47. MAGNETOMETER MEASUREMENTS ON THE DRILLING FLOOR OF THE *GLOMAR CHALLENGER:* POSSIBLE CAUSES OF ROCK REMAGNETIZATION[1]

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ABSTRACT

Cursory shipboard magnetic surveys were conducted on the *Glomar Challenger's* drill rig floor. The surveys included measurement of the field associated with: the drill string, with 1300 m of pipe extended below the ship; the drill pipe stored on the pipe racks at the bow of the ship; and the core racks where the core liners are cut to 1.5-m segments. The results of these measurements indicate that rocks are being exposed to very large magnetic fields associated with the core racks. As a result of these studies, scientists on the *Glomar Challenger* requested that the steel core racks be replaced by aluminum ones during the dry-dock period subsequent to Leg 75. By utilizing a less magnetic metal, the possibility of remagnetization of core material should be greatly reduced.

INTRODUCTION

During Leg 75 of the Deep Sea Drilling Project (DSDP), rudimentary magnetic surveys were conducted on the drill rig floor of the *Glomar Challenger.* These surveys were conducted in order to evaluate the potential for remagnetization of rocks while on the drill rig floor, subsequent to drilling. Previous magnetic-field measurements of this type by Peterson were restricted to the field associated with the drill bit.

The surveys outlined here were made while the drill string was down, at site, with a total of 1300 m of pipe extended below the ship, subsequent to drilling DSDP Hole 532B. Ideally, these measurements should have been made in calm seas. Because of the motion of the ship, however, the precision in measuring orthogonal components of the field for this type of survey, was poor. Following this study, shipboard surveys were conducted while the *Glomar Challenger* was in port. These studies by Levi (pers. comm.) should be more accurate. Nevertheless, since the two shipboard surveys involved different types of measurements and concentrated on different aspects of the drilling platform and equipment, we will briefly outline our observations for the benefit of subsequent investigators.

Our observations indicate that the largest field that the cores are exposed to is associated with the core racks where the cores are cut into sections. Neither the fields on the rig floor nor those associated with the drill string or with individual stands of pipe compare in magnitude to those observed at the core racks.

MAGNETOMETER SURVEY

The shipboard Schonstedt digital (Heliflux) magnetometer was used for this study. The sensing range of this machine is 2000 milligauss or 200,000 gammas (0.01 mG = 1 γ). The procedure followed in surveying was to measure the orthogonal components of the magnetic field associated with a given object on the drill floor. These measurements were made relative to the bow of the ship. Each point included measurements in both a positive and negative direction in an orthogonal framework (see Fig. 1). Several 1-m-long rulers were used on the drill floor as a framework for the orthogonal measurements. While one person positioned the probe and read aloud the six magnetometer measurements made at each point, a second person recorded the m. The measurements were made progressively from +100 or +40 cm to −100 or −40 cm distance, at 10-cm intervals about the center of the orthogonal framework (shown in Fig. 1). Often a full survey to 100 cm was not possible since the desired positions were occupied by drill equipment or permanent rails, as was the case with the core rack (Fig. 2).

The zero measurements were repeated at significantly different times; thus, some variation was found. This is probably the result of variations in the positioning of the probe as a result of the motion of the ship, and repositioning of the ship (the *Glomar Challenger's* dynamic positioning system was maneuvering the ship in order to keep the bow headed into the wind). Three course changes occurred during the 1½ hour survey.

In order to calculate the total strength of the magnetic field, we have averaged the positive and negative orthogonal field component values in the *x, y,* and *z* direction (Fig. 1). In a few cases, the intensity of a single component of the field was found to exceed the sensing limit of the magnetometer (±2000 mG), while the same component measured in the opposite direction (±180°) proved to be slightly less than the 2000 mG limit. In this case, we averaged the observed value and the 2000 mG peak value in order to estimate the value of the component.

The magnetic surveys were conducted in three areas:

1) On the drill table, at the center of the drill rig floor;

2) At the drill pipe rack;

[1] Hay, W. W., Sibuet, J.-C., et al., *Init. Repts. DSDP,* 75: Washington (U.S. Govt. Printing Office).

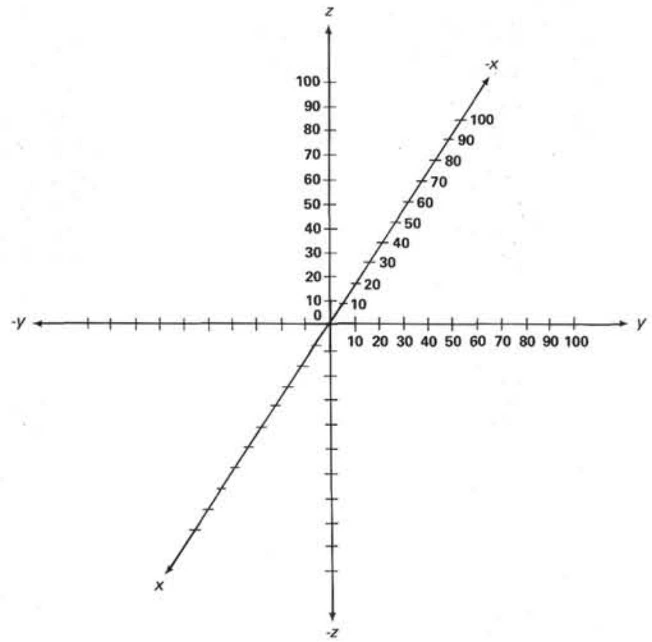


Figure 1. Illustration of orthogonal framework for measurements. The two horizontal axes are 90° apart with the vertical (z axis) 90° from the x and y orthogonal axis. Measurements were made in 10-cm intervals along each axis.

3) At the core rack on the cat walk between the drill rig floor and the core laboratory.

Survey 1—The Drill String

The first survey measured the total strength of the magnetic field at the drill floor near the end of the open drill pipe. This survey was conducted immediately after the drill pipe had been pulled free of the bottom at Hole 532B. Since the bottom depth at this site was 1339.5 m from the drill rig floor, approximately 1330 m of drill string were suspended below the ship. The top of the drill string was positioned 40 cm above the drill floor. The total field intensity calculated for the orthogonal profiles (shown in Figs. 3A and B) are plotted in Figure 4. The fields observed in the horizontal directions at the mouth of the drill string range from 400 to 800 mG (40,000–80,000 γ). The local field strength is on the order of 31,000 γ based upon Total Field Intensity Maps of the area (Defense Mapping Agency Map 39, DMA Stock #WOXZC39, 1975). The field measured above the drill string, however, is exceptionally strong. The field at +40 cm was 1700 mG or 170,000 γ, increasing rapidly away from the drill string. Based upon this cursory survey, we cannot extrapolate the peak field associated with the drill floor and drilling derrick; however, we can say that it is concentrated in the vertical direction. The field in the horizontal plane varies from approximately local field strength to twice the local field strength. At 20 cm inside the drill string the field is negligible (on the order of 3000 γ or 1/10 of the local field strength of the earth). Thus, it is unlikely that the cores are being affected while in the drill string itself, but they may be affected by other objects on the drill floor.

Survey 2—The Pipe Rack

Three sets of magnetic measurements were made near the pipe rack. The measurements consisted of total field intensity measurements in the horizontal plane, at right angles to the drill collars. These measurements were tangential to the upper surface of the drill collars as shown in Figures 5A and B. Three sets of measurements were made: The first was at a joint in the steel pipes connecting the 30-ft. collars; the second set of measurements was made 2 ft. from the end of a steel drill collar in the port rack; the third set of measurements was made 2 ft. from the end of an aluminium drill collar, on the starboard drill pipe rack.

Because the sensing limit of the magnetometer was often exceeded by one or more components of the field, we have arbitrarily assigned a maximum value of 3000 mG (300,000 γ) to measurements which clearly exceeded the limits of the magnetometer for the purpose of illustration. Thus, we are estimating the field in excess of 2000 mG. The field was strongest at the joint between two steel drill collars. Adjacent to the drill pipe, fields were estimated to be approximately 3500 mG. Within 20 cm of the pipe, the field rose to an estimated 4300 mG and then decreased rapidly. The fields associated with the drill collars are shown in Figure 6. The peak field associated with the steel pipe was estimated to be approximately 3300 mG, while the maximum field associated with the aluminium pipe was approximately 800 mG.

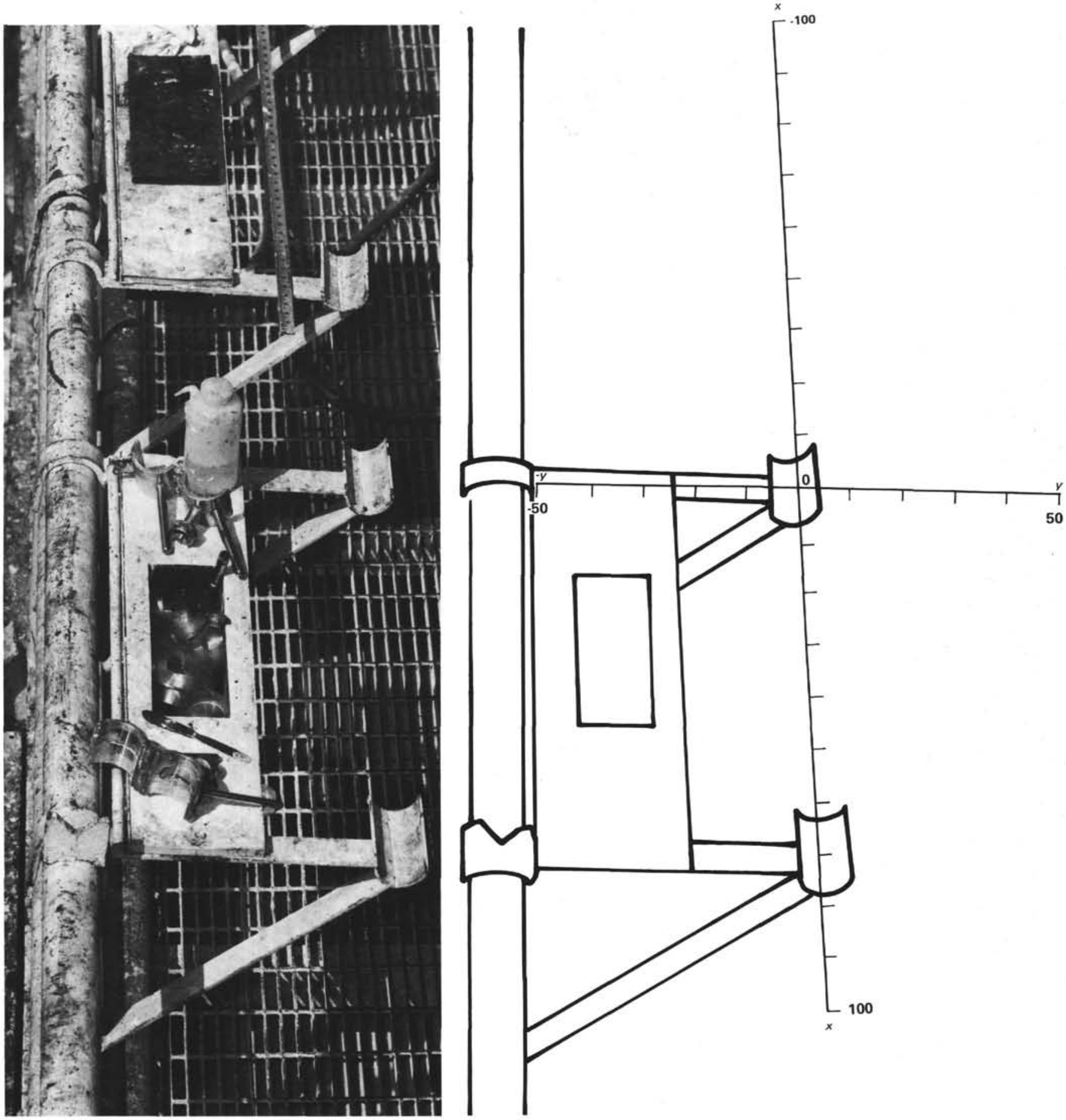
Survey 3—The Core Rack

The third magnetometer survey mapped the field associated with the core rack used to hold the core liner while it is scribed and cut into 1.5-m sections. Surprisingly, the largest fields observed on the ship were those associated with these steel core racks. In fact, the sensing range of the magnetometer was most often exceeded.

For purposes of illustration, we have again arbitrarily assigned a maximum value of 3000 mG (300,000 γ) to measurements which clearly exceeded the limits of the magnetometer. Because the fields found greatly exceeded the sensing range of the magnetometer, it is impossible to estimate the peak fields to which rocks are exposed on the ship due to the magnetization of the core rack. Profiles of the field intensity mapped along the x and y horizontal directions are illustrated in Figure 7. The field directly above and below the arm of the core rack (in the z direction) in the vertical direction and in one horizontal component (the y direction) exceeded the limits of the sensing apparatus. The only field values that could be measured above and below the rack were the components in the x direction; they ranged from 473 to 1907 mG.

OBSERVATIONS

As discussed previously, these measurements are limited. The measurement techniques were severely limited by the time and equipment available and by the stability of the ship in open seas. The observations for the most part were predictable. Our observations indicate that a



A B

Figure 2. A. Photograph of a core rack. B. Sketch of a core rack illustrating the two horizontal axes along which total field intensity was measured every 10 cm. The vertical axis (z) would come off the picture toward and away from the viewer.

large vertical field was associated with equipment above the drill floor.

They also indicate that weak magnetic fields are found associated with the aluminium drill stands (see Fig. 6), and stronger fields are associated with steel drill stands. Stronger fields are present in the vicinity of junctions. Surprisingly, the strongest fields to which core materials are exposed are associated with the racks where the cores are cut into 1½-m sections. These fields are strongest in the horizontal direction above and below the core rack.

These observations are pertinent to paleomagnetic studies of DSDP rock samples since there have been frequent reports of anomalous paleomagnetic directions in core material. Over the last several years, investigators reporting DSDP paleomagnetic results (at the American

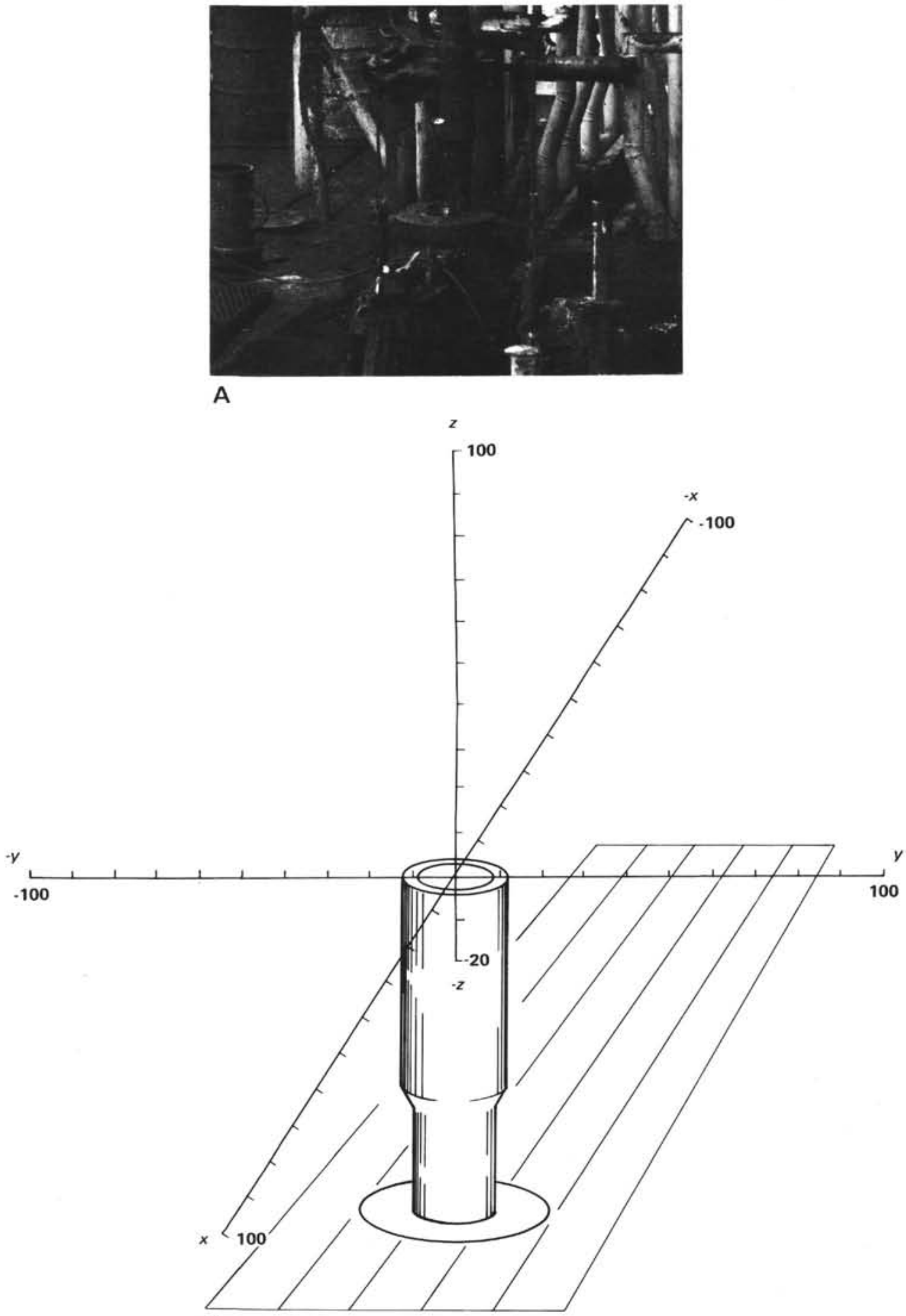


Figure 3. A. Photograph of the drill rig floor with the drill string in position prior to disconnecting joints. B. Measurement framework about the top of the drill string.

Geophysical Union meetings in particular) have observed frequent anomalous paleomagnetic inclinations from both sediments and basalts collected by the Project. This problem, however, has never been addressed in an organized fashion since the observations were made by individuals at various academic institutions around the world. Thus, detailed discussions between investigators were impossible. A brief discussion of this topic, however, was held at the American Geophysical Union meeting in Washington in 1977. The problem of anomalous inclination, while conspicuous, seems to vary in severity. While some investigators find it serious, others do not. Most, however, seem to be aware of the problem.

Our experience reflects that of our colleagues. Magnetostratigraphic studies conducted by Keating and

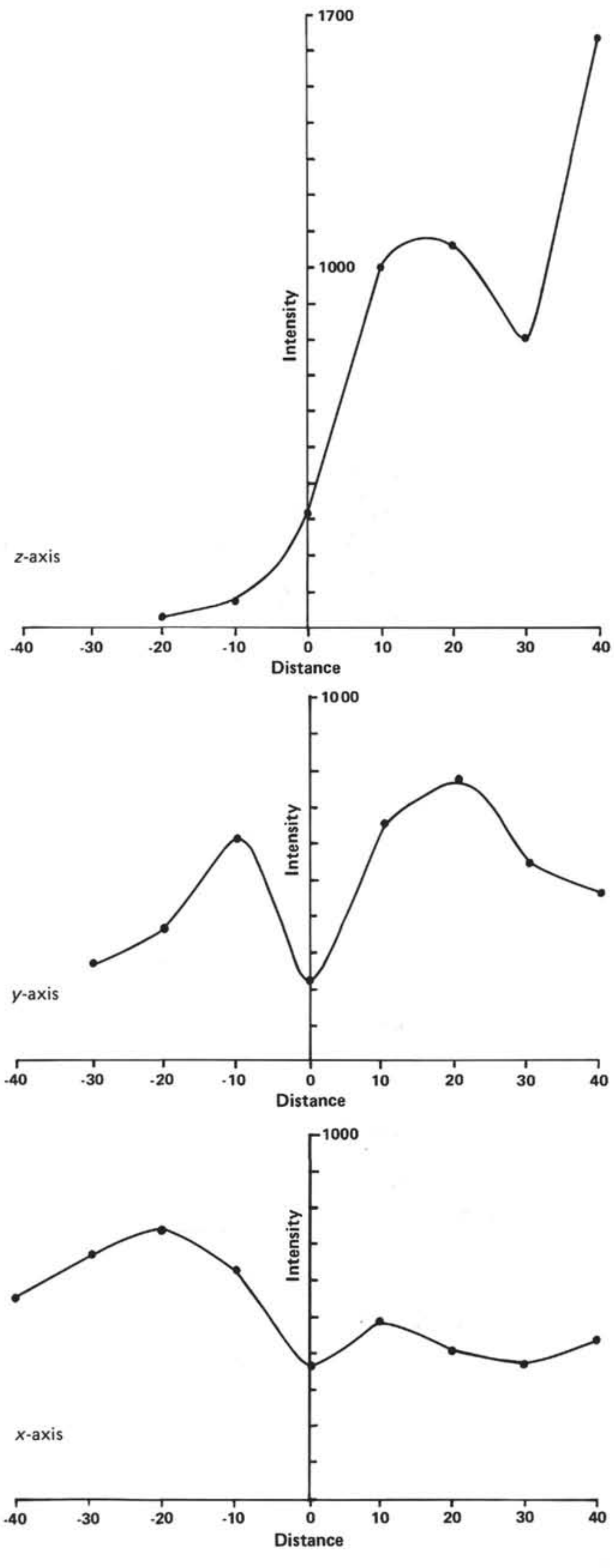


Figure 4. Profile of the total magnetic field intensity associated with the top of the drill string. The horizontal direction is parallel to the length of the *Glomar Challenger*. The positive *y* direction is in the direction of the bow. The vertical field was measured from a height of 40 cm above the collar to a depth of 20 cm within the collar.

Helsley for over a decade on sediments from the DSDP have been (for the most part) restricted to lithified Mesozoic sediments. Within these sedimentary sequences the anomalously high inclinations were observed to a variable extent. Detailed studies were made of sediments from Holes 207 and 208 in an attempt to explain the anomalous directions. Examination of the archive and working halves of the cores in 1974 indicated that there was no detectable sedimentary process associated with the steep paleomagnetic inclinations.

Similar anomalously steep paleomagnetic inclinations have been seen in igneous rocks and were often cited in reviews of paleomagnetic studies of basalts from the Mid-Atlantic Ridge (Legs 37 and 49). In this case, many authors attempted to explain the inclinations as resulting from structural tilting of blocks within and adjacent to the median rift valley. Unfortunately, while this observation is applicable to basalts, it is not applicable to most sediments. Thus, a different mechanism is likely.

One possible explanation for the anomalous inclinations is that excursions or secular variation of the field has been recorded. However, this is unlikely. In most of the magnetostratigraphic studies of deep sea sediments, the sedimentation rates are such that secular variation should have been averaged out within a 1-inch cylindrical sample (results from the Mariana back arc are an exception). The samples normally represent sedimentation averaged over at least 100,000 yr. An alternative explanation of these anomalous results is that isolated samples have been remagnetized. This possibility has long been considered, but one can envision few possibilities for this rather arbitrary type of remagnetization.

The observations of our survey, however, indicate that this type of remagnetization is possible. This shipboard survey indicates that the arms of the core rack, shown in Figure 2, are strongly magnetized. Exposure of sediments or basalts to the magnetic fields associated with them may result in partial remagnetization. The possibility of remagnetization is likely to be restricted in area to the 2 to 10 inches of core immediately adjacent to the arms of the rack. Since the cores should be exposed to these high fields at two or three intervals in any core section, and since samples are taken only periodically in any core section, the observation of anomalously steep inclinations should vary. Since these results do fit the observations, we suggest this as a possible explanation of these anomalies.

SUMMARY

Magnetic surveys of the drill rig floor were conducted by shipboard scientists during Leg 75 in order to explore the possibility that DSDP rock samples had been exposed to large enough magnetic fields on board the *Glomar Challenger* to remagnetize portions of the drill core. Observations on the drill rig floor suggest to us that the variable remagnetization observed in DSDP sediment and basalt cores which produces anomalously steep paleoinclinations may result from the highly magnetic arms of the core rack. The fields associated with the core rack (which are strongest in the *z* and *y* direc-

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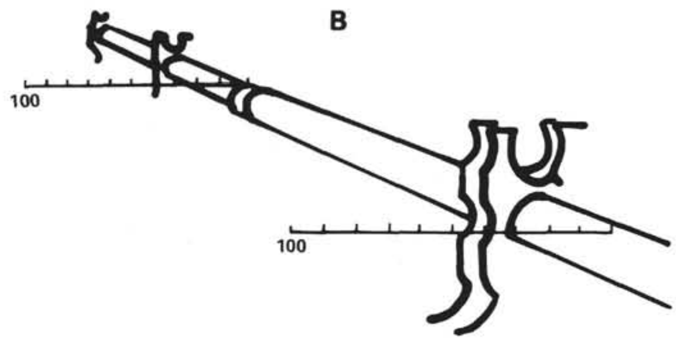

Figure 5. A. Photograph of the pipe racks aboard the *Glomar Challenger.* The aluminum collars were mounted to the right, while the steel collars were mounted to the left. B. A sketch of the survey locations along the pipe racks. One survey was conducted at a joint between stands; the others were conducted 2 feet from the end of the collar.

tions) are such that the remagnetization would act to increase the observed paleoinclinations observed in the rock cores. The remagnetization should also display an irregular frequency dependent upon the placement of cores on the rack and the sampling frequency used in each paleomagnetic study.

Taking the observations discussed here into account, the scientists on the *Glomar Challenger* requested that the steel core racks be replaced by aluminum ones during the dry dock period subsequent to Leg 75. By utilizing a less magnetic metal for the core racks, the possibility of remagnetization should be greatly reduced.

Date of Initial Receipt: November 10, 1982

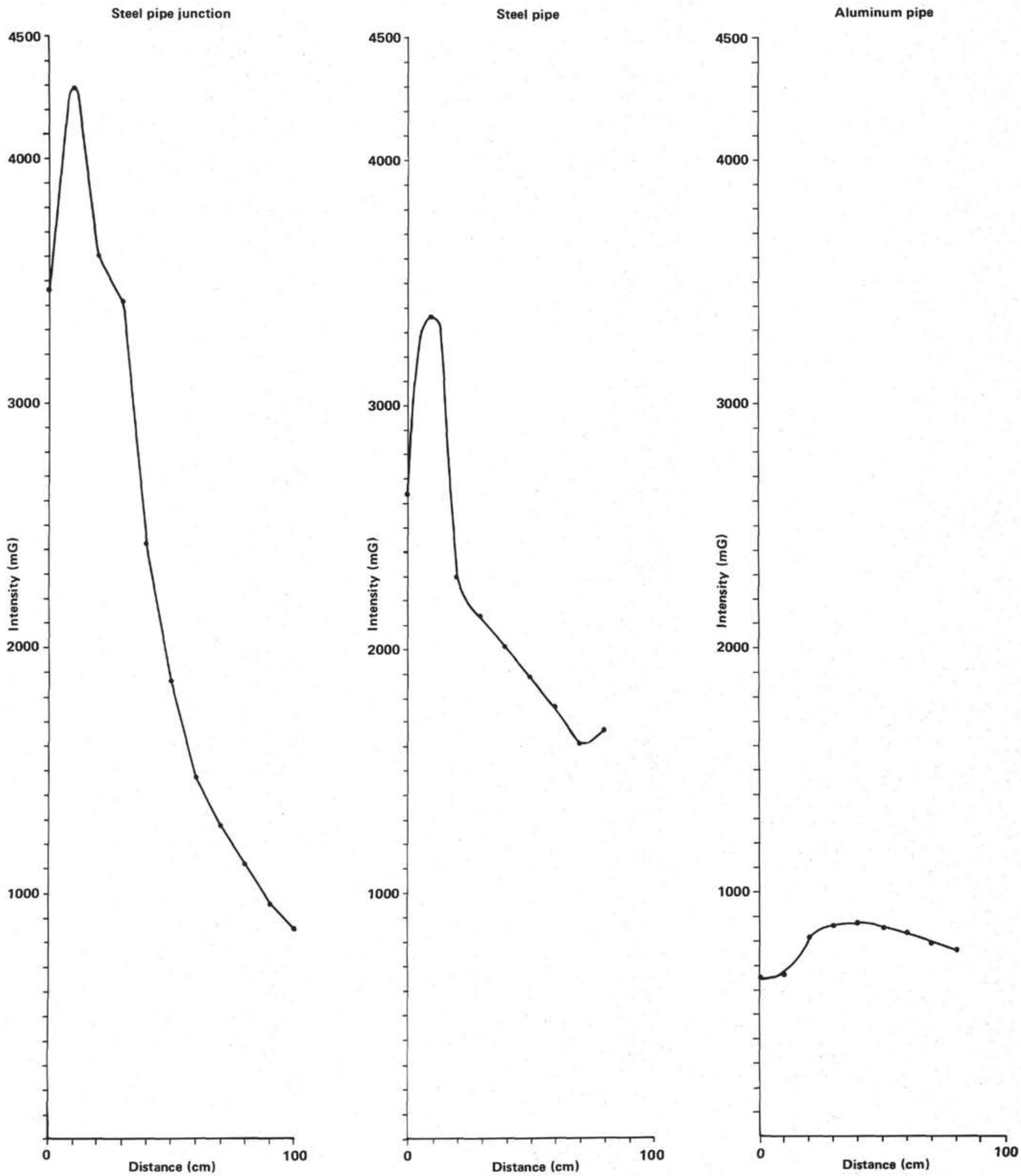

Figure 6. Total field intensity associated with drill pipes. These surveys were limited to the horizontal direction perpendicular to the pipe rack.

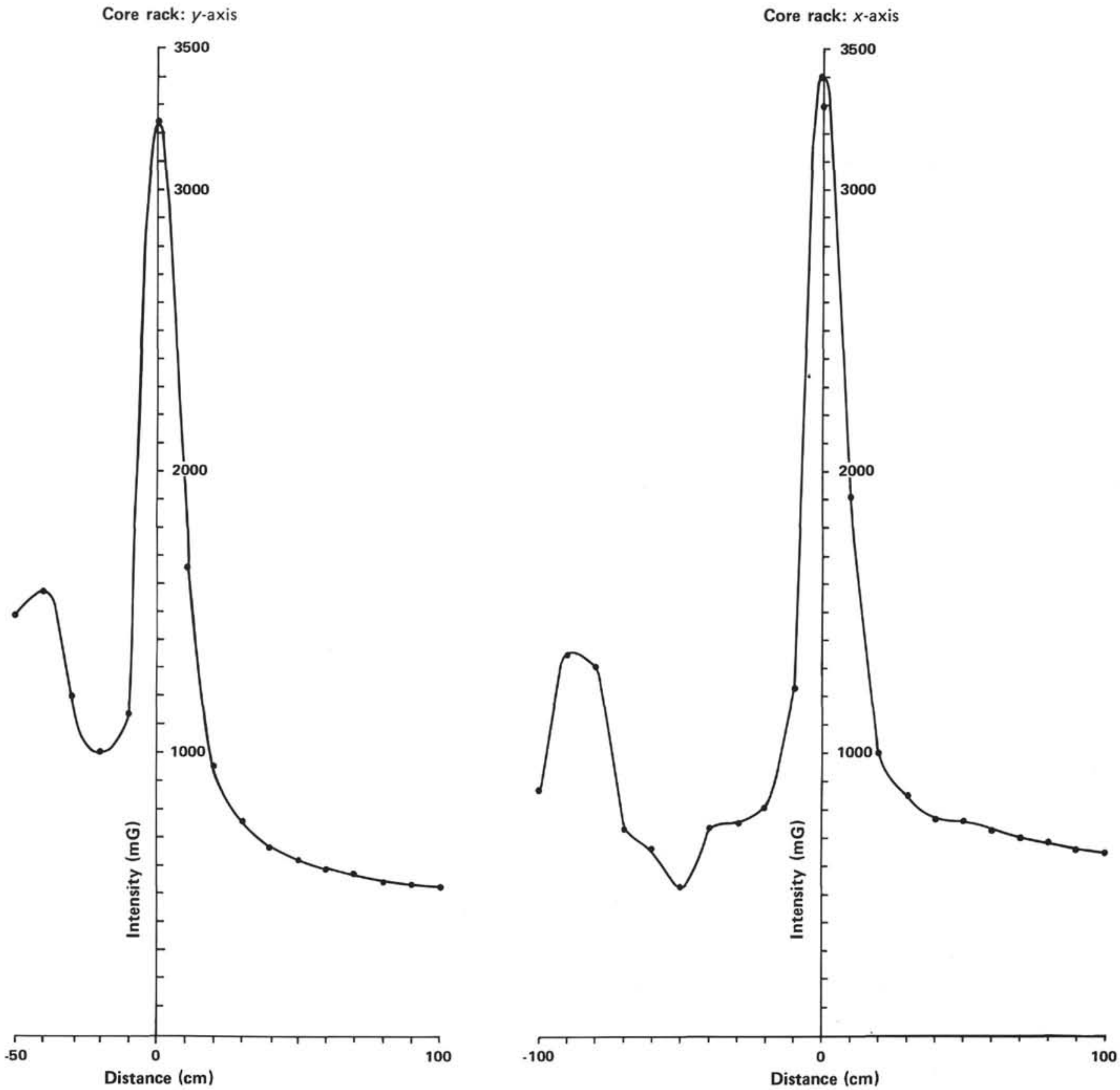

Figure 7. The total field intensity measured at 10-cm intervals in the horizontal x and y directions near the core rack. The intensity in the vertical direction was too high to be measured on the magnetometer in the z and y directions, thus no z axis measurements are shown.