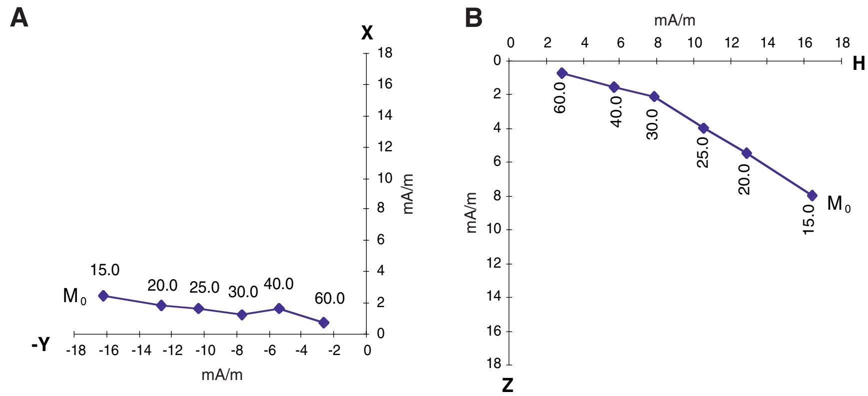

Figure 1. Zijderveld plots for Sample 165-1001A-38R-5, 48–50 cm; 348.99 mbsf. **A.** Horizontal component. **B.** Vertical component. A small secondary component is removed by demagnetization at 30.0 mT.

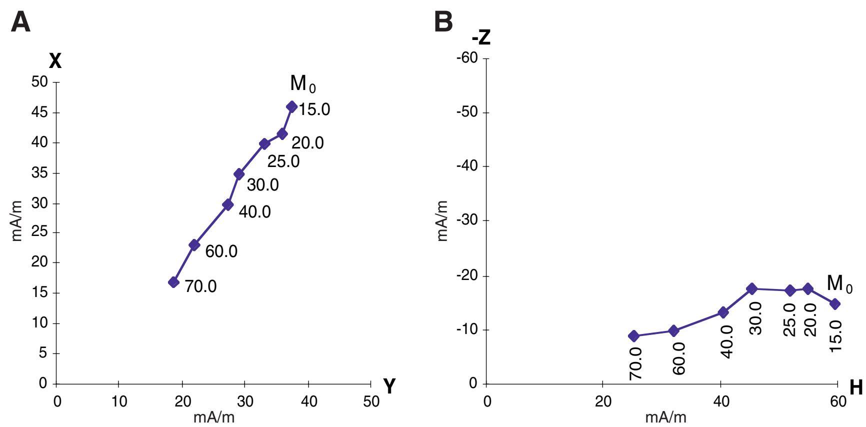

Figure 2. Zijderveld plots for Sample 165-1001A-39R-2, 101–103 cm; 353.92 mbsf. **A.** Horizontal component. **B.** Vertical component. A small secondary component is removed by demagnetization between 30.0 and 40.0 mT.

Age Modeling

Age modeling of Hole 1001A data was done by comparison to the Leg 165 polarity time scale (Sigurdsson et al., 1997).

RESULTS

Hole 1001A K/T Boundary Interval

Samples were stepwise AF demagnetized and the results are shown in Zijderveld plots in Figures 1 and 2. These results indicate that secondary components were removed by 30.0–40.0 mT. The paleomagnetic results after AF demagnetization at 40.0–70.0 mT from the K/T boundary interval of Hole 1001A are shown in Figure 2. Two polarity transitions interpreted in Figure 3 as the C29N onset and the C30N termination are shown. Sedimentation rates above and below the K/T boundary are shown in Table 1.

Hole 1002C

The results from paleomagnetic and rock-magnetic studies of Hole 1002C samples are shown in Figures 4 and 5, respectively. The inclination record indicates that AF demagnetization removes the drilling overprint and that the entire section is Brunhes (Chron 1N) in age. The rock-magnetic record shown in Figure 5 shows interesting recurring features at ~10 mbsf, ~50 mbsf, ~120 mbsf, and ~155 mbsf. These recurring features are characterized by changes indicative of rapid magnetic grain-size changes and increases in the high coercivity (hematite/goethite) magnetic component.

DISCUSSION

Hole 1001A K/T Boundary Interval

The paleomagnetic results from the Hole 1001A K/T boundary interval are good, and drilling overprints appear to be removed by AF demagnetization in fields of 40.0–80.0 mT. However, the declination data show changes of <180° (120°–140°) at the polarity transitions. This observation may either reflect orientation problems in the rotary cores, or incomplete removal of a radial drilling overprint (Sigurdsson et al., 1997). The radial overprint tends to decrease the amplitude of declination variations. Comparison of sedimentation rates above and below the boundary indicates that higher rates were found above the boundary in Hole 1001A. In contrast, a previous study of Deep Sea Drilling Project (DSDP) Site 528 in the South Atlantic (D'Hondt et al., 1996) showed that higher sedimentation rates were found below the K/T boundary (Table 1). Additional studies are planned to examine these contrasting results.

Hole 1002C

The recurring rock-magnetic features observed in Hole 1002C are interpreted as paleoredox boundaries that mark major transitions between glacial and interglacial sediments. The presence of abundant high-coercivity magnetic oxides (hematite/goethite) may be indicative of the transition from oxic conditions during glacial intervals to anoxic conditions during interglacials that occurred in the Cariaco Basin (Peterson et al., 1991).

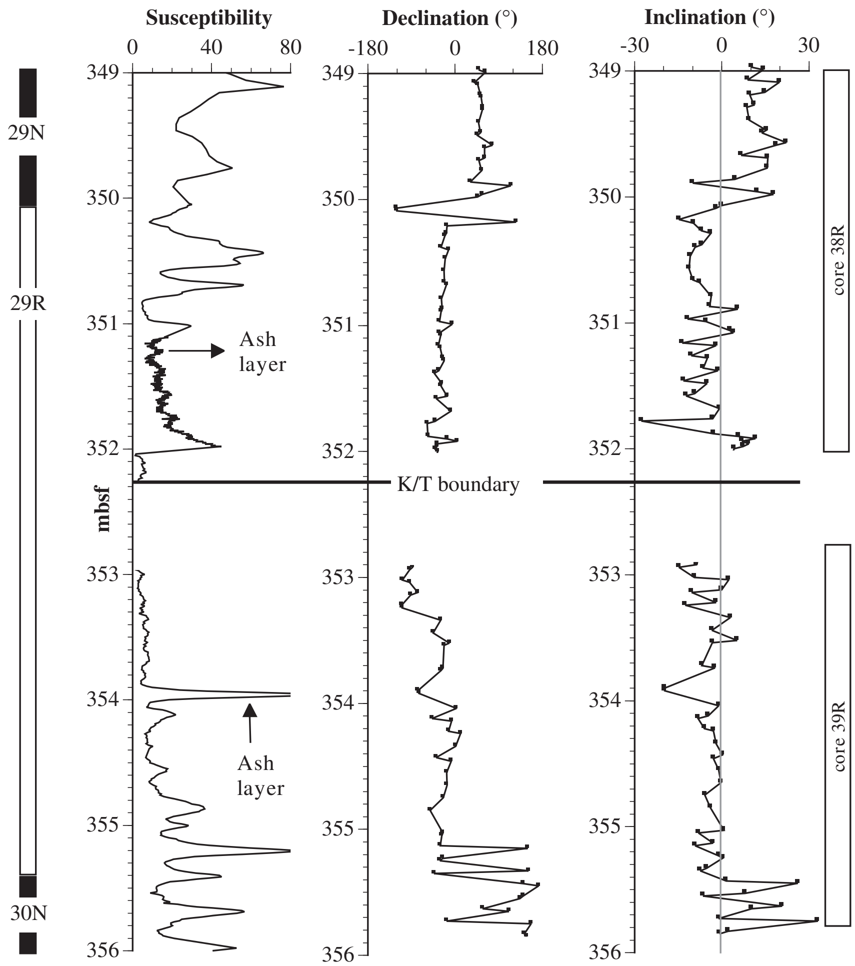

Figure 3. Magnetic stratigraphy of the K/T boundary interval of Hole 1001A. Data are AF demagnetized between 40.0 and 80.0 mT. Polarity time scale interpretation is shown in the left column. The susceptibility data is whole core data in SI units, whereas the directional data is from subsamples.

Table 1. Magnetostratigraphy and sedimentation rates of the K/T boundary interval.

Interval	Depth (mbsf)	Sedimentation rate (cm/k.y.)
ODP Hole 165-1001A		
C29N, Onset-K–T	350.2–352.25	0.8
K–T - C30N, Termination	352.5–355.4	0.54
DSDP Site 528		
C 29N, Onset - K–T	405.97–407.00	0.4
K–T - C 30N, Termination	407.0–413.34	1.1

CONCLUSIONS

1. Good magnetostratigraphy has been obtained from the K/T boundary interval of Hole 1001A.
2. A good high-resolution Brunhes age paleomagnetic record has been obtained from Hole 1002C, and rock-magnetic parameters record major glacial-interglacial transitions.

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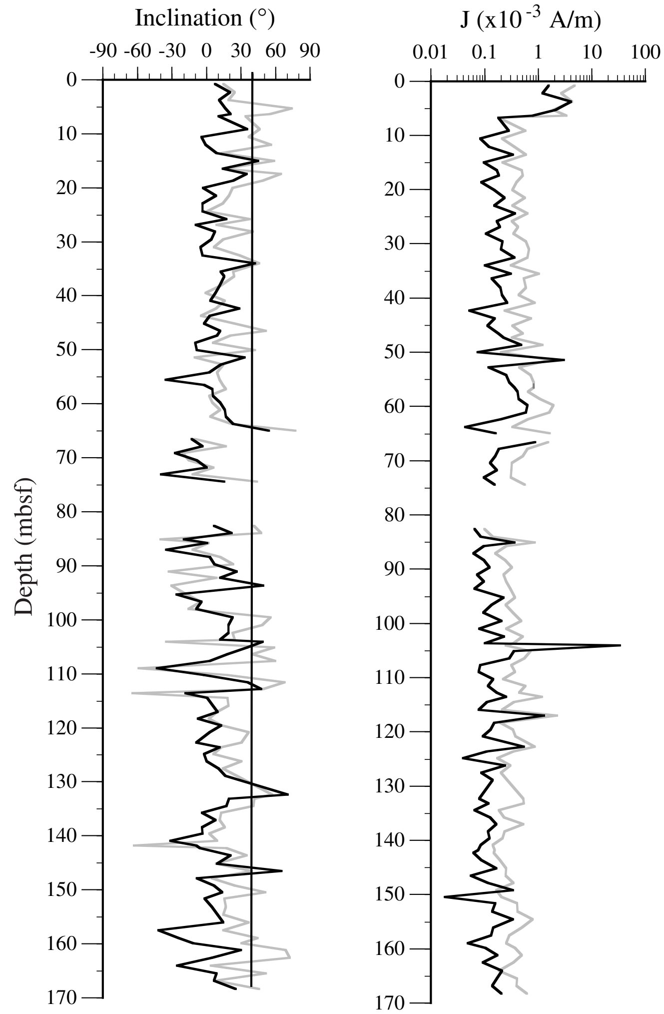

Figure 4. Inclination and magnetization data from Hole 1002C. The gray curve represents NRM data, and the black curve is the NRM data after AF demagnetization at 15.0 mT. The vertical line on the inclination curve is the expected axial dipole inclination for the site latitude.

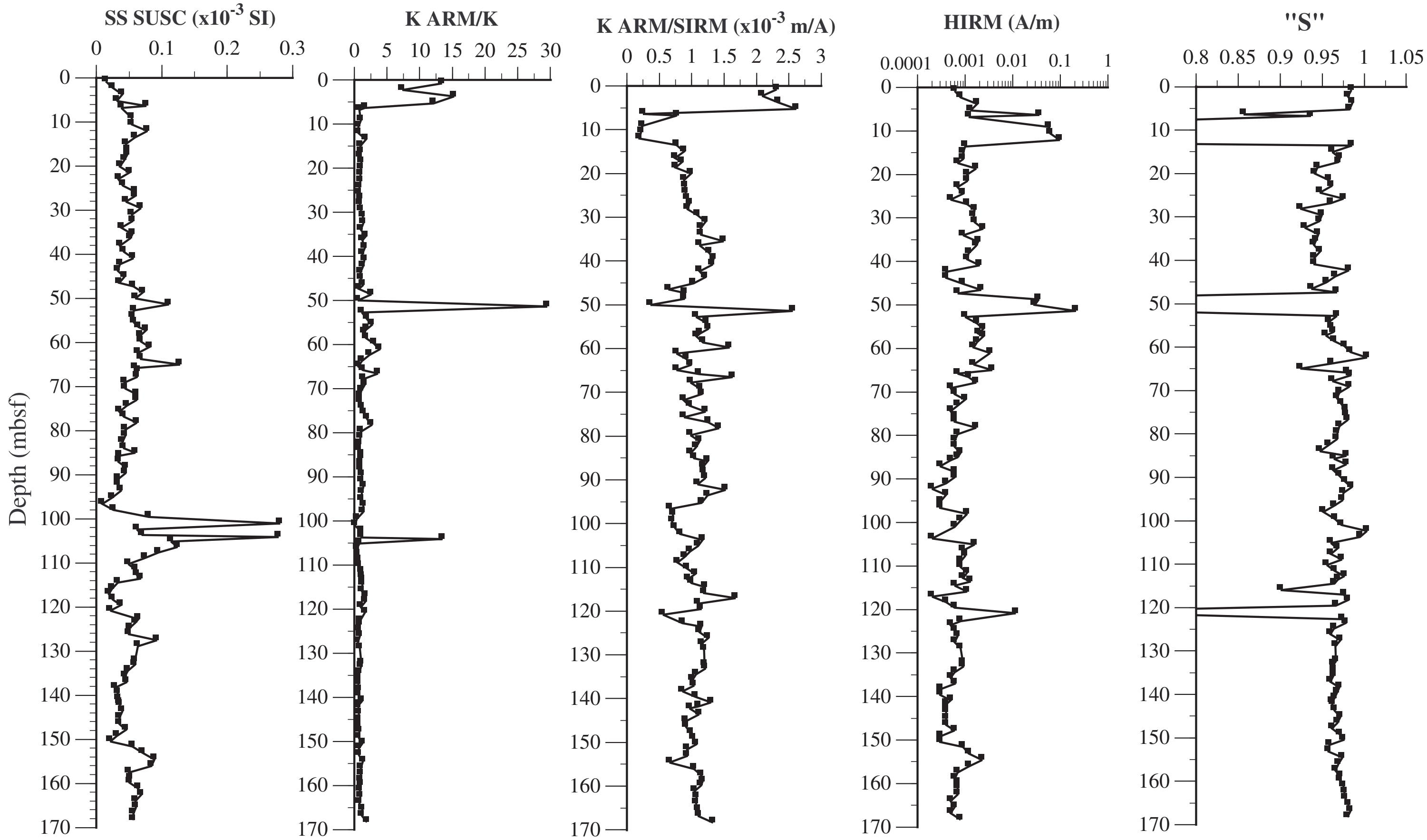

Figure 5. Rock-magnetic stratigraphy for Hole 1002C. The first column is the single-sample susceptibility (SS SUSC), the second column is anhysteretic susceptibility over single-sample low-field susceptibility (K ARM/K), and the third column is anhysteretic susceptibility over saturation isothermal remanent magnetization (K ARM/SIRM). The parameters HIRM and S are described in the "Methods" section.