APPENDIX

MAGNETIC EXPERIMENTS[1,2]

INTRODUCTION

As noted in the Handbook for Shipboard Paleomagnetists (Stokking et al., 1993), a common feature of the paleomagnetic record of recovered core is a vertically downward magnetization, much of which is frequently an easily demagnetized, or soft, magnetization removed by ~10-mT demagnetization. There is also sometimes a radially inward horizontal component, which on occasions has precluded on board magnetostratigraphy (e.g., Leg 154). This radial component of magnetization and some of the vertical component tend to be magnetically harder, or less easily demagnetized.

It has frequently been suggested that the repeated banging of the APC barrel as it passes up the pipe might impart a shock magnetization to the core inside the barrel. During the trip up the string, the core is in the magnetic field of the APC barrel and the field of the drill pipe that leaks through the APC barrel. A second obvious source of contamination is the coring process itself, in which the sediments are known to be deformed and maybe partially remobilized, before they eventually come to rest in the APC barrel. It is not presently clear how much of the magnetic contamination is acquired during coring and how much during passage up the pipe.

On Leg 174B, two experiments were carried out to investigate the problem of magnetic contamination. The first related to contamination acquired in the trip up the barrel and the second to contamination acquired during coring.

EXPERIMENT 1: INVESTIGATION OF MAGNETIC CONTAMINATION ACQUIRED IN THE DRILL PIPE

This experiment was designed to check the effect of passage up the pipe on the paleomagnetic record of recovered core. Wash cores from Leg 174A, Sections 174A-1071C-1W-1, 174A-1073A-1W-1, 174A-1073A-1W-2, and 174A-1073A-1W-3, were used in the experiment. The experiment also compares the effect of passage up the string in a standard APC barrel with passage in a specially fabricated nonmagnetic barrel. For the experiment, a special 10-ft inner core barrel (ODP OP3212) was made of 15-15-LC (15% manganese low-carbon austenitic stainless steel) and a second 10-ft inner barrel (ODP 3217) was made of standard 4130 steel (chrome molybdenum, 0.3% carbon).

Experimental Plan

The experimental plan was as follows: (1) initial magnetic survey of the two barrels; (2) measurement of the magnetization and demagnetization of the wash cores to be used in the experiment to establish their demagnetization characteristics and to reduce their magnetization to make any contamination acquired in the pipe more readily analyzed; (3) loading cores in barrels and tripping of the cores; (4) remeasurement and demagnetization of the cores to analyze the demagnetization spectrum of any contamination acquired during tripping; and (5) repetition of the magnetic survey of the barrels to see the effect on their magnetization of tripping.

Results

Magnetic Survey of Nonmagnetic and Standard Barrels

The magnetic survey of the barrels was carried out with the barrels held in the shucks by the rig floor alongside the passage to the catwalk. Measurements were made with a Walker Scientific MG-5D Hall probe with a quoted accuracy 0.01 Gauss (0.001 mT). They were taken every 20 cm downcore and beyond the end of the core. The vertical field was measured axially and also off center ~5 mm from the inner wall of the barrel. The offset measurements were made at 90° intervals, starting at a locator mark on the core barrels. The radial and tangential fields were also observed off center at the same intervals.

Figure 1 shows the vertical fields of the two core barrels measured ~5 mm from the inner wall of the barrel. The fields are dominantly downward with a smaller radially inward horizontal component. At the bottom of the barrels at ~3 m, a very clear distinction is seen in the magnetic signatures. The nonmagnetic barrel has no significant feature at the bottom of the barrel (Fig. 1), whereas the standard barrel has a classic end anomaly, analogous to that at the edge of an infinite thin sheet (Fig. 1). Hence, the nonmagnetic barrel is indeed much less magnetic than the standard barrel. Measurements were made around the inside of the barrels in the offset position, but the magnetic fields did not depart strongly from axial symmetry. Toward the tops of the barrels the contrast between the two barrels is less apparent than below. The nonmagnetic barrel appears to be somewhat more strongly magnetized than the standard barrel. However, this is an artifact of the experiment: the magnetic field from the drill floor and shucks leaks through the nonmagnetic barrel more than through the standard barrel.

Magnetic Measurements of Cores

The wash cores were measured as whole cores on the 2G magnetometer and demagnetized at 2, 5, 10, 15, 20, 30, and 50 mT before tripping. There is a strong vertical component that is readily demagnetized and smaller horizontal components. The detailed description of the magnetization is given below when it is compared with the magnetization after tripping.

Tripping

The core liner sections were joined with shrink wrap. To reduce the possibility of relative rotation, a plastic slat was placed in cuts in the ends of adjacent core liners. The sections were assembled as they were loaded into the barrels. The locator mark on the core barrels was aligned with the double line on the core liner. The core sections were loaded into the barrel upside down to pick up a soft component on the tripping in the opposite direction to that originally acquired for ease of analysis. The barrels were then picked up and tripped into the hole above a temperature probe.

The barrels passed out of the bottom-hole assembly into the hole. The hole penetrated basalts, but the field as measured in previous logging was not significantly larger than the local geomagnetic field: B(h) varied between 24 and 32 mT and B(z) between 22 and 30 mT (Bosum and Kopietz, 1990; Hamano and Kinoshita, 1990). These fields are smaller than the fields in the APC barrels and those in the pipe, so that the passage into the hole should not degrade the experimental observation of the effects of the drill pipe. The temperature in the hole was close to 20°C. This is sufficiently close to the laboratory temperature at which observations are made that it is not a significant factor.

On recovery, a core-catcher section placed at the top of the assembled sections was destroyed, and the bottom 20 cm of wash core from Section 174A-1073A-1W-2 were substantially disturbed. However, the remaining sections (Sections 174A-1073A-1W-1, 174A-1073A-1W-3, and 174A-1071C-1W-1) appeared to be essentially intact. In addition, the cores had picked up water.

Measurement of Magnetization of Cores After Tripping

On recovery, the wash cores were again measured and demagnetized with the same sequence of steps used before tripping. The comparison between before and after tripping is shown in Figure 2 for inclination and intensity. The inclination in the initial magnetization state, or Natural Remanent Magnetization (NRM), is near to vertical and positive. Demagnetization to 50 mT reduced the inclination, but it remained dominantly positive. The intensity plots reveal the demagnetization of a strong soft moment, so that after demagnetization the intensity has dropped by an order of magnitude from 0.1 to 0.01 A/m. After tripping, the inclination has changed to nearly vertical in the negative sense, reflecting the acquisition of magnetization in the opposite sense to the initial soft moment, because the cores were loaded inverted in the barrel. A soft moment has again been acquired, but it is not so large as the initial soft moment in the NRM. However, this vertical component was sufficient to switch the inclination from high positive to high negative values. Upon demagnetization, the moment picked up in the trip is lost, and the magnetization is similar to that it had before tripping.

These results demonstrate that the magnetic contamination picked up in tripping is soft and readily demagnetized by AF demagnetization. It is also clear that the soft moment picked up on this occasion in the pipe is not as large as the wash core acquired during initial recovery. The magnetization acquired in tripping is consistent with earlier related observations of magnetic contamination in that the magnetization is soft and usually almost vertically downward (e.g., Stokking et al., 1993).

Survey of Barrels after Tripping

The barrels were returned to the shucks after unloading following tripping, and their magnetic fields remeasured. Measurements were made of the vertical fields in the same offset position. The nonmagnetic barrel remained as before (Fig. 1). Both axial and radial fields measurements reflected a homogeneous field that offset the whole record and the local field from the deck and chuck that accounts for the contrast at the top. The survey of the standard barrel revealed a significant increase in the magnetic contrast at the bottom of the barrel, indicating that tripping had increased its magnetization. This is also consistent with an earlier result (Stokking et al., 1993).

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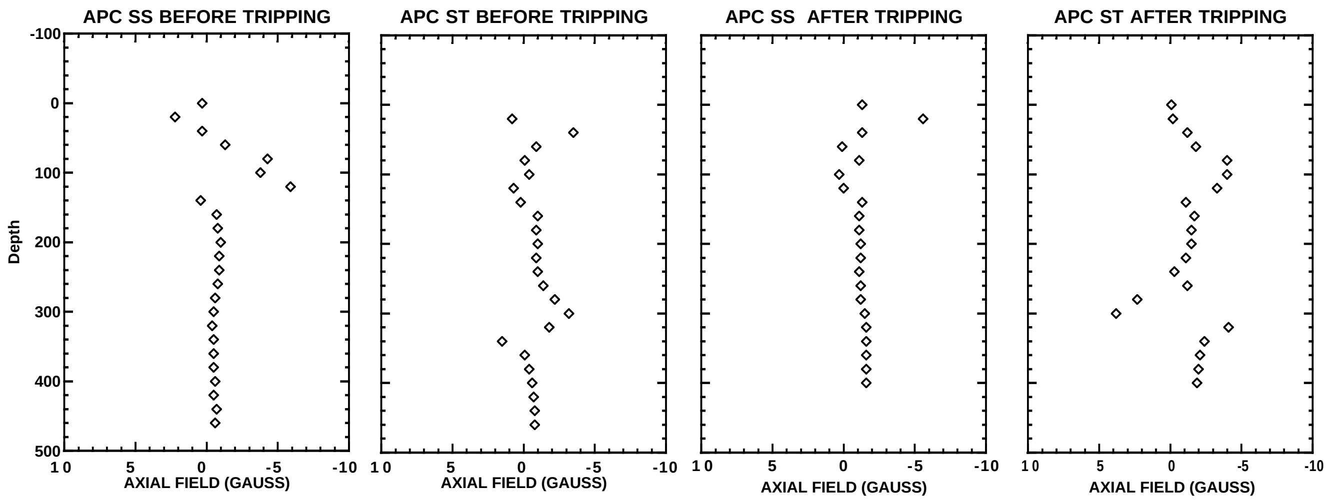

Figure 1. Magnetic fields of barrels before and after tripping. ST is the standard steel core barrel, SS is the stainless (austenitic, nonmagnetic) steel core barrel.

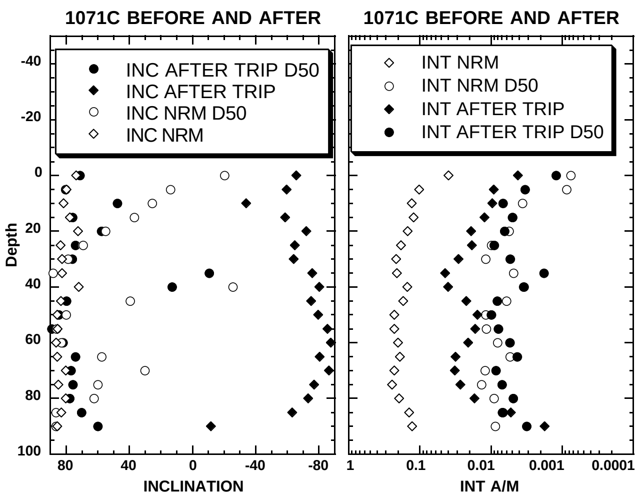

Figure 2. Comparison of magnetization of wash-core Section 174B-1071C-1W-1 before and after tripping.

Conclusions

This experiment has demonstrated that relatively strong, predominantly downward contamination is acquired during passage up and down the drill string. The contamination is largely soft and readily demagnetized. The experiment has also demonstrated that whereas the standard barrel increases its magnetization on tripping, the nonmagnetic barrel remains unchanged. It is not yet evident whether there is a significant difference between the contamination picked up in the nonmagnetic and the magnetic barrels, but additional work onshore should clarify this.

EXPERIMENT 2: INVESTIGATION OF THE EFFECT OF NONMAGNETIC BARRELS ON CONTAMINATION ACQUIRED DURING APC CORING

Introduction

The decision to carry out APC coring permitted a test of the effect of the nonmagnetic barrel on the magnetization acquired during the APC-coring process. A composite barrel consisting of the special nonmagnetic barrel, the special standard barrel, and the necessary subs required to make the length of the barrel such that the end of the shoe was in the appropriate position was assembled. Cores were drilled with this barrel, alternating with a standard APC barrel. The first core was obtained with the standard APC barrel and shoe. The second barrel was the first with the nonmagnetic barrel, which had a new standard shoe. The next four cores were all taken with Adara shoes and oriented with the tensor tool. Cores 4H and 6H were taken with the special barrel, including the nonmagnetic section.

Magnetic Measurements

All cores were split in the normal manner, and the archive halves run through the 2G cryogenic magnetometer. Discrete samples were also run to compare the behavior of the core in nonmagnetic sections of the barrels of Cores 174B-1074A-4H and 6H with sections collected in standard barrels.

Results

Archive-core results from the sections of Cores 174B-1074A-2H, 4H, and 6H collected in the nonmagnetic barrels were not distinguishable from those that were taken in the standard sections. All had declinations close to 0° in the ODP convention, in the direction that is radially inward (Fig. 3).

In Sections 4H-5 and 6H-5, there is a major anomaly in the magnetization of the sediments (Fig. 4) that persists after demagnetization to 30 mT. This anomaly is found at the point in the core at the join of the nonmagnetic barrel below to the standard barrel above. This is precisely where the 5 Gauss or 0.5-mT field at the bottom of the standard barrel would leak through the nonmagnetic barrel to give an anomalous field.

Analysis of the discrete samples is incomplete, but their intensity of magnetization and demagnetization characteristics are not consistent with a simple ocean sediment magnetization of in the geomagnetic field. This behavior is similar to that found on Leg 157 (Fuller et al., 1998).

Discussion

Evidently, the nonmagnetic barrel does not solve the problem of radial moments. However, in conjunction with the experiment on the effect of tripping, the relative importance of contamination acquired in the pipe vs. in the APC barrel before it returns up the pipe was demonstrated. The presence of the magnetization anomaly demonstrates that hard magnetization can be acquired if there are strong fields within the APC barrel. From this observation alone we cannot tell whether the magnetization was picked up in the hole, or when the core was returning up the string. However, because there was no comparable anomaly in the magnetization acquired by the sediment in the tripping experiment in which sediment was subjected to the same field at the join of the sections, we can be sure that this contamination was picked up when the sediment came to rest in the barrel on the seafloor.

It appears that the primary cause of the magnetization must be in the coring process and must take place as the shoe hits the sediments. Earlier work (Herr et al., 1998) had demonstrated that the magnetic susceptibility anisotropy of the sediments was controlled by a deformation fabric that defined planes of easy magnetization arranged in a cone-like configuration with the apices upward. This is consistent with the downturning of the bedding planes often seen at the margin of the cores. However, the magnetization is not in this plane. It is very roughly at the pole of the plane. Hence, it is very unlikely that the deformation alone can explain the magnetic contamination and more likely that the coring process provides the energy, possibly remobilizing the sediment and realigning particles in the field of the shoe.

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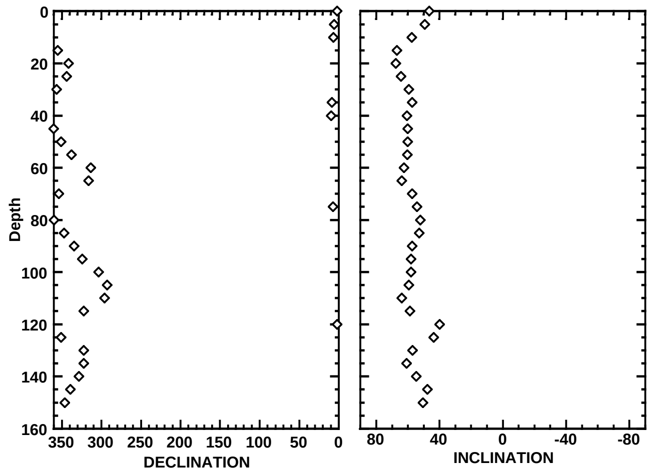

Figure 3. Declination and inclination after demagnetization to 30 mT of the archive half of Section 174B-1074A-6H-6 collected in nonmagnetic barrel length.

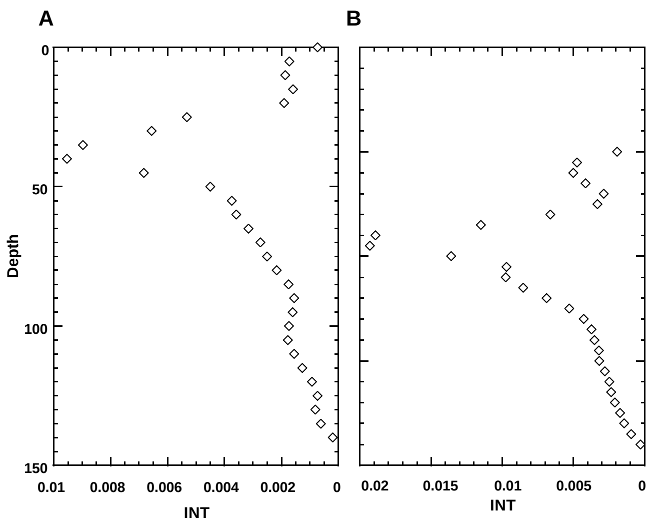

Figure 4. Magnetic anomaly in sediment magnetization intensity at the join of core barrels. **A.** Section 174B-1074A-4H-5. **B.** Section 174B-1074A-6H-5.

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