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27. PALEOMAGNETIC AND ROCK MAGNETIC PROPERTIES OF SEDIMENT SAMPLES FROM OCEAN DRILLING PROGRAM LEG 116, CENTRAL INDIAN OCEAN[1]

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ABSTRACT

A representative suite of samples from cores obtained at the three Leg 116 sites, 717, 718, and 719, were studied to determine their magnetic properties and measure paleomagnetic directions. These samples were treated to alternating field and thermal demagnetization. Additionally, selected samples were examined by thermomagnetic analysis, isothermal remanent magnetization acquisition analysis, and measurement of the anisotropy of magnetic susceptibility (AMS). Most samples were dominated by a vertical overprint that in many cases was impossible to fully remove. As a consequence, paleolatitudes determined from these samples are unreliable. The rock magnetic studies indicate that magnetite and hematite are probably the primary magnetic minerals, but that maghemite and goethite also contribute to the magnetism of these sediments. Attempts to correlate magnetic behavior with sediment lithology met with little success and demonstrated that the magnetic properties vary as much within each lithology as between different lithologies. AMS measurements showed a clear sedimentary fabric with a horizontal axis of maximum susceptibility. However, because of the lack of azimuthal orientation of the cores, it was not possible to determine whether the maximum susceptibility axes show a preferred direction or trend.

INTRODUCTION

During Leg 116 of the Ocean Drilling Program in the central Indian Ocean, approximately 991.4 m of sedimentary core material was recovered from three sites just south of the Equator near 1°S, 81°24′E. Nearly all this material was obtained by rotary drilling with the Extended Core Barrel (XCB). Consequently, all cores were neither oriented with respect to geographic north nor intact. Instead, much of sampled sedimentary material was "biscuited" into 2- to 5-cm-thick, disk-shaped pieces whose azimuthal orientation was randomized by the coring process. As all sites are located near to the Equator and all consist of relatively young (<17 m.y.) sediments, the magnetic inclinations predicted for an axial dipole geomagnetic field are close to zero. Consequently, reversals of the geomagnetic field recorded in such equatorial regions can only be detected through 180° changes in magnetic declination. The lack of azimuthal control of the cores, therefore, precluded the possibility of unequivocally determining the polarity of any stable remanent magnetization present in the samples. As a result, it was not possible to date the sediments using magnetostratigraphic techniques. Additional problems, associated with strong magnetic fields from the drilling equipment, also limited the reliability of paleomagnetic directions obtained from Leg 116 samples. Analyses of magnetic properties, however, provided useful and interesting information on the nature of the remanence, the minerals responsible for stable remanence, and the relationship of these parameters to variations in the lithology of the recovered core material. Of special interest is the relation of the strength, stability, and directional information obtained from the measurements of remanence to the various kinds of turbidites recognized at the three sites. In this paper we examine the remanence properties and magnetic mineralogy of a suite of samples that cover a full stratigraphic range and which are reasonably representative of the various lithologic types encountered. In a companion paper (Sager and Hall, this volume), we carry out a detailed investigation of the magnetic properties of two black mud turbidites.

PALEOMAGNETIC ANALYSIS

Samples for paleomagnetic analysis were collected from Leg 116 cores by pressing 6-cm^3 plastic cubes into the soft sedimentary material. A scribe mark on the cubes was oriented relative to the vertical axis of the core. Upon return to Houston, all samples were stored in a magnetically shielded room with an ambient field of 200–300 nT for a period of several months prior to measurement. Evidence from onboard measurements suggests that some of the samples are highly susceptible to viscous remanence (Cochran, Stow, et al., 1989), and storage in the quiet room reduced the possibility of contamination from extraneous laboratory magnetic fields. A total of 127 samples from Sites 717, 718, and 719 were selected for paleomagnetic analysis. Samples were chosen to be representative of the various types of sediments encountered while drilling the three sites during Leg 116. The sedimentary material is largely composed of silty sands and mud turbidites. Most of the recovered core material is of similar grain size but differs noticeably in color varying from light gray to black. Four main classes of turbidites were recognized: (1) gray silt and silt mud, (2) black or dark gray organic-rich mud, (3) light gray organic-poor mud, and (4) olive gray biogenic mud (Cochran, Stow, et al., 1989). The magnetic properties of samples from each of these four were examined for evidence of diagnostic behavior that could be used to distinguish differences in their composition and in the sedimentary processes responsible for their deposition.

Intensity of Magnetization

The natural remanent magnetization (NRM) of each sample was measured using a two-component cryogenic magnetometer also housed in the magnetically shielded room. The noise level of the magnetometer allows magnetizations of approxi-

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mately 6 × 10^{-9} emu/g to be reliably measured. All samples possessed NRM magnetizations substantially stronger than this and most samples remained well above the noise level throughout the full range of demagnetization. In general, the sediments are more strongly magnetized than other marine sediments by more than an order of magnitude, although some of this intensity is ascribed to drilling-induced remanences (see below). Other authors have commented upon the strong magnetizations displayed by sandy turbidites (e.g. Merrill, this volume). Calcareous turbidites, on the other hand, appear to be weakly magnetized, reflecting significant differences in either the abundance or nature of the magnetic minerals present (Backman, Duncan, et al, 1988). A histogram of the log intensity of the NRM (Fig. 1) shows that while the mean NRM intensity is 2.10 × 10^{-5} emu/g, values range over three orders of magnitude. The similarity between the NRM intensities shown in Figure 1 and those obtained from shipboard measurements of entire cores (Cochran, Stow, et al., 1989) indicates that the samples used in the study are fairly representative of the entire sedimentary section cored during Leg 116. The pattern of variation in NRM intensity with turbidite color is by no means simple (Fig. 2) and it is clear that color is not diagnostic of the strength of remanence. Figure 2 shows, however, that although each class of turbidite can be either strongly or weakly magnetized, many of the dark gray-black mud turbidites are associated with strong remanence (see Sager and Hall, this volume).

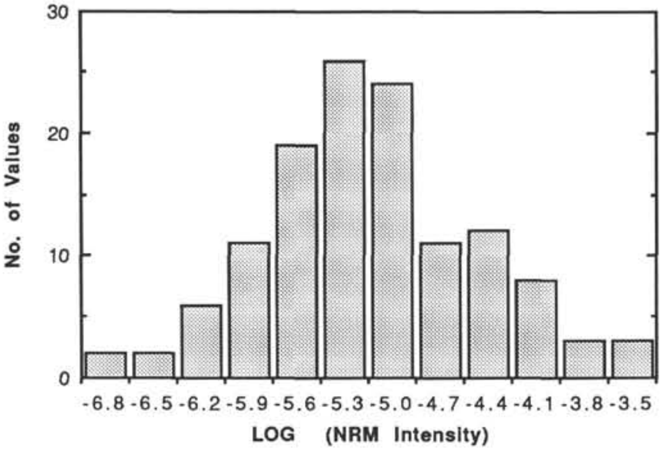

Figure 1. Histogram of Log (NRM intensity) for all samples studied.

The NRM intensities may, in part, be an indicator of the sensitivity of samples to overprinting by the fields associated with the drilling operation. If this is the case then it is perhaps more meaningful to compare the intensities after AF demagnetization through 20 mT. A field of 20 mT appears to represent the average median destructive field. In addition, the magnetic directions of most samples change little above 20 mT, indicating that either the effect of the overprint above this point is negligible or, alternatively, that the sample is so overprinted as to retain negligible amounts of the original remanence. However, when the intensities after demagnetization are compared with turbidite color, the pattern is more or less identical to that shown in Figure 2.

To isolate stable components of remanence, samples were demagnetized using either alternating field (AF) or thermal demagnetization procedures. A majority of samples were "cleaned" using the AF demagnetization method as this did not require removal of the sample from the plastic sampling cube. Samples were demagnetized along three orthogonal axes in a stepwise manner and the remaining magnetization measured after each step. Although most samples displayed a marked decrease in intensity over the low-field range 0–20 mT, very few were completely demagnetized even in the largest available field strength (viz., 100 mT). It is perhaps important to note that the maximum AF demagnetization field available aboard the *JOIDES Resolution* for the measurement of entire cores was 9 mT during Leg 116 and that it is therefore likely that few cores were sufficiently demagnetized to reveal their characteristic remanence. Above 40 mT the intensity of most samples remained more or less constant with a few displaying a slow decline through 100 mT. Some samples, however, showed erratic fluctuations in intensity which are thought to be due to an anhysteretic magnetization (ARM) acquired in the demagnetizer. The ambient magnetic field inside the demagnetizer coil is less than 1 nT and consequently it would appear that these samples are especially susceptible to ARM. Again there did not appear to be any relationship between this erratic behavior and the class of turbidite. Figure 3 shows examples of AF demagnetization curves from each of the four classes of turbidite. Because none of the samples can strictly be regarded as typical of its class,

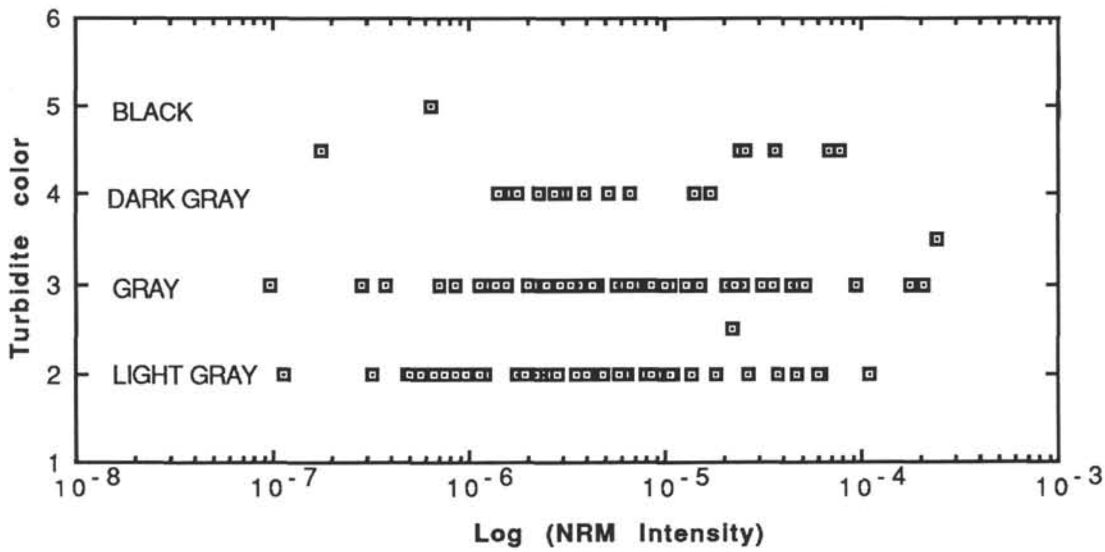

Figure 2. Variation in Log (NRM intensity) with turbidite color.

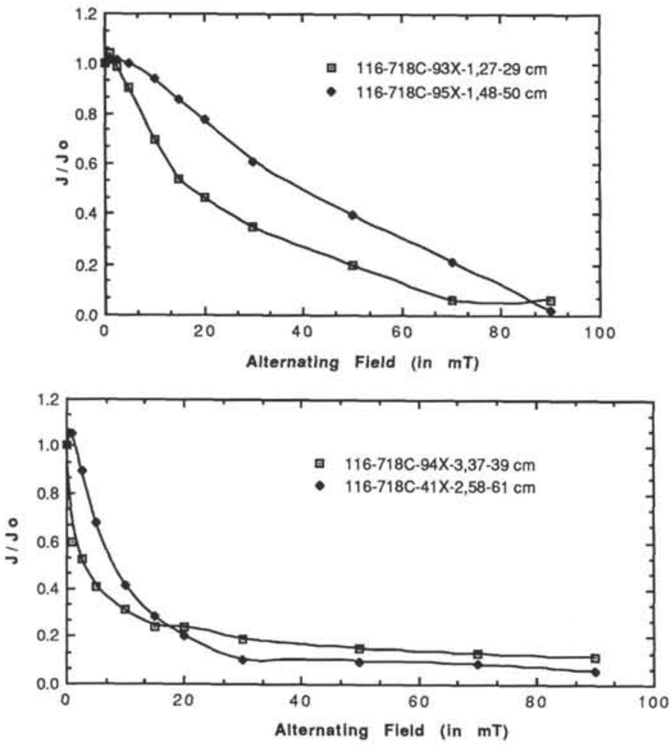

Figure 3. Alternating field demagnetization curves of NRM for samples from Hole 718C.

Figure 3 should be considered as merely an illustration of the range of demagnetization behavior observed.

A small subset of the samples studied were demagnetized using a stepwise heating procedure. Samples were prepared by carefully removing the sediment from the plastic sampling cube, painting them with a dilute solution of sodium silicate, and allowing them to dry. In certain samples it was necessary to apply several coats of the solution. The resulting samples were stepwise heated in 50°C steps through 600°–700°C, allowed to cool in a low-field (<5 nT) region, and their magnetization measured after each step. It was necessary in most cases to apply additional coats of the sodium silicate solution after heating beyond 400°C. In Figure 4, the change in remanent intensity upon heating for several of these samples is shown. An insufficient number of samples were thermally demagnetized to form firm statistical results but the available evidence demonstrates that thermal demagnetization was also not entirely successful in isolating stable components of remanence.

As discussed below, neither the AF nor the thermal demagnetization method appears to have been entirely successful in eliminating secondary components. The demagnetization results, both thermal and AF, were examined for evidence of stable components of remanence by visual inspection of vector demagnetization plots and by principal-component analyses of the directional information. Most samples displayed at least one component of remanence and several displayed two or more components. Each had a low-field, low-temperature component, frequently steeply dipping (usually upward, i.e., negative inclination) representing an overprint component from the drilling process. The second component appears commonly between 10 and 40 mT (250°–400°C) and is frequently but not always more shallowly inclined than the low field component. A discussion of the directional information is given below.

Inclination Data

From the histogram of NRM inclinations shown in Figure 5, it is clear that the magnetic inclinations are dominated by a moderately steep,negative component consistent with the samples having been exposed to a strong vertical magnetic field. The similarity between the inclination values of the individual samples as measured at the University of Houston Paleomagnetic Research Laboratory (PRL) and those measured from entire cores on board the *JOIDES Resolution* indicates that this steep overprinting magnetization does not come from spurious laboratory fields in the PRL. Instead, the causative field was encountered by the sediments before they were initially measured. We suggest that it was a coherent magnetic field associated with the drilling operation, perhaps produced by either the core barrel or the drill pipe itself.

Many of the inclination values display a substantial shallowing with progressive demagnetization producing a distribution of values that is bimodal but still skewed toward negative values rather than centered on zero as expected (Fig. 6). Most positive inclinations are small, but negative inclinations persist in being steeper than the predicted inclinations and appear to continue to carry some contribution from the

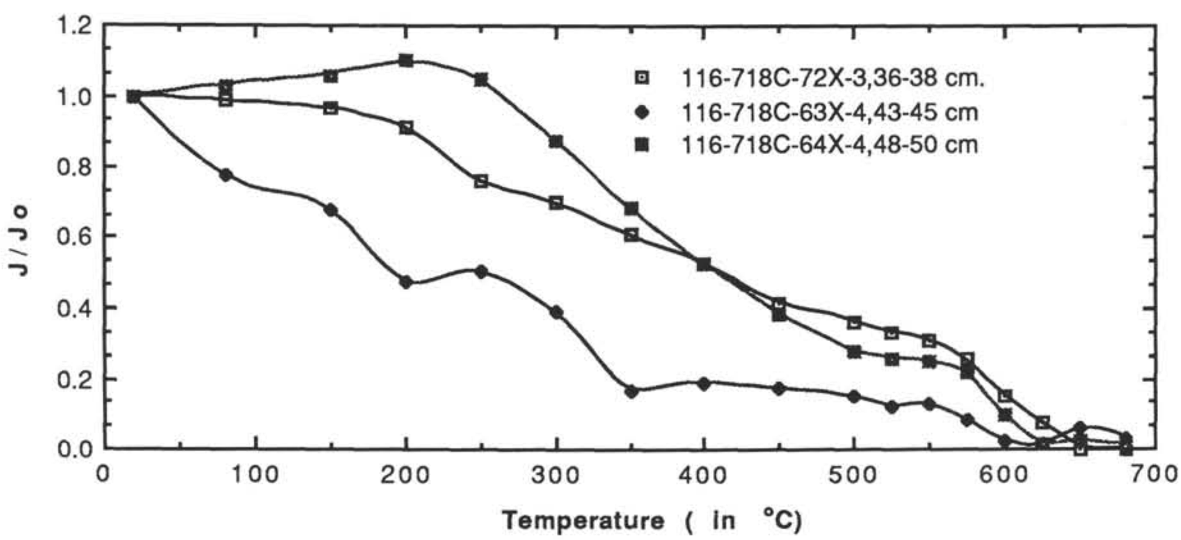

Figure 4. Thermal demagnetization curves of NRM for samples from Hole 718C.

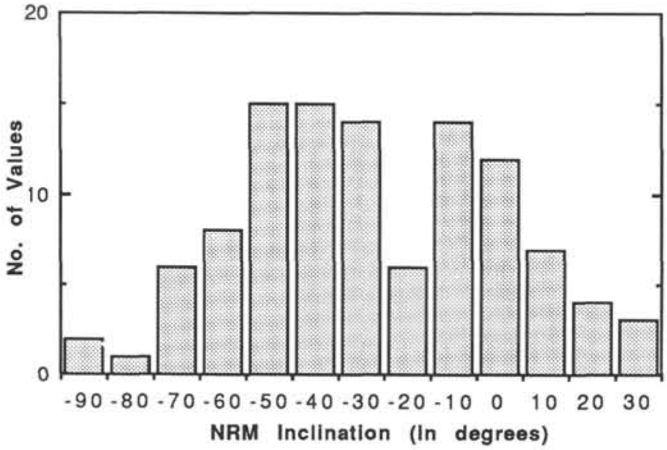

Figure 5. Histogram of NRM magnetic inclination values for all samples studied.

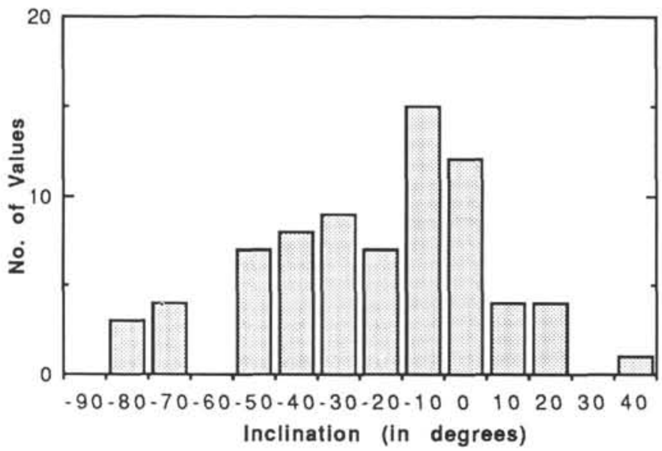

Figure 6. Histogram of magnetic inclination values for samples after alternating field demagnetization through 20 mT.

steep vertical, upward overprint of the drilling process. Comparisons of the mean inclination after demagnetization in 5, 10, and 15 mT fields indicate that the changes in mean value become smaller with progressive demagnetization, implying that a stable magnetization is being reached. This asymptotic behavior may reflect the almost total removal of the drilling overprint or alternatively the removal of only the soft components of this overprint. The fact that many samples continue to display steep inclinations which change little above 20 mT suggests that such samples are more or less completely overprinted and that the original remanence cannot be determined from the demagnetization results.

A number of samples display remarkably consistent steep inclinations (both positive and negative) throughout the demagnetization process obviously reflecting the influence of the drilling. The fact that both positive and negative inclination samples are observed, however, can only be explained in terms of a drilling-induced remanence related to the core barrel. Shipborne measurements of the magnetic field of one of the core barrels showed it to be intensely magnetized (approximately 1 mT). The barrel was demagnetized using a degaussing coil which reduced this field to less than 0.1 mT over most of its length. However, upon its return to the surface after obtaining only one core, the barrel was once again intensely magnetized. Given that the study area is not believed to have held a high latitudinal position during the past 15–20 m.y. we interpret these steep inclinations to be solely due to the drilling process.

Declination Data

Figure 7A is a histogram of the NRM declination values. It is apparent that the distribution of declinations is essentially random and displays no preferred orientations. This is the distribution that is expected from cores obtained with the XCB, which causes the core to break into small biscuit-like pieces that are then rotated by variable but unknown amounts prior to being inserted into the core barrel. The distribution of declination values shows little change with progressive demagnetization and a more or less random distribution of values persists at 20 mT (Fig. 7B). It is interesting to note that demagnetization produces very little change in the individual declination values in marked contrast to its effect upon the inclinations. Figure 8 shows a plot of NRM declinations against the declinations after demagnetization through 20 mT. Demagnetization at 20 mT has been chosen for this comparison as the majority of samples have median destructive fields (MDF) of approximately this amount. Declinations at other demagnetization steps < 40 mT do not differ significantly from those at 20 mT. In addition, principal-component analysis indicates that in nearly all cases, the stable remanence is isolated by fields of 20 mT or less. In light of the inclination results, the correlation between these declination values can only be explained if we assume that the magnetic field due to drilling is essentially vertical (i.e., axial to the core barrel itself). If the overprint has a significant horizontal component, then we would expect the individual declination values to change between their NRM values and those determined after demagnetization through 20 mT. Figure 9 shows the change in inclination between NRM and 20 mT plotted against the corresponding change in declination. It is clear that the inclinations are affected substantially more by the demagnetization than are the declinations. From our results it is not clear whether the AF demagnetization is entirely successful in removing the influence of the overprint. Consequently, we feel that it is extremely unlikely that reliable information concerning the original remanence can be obtained from these samples.

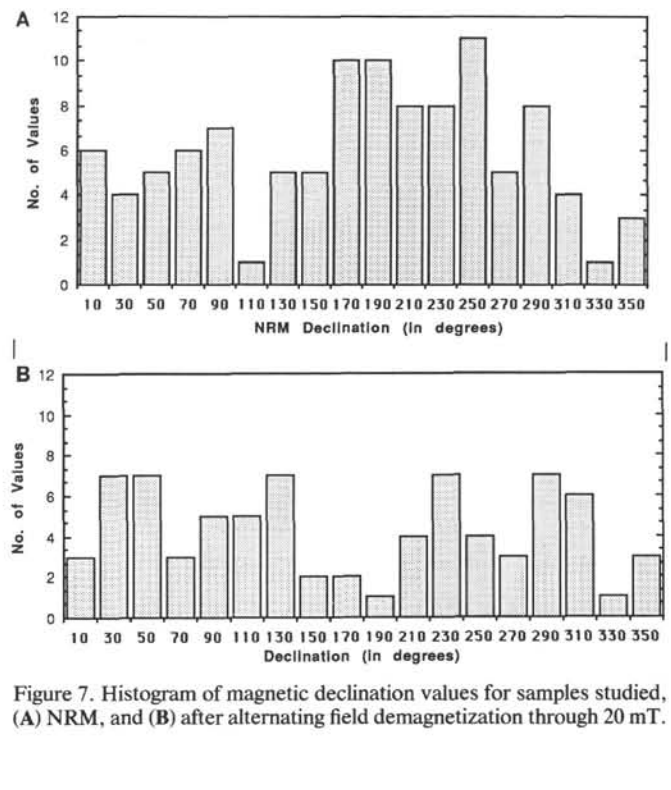

Figure 7. Histogram of magnetic declination values for samples studied, (**A**) NRM, and (**B**) after alternating field demagnetization through 20 mT.

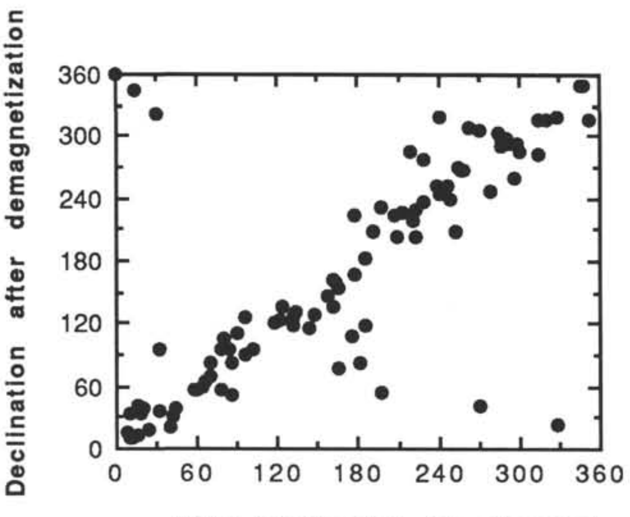

Figure 8. Magnetic declination after alternating field demagnetization through 20 mT plotted vs. NRM magnetic declination.

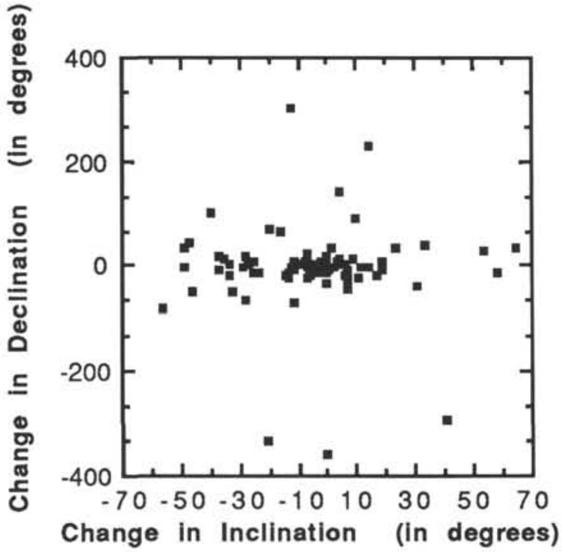

Figure 9. Change in magnetic declination after alternating field demagnetization through 20 mT plotted vs. the change in magnetic inclination after alternating field demagnetization through 20 mT.

To investigate the coherence of the declination values, they were compared with the direction of maximum anisotropy of magnetic susceptibility. The distribution of maximum AMS directions is unknown but is assumed to have a uniform, dominant trend. As both the declinations and the directions of maximum AMS are related to the coordinate axes of individual samples, meaningful magnetizations, (i.e., those not dominated by the drilling overprint) might be expected to have a constant angular relationship with the azimuth of maximum susceptibility. Turbidites, however, are known to show complex flow structures that vary considerably from top to bottom (Ledbetter and Ellwood, 1980) and consequently the AMS directions may possibly encompass a broad range of azimuths. Figure 10 is a histogram of the angular difference between the magnetic declinations and the azimuthal values of maximum AMS. Because of the ambiguity involved in defining both azimuths, the smaller angular difference has been plotted. Unfortunately, in spite of over 51 samples examined, there appears to be no dominant value for this angular difference. The large scatter in the angular differences (Fig. 10) indicates a lack of consistency in the "stable" magnetic declinations and/or the maximum AMS azimuths.

MAGNETIC MINERALOGY

IRM Analysis

Ten samples were used in isothermal remanence acquisition (IRM) experiments in which the samples were placed in progressively stronger magnetic fields up to a maximum of 700 mT and their magnetization measured. The results of these IRM experiments (Fig. 11) show that samples display two types of behavior. Samples such as 116-717C-91X-1, 97–99 cm, display a sharp increase in magnetization in fields less than 150–200 mT followed by a slow increase through 700 mT. The rapid increase in magnetization in low fields is typical of magnetite, which because of its high spontaneous magnetization tends to dominate the IRM even when it is less abundant than other minerals. The second type (e.g., Sample 116-718C-94X-3, 37–39 cm) displays a more continuous increase through 700 mT and is consistent with the dominant presence of a high-coercivity mineral such as hematite but may also be due to goethite (Dekkers, 1989b). Both types of behavior are indicative of the simultaneous presence of low- and high-coercivity minerals. The differences appear to reflect the relative contributions from each of these mineral types. Because of the high spontaneous magnetization of magnetite, magnetite is probably substantially less abundant in those samples such as 116-718C-94X-3, 37–39 cm that exhibit a slow increase in magnetization. As only 10 samples were used in this analysis, however, it is difficult to make general statements, but there appears to be little correlation between the presence or absence of the low-coercivity mineral(s) and the gross lithology. There is some evidence from detailed studies of the black mud turbidites to suggest that magnetite may be more abundant in these types of turbidite (Sager and Hall, this volume). As noted above, however, differences in the magnetic properties of individual classes of turbidite are often as large as the differences between the classes.

Thermomagnetic Analysis

Thermomagnetic analyses were carried out at the paleomagnetic facility at the University of Texas at Arlington. Samples were heated between room temperature and 700°C in vacuum in the presence of a magnetic field. Results from two

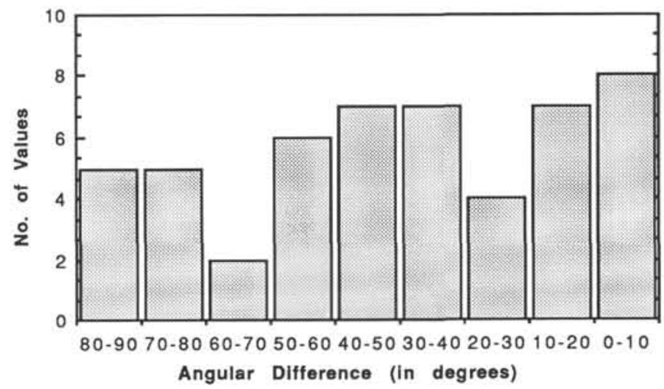

Figure 10. Histogram of the angular difference between the magnetic declination after alternating field demagnetization through 20 mT and the azimuth of maximum AMS.

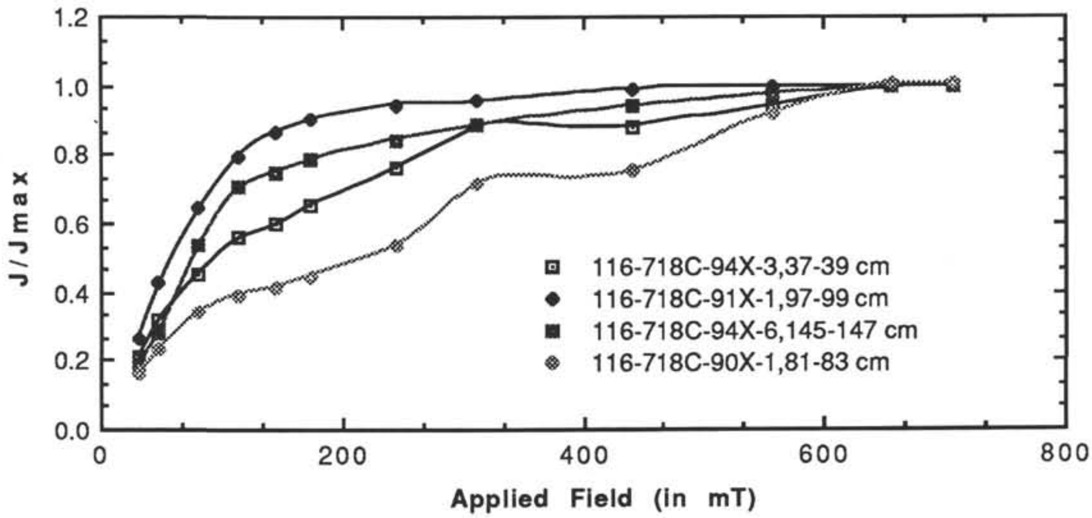

Figure 11. Normalized isothermal remanent magnetization (IRM) acquisition curves for Samples 116-718C-90X-1, 81–83 cm; 116-718C-94X-6, 145–147 cm; 116-718C-94X-3, 37–39 cm, and 116-717C-91X-1, 97–99 cm.

of these samples (Fig. 12) show irreversible behavior consistent with the conversion of a high-magnetization component to a lower magnetization component. The heating cycle for Sample 116-718C-95X-1, 48–50 cm (Fig. 12B) shows a remarkably constant intensity between 150° and 400°C followed by a major, steep decline in intensity between 500°C and 600°C that is consistent with the removal of a mineral whose blocking temperature lies within this range. In light of the results of the IRM study it is likely that this mineral is magnetite (or a low Ti-magnetite). The magnetization, however, continues to decrease through 700°C albeit at a slower rate indicating the presence of a mineral whose blocking temperature exceeds the Curie point for magnetite. The cooling cycle is markedly linear, increasing steadily down to 50°C and eventually reaching 90% of the initial, pre-heating intensity. This behavior is consistent with distributed blocking temperatures carried by a mineral whose Curie point appears to be just less than 600°C.

Sample 116-718C-94X-3, 37–39 cm (Fig. 12A), displays a somewhat more continuous decrease during heating and does not increase in slope until 550°C. Above 610°C the intensity continues to decrease, but very slowly. During cooling the magnetization increases by a very small amount, reaching only about 10%–15% of the initial value. The dramatically lower intensity during the cooling cycle clearly indicates the conversion during heating of a strongly magnetic mineral phase to one with a much smaller spontaneous magnetization. A likely candidate for such behavior is maghemite which converts to hematite upon heating. Maghemite has a spontaneous magnetization similar to magnetite and is therefore believed to be responsible for the large magnetization displayed during the heating cycle.

Both samples show a sudden decrease in intensity upon heating between 50°C and 150°C followed by a slower decrease through 500°C. This decrease is ascribed to the removal of contributions from a low blocking temperature mineral. The mineral accounts for only about 10% of the initial intensity for Sample 116-718C-95X-1, 48–50 cm, but approximately 30% for Sample 116-718C-94X-3, 37–39 cm. Because of the irreversible nature of the magnetization it is likely that this low-temperature mineral undergoes chemical conversion during heating and therefore contributes little to the intensity during cooling. An alternative explanation of the decrease in magnetization between 50°C and 150°C is that it is due to dehydration of the samples and simply represents a mass loss. In the case of Sample 116-718C-95X-1, 48–50 cm, this is a reasonable possibility as the intensities at 50°C before and after heating differ by almost exactly the amount of the observed sudden decrease. In the case of Sample 116-718C-94X-3, 37–39 cm, however, the change in intensity is too large to be accounted for in this way. In thermal demagnetization experiments, the turbidites underwent weight losses of generally less than 10% between 20° and 700°C. In addition, in experiments carried out on black mud turbidites (Sager and Hall, this volume), samples were dried for three days at 100°C and underwent similar small weight losses. For this sample, the situation is not as clear, because the cooling curve shows very little change in intensity during cooling from 500° to 50°C. A possible candidate for this low-temperature mineral is goethite which has a Neel temperature of approximately 110°C (the exact temperature depends upon the amount of isomorphous substitution in the goethite (Dekkers, 1989a)). Goethite is known to dehydrate and convert to hematite upon heating above 350°C (Strangway et al., 1968). Once above this temperature, therefore, cooling the sample will reflect the contributions from the hematite. The change from goethite to hematite can produce either an increase or decrease in magnetization depending upon the grain size of the resulting hematite (Strangway et al., 1968). When the grain size is larger than 0.5 μm, the hematite shows characteristic ferromagnetic behavior. At smaller grain size, a weak thermal remanence is acquired that displays none of the usual ferromagnetic properties. In neither of the samples shown in Figure 12 is there any substantial change in intensity in heating or cooling through this temperature range. The cooling behavior of Sample 116-718C-95X-1, 48–50 cm, suggests that a single mineral, magnetite, is present whereas the heating curve indicates the presence of possibly three mineral types: magnetite, hematite, and possibly goethite. This suggests that heating of the sample has converted the hematite and possibly the goethite (via hematite) to magnetite of various grain sizes and has thereby produced the distributed blocking temperature behavior (Fig. 12). This appears to be corroborated by the extremely small change in intensity upon cooling this sample from 700° to 580°C.

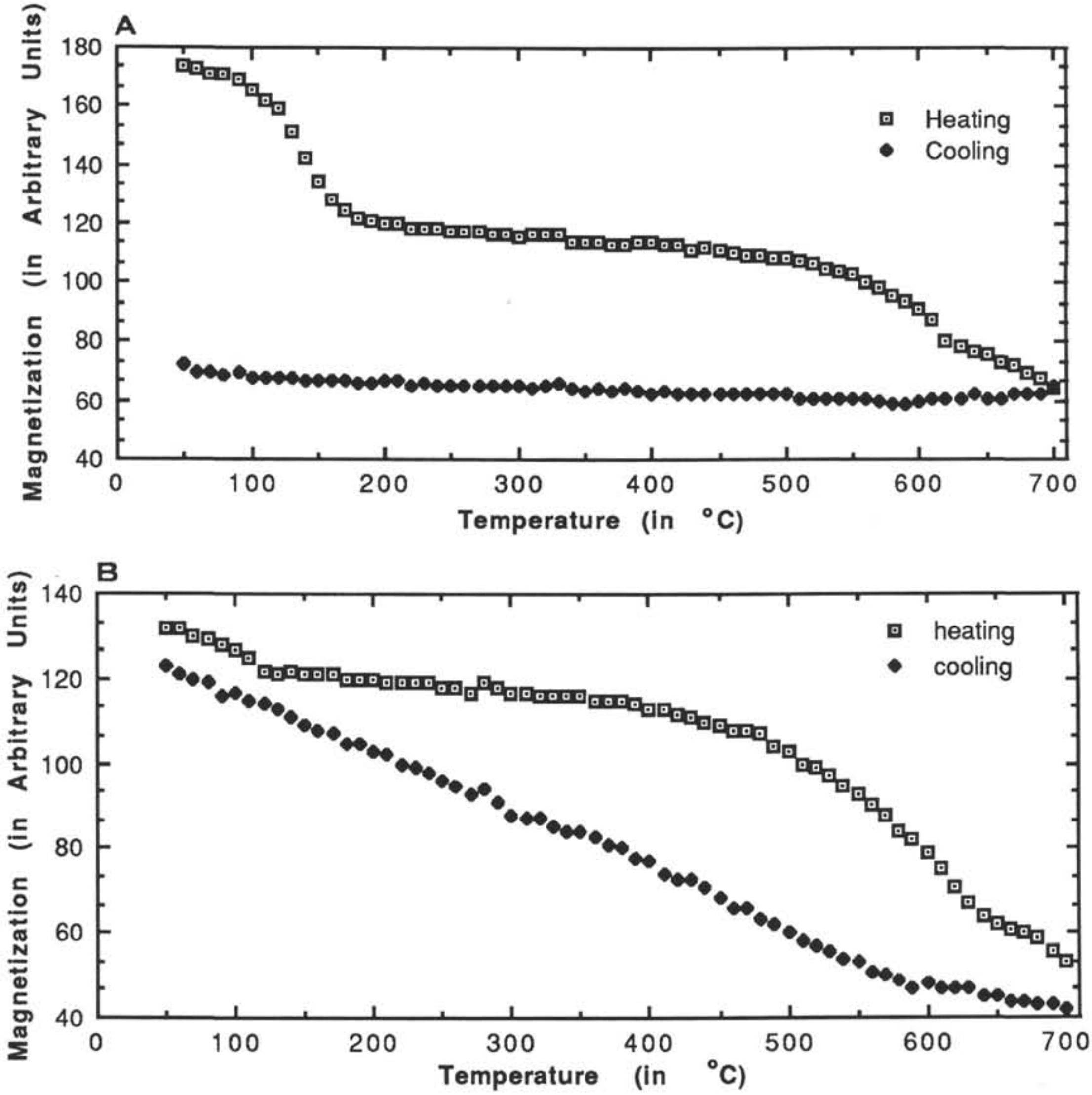

Figure 12. Thermomagnetic analysis. **A.** Sample 116-718C-94X-3, 37–39 cm. **B.** Sample 116-718C-95X-1, 48–50 cm.

Anisotropy of Magnetic Susceptibility

The anisotropy of magnetic susceptibility (AMS) of 51 samples was determined using the facilities at the University of Texas at Arlington and the University of Hawaii. Nearly all samples show a maximum anisotropy that is nearly horizontal, indicating a sedimentary fabric. Figure 13 shows a plot of the NRM intensity against the mean susceptibility for each of these samples. As in the case of the azimuths of maximum AMS and magnetic declinations described above, there is no apparent correlation between the NRM intensity and susceptibility. The remanent intensities after AF demagnetization through 20 mT show that even with the partial or complete removal of a drilling-induced remanence, there is still no obvious correlation between the remanent magnetization and the magnetic susceptibility. This is in marked contrast to the results from some individual turbidites (see Sager and Hall, this volume), which show a high degree of correlation and appear to reflect the dominance of small, possibly single domain, ferromagnetic grains in these sediments (Dunlop, 1986).

A major reason for carrying out these measurements was to try to obtain some directional control for the cores by comparing the azimuths of maximum AMS with the declinations of any stable remanence present in the samples. Unfortunately, as described above, there appears to be little consistency between these azimuthal directions and in fact the differences appear to be fairly random (Fig. 10). Choosing only those

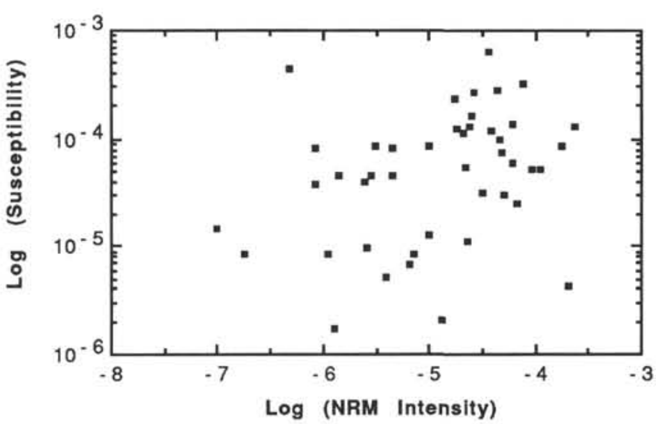

Figure 13. Mean magnetic susceptibility plotted vs. NRM intensity of samples. Both scales are logarithmic.

measurements with high reliability does not appear to improve the consistency. In addition, there seem to be no differences in the consistency of directions between the different lithologies.

In addition to the directional information provided by the AMS measurements, there is also information on the degree of anisotropy. The ratio of maximum to minimum susceptibility, used here as a measure of the degree of anisotropy, lies in the range 1.0–1.2 with a majority of samples grouping between 1.0 and 1.1. A plot of this ratio vs. class of turbidite is shown in Figure 14. In a similar way to other magnetic parameters, the degree of anisotropy does not correlate with lithologic type but rather appears to suggest that all turbidites exhibit a range of anisotropies. A detailed study of AMS from a black mud turbidite in Core 116-717C-48X also shows a broad range of anisotropy, further illustrating the internal variability of many rock magnetic parameters.

CONCLUSIONS

The remanent magnetizations of turbidites drilled in the central Indian Ocean during Leg 116 are dominated by a strong, near-vertical component produced by the drilling process. Although this component was partially removed during demagnetization, steeper than predicted magnetizations indicate that a significant portion remains in the bulk of the samples examined. Consequently, few reliable magnetization directions were obtained and it was not possible to determine paleolatitudes of the sites with any confidence.

Rock magnetic studies including IRM acquisition experiments, thermomagnetic analyses, and anisotropy of magnetic susceptibility measurements indicate no characteristic behavior correlated with turbidite lithology (i.e., organic-rich, organic-poor, etc) but rather a wide range of magnetic behavior that varies as much within each type of lithology as between different types. The magnetic properties of samples are consistent with the presence of both high and low-coercivity minerals. There is strong evidence for magnetite (or low Ti-magnetite) in many of the samples but maghemite probably also plays a significant role. The low-temperature behavior of many samples during thermomagnetic analysis indicates significant amounts of a mineral with a blocking temperature of approximately 100°C, which thermal demagnetization results suggest is goethite. No evidence of pyrrhotite was found in spite of abundant amounts of pyrite in the cores.

AMS measurements carried out on samples of all four turbidite classes show a clear sedimentary fabric with the axis of maximum susceptibility in all cases dominantly horizontal. The degree of anisotropy is typically 10% (i.e., maximum/minimum susceptibility = 1.1) and appears to be independent of the lithology of the turbidite. Unfortunately, because of the lack of azimuthal control, it was not possible to determine whether there are systematic differences between the direction of maximum susceptibility and the type of turbidite involved. Nor was it possible to test for systematic variations in the direction of maximum susceptibility between the top and bottom of individual turbidites.

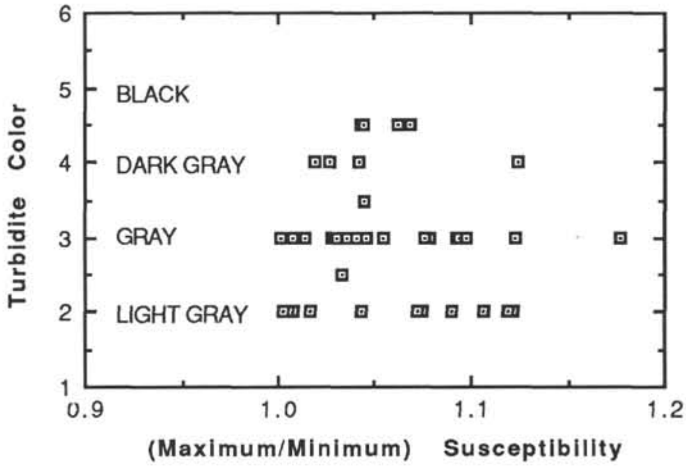

Figure 14. Degree of magnetic anisotropy, expressed as (maximum/minimum) magnetic susceptibility, plotted vs. turbidite color.

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