OCEAN DRILLING PROGRAM

LEG 106 PRELIMINARY REPORT

BARE ROCK DRILLING IN THE MID-ATLANTIC RIDGE RIFT VALLEY

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SCIENTIFIC REPORT

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INTRODUCTION

Leg 106 of the Ocean Drilling Program, which began on November 1, 1985 in St. John's, Newfoundland, Canada, and ended on December 26, 1985 in Malaga, Spain, was dedicated to studying accretionary processes at a slow-spreading ridge and testing and evaluating a number of new "bare-rock" drilling techniques. A total of 12 holes were drilled at two separate sites in the median valley of the Mid-Atlantic Ridge (MAR), south of the Kane Fracture Zone (KFZ) (Figure 1). Site 648 is situated on the summit plateau of a small axial volcano about 70 km south of the KFZ (Figure 2). Two holes were drilled into lightly sedimented pillow basalts, Hole 648B using a Hard Rock Guide Base. Site 649 is located about 25 km south of the KFZ (Figure 2) on the summit of a linear volcanic ridge. A TV video survey of the area revealed the presence of an active hydrothermal vent field. Ten holes were drilled in the hydrothermal sediments around an active "black smoker" chimney, and in adjacent hydrothermal deposits.

SITE 648

Background and Objectives

Since Deep Sea Drilling Project Leg 37 first demonstrated the feasibility of drilling to substantial depths within the oceanic crust, numerous basement holes have been attempted on very young (<1 m.y. old) sea floor, without notable success. The majority of these holes had to be abandoned after only a few meters of penetration due to premature bit destruction, frictional binding, extreme torquing of the drill string, and continual sloughing of rock debris into the holes. Moreover, the requirement for significant thicknesses of sediment (>100 m) on basement in order to spud in precluded any drilling within the very young, largely sediment-free accretionary zone.

In light of these problems and the importance of drilling at mid-ocean ridges, the COSOD report (COSOD, 1981) and the JOIDES Planning Committee recommended the development of new technology for drilling young, fresh volcanic rocks in areas with little or no sediment cover. During the past year, ODP engineers have been developing these "bare-rock" drilling techniques. A specially designed guide base was constructed to provide lateral support for the drill string during "bare-rock" spud-in and new drilling and coring techniques were developed for use in the hard, highly abrasive, fractured volcanic rocks found at mid-ocean ridges.

Scientific Objectives

A variety of important scientific questions can be addressed by a "zero-age," crustal drill hole at a slow-spreading ridge (<2 cm/year). These include:

1. The composition and relative abundance of the parental magmas at a slow-spreading ridge and their relation to the "evolved" basalts erupted at the sea floor;

2. The variation in magma generation and crustal accretion rates in time and space, and how these magmatic processes are linked to tectonic and hydrothermal activity within the rift valley;

3. The effect of transforms on crustal accretion processes at a slow-spreading ridge;

4. The duration and extent of hydrothermal activity within the rift valley, and the imprint of this activity on the alteration history of oceanic crust;

5. The nature of the earliest low-temperature alteration of "zero-age" basalts and its effects on crustal mineralogy; and

6. The variation of crustal magnetization with depth in newly accreted crust and how it is affected by hydrothermal and tectonic processes in the rift valley.

In addition to these specific questions, a crustal drill hole at a mid-ocean ridge offers a unique setting for a variety of downhole geophysical experiments and for long-term monitoring of accretionary processes. The drilling of such holes, like that started on Leg 106, is thus a first step toward establishing "natural" laboratories where geological processes at submarine spreading centers can be studied using many different kinds of downhole instrumentation over an extended period of time.

Engineering Objectives

The difficulties previously experienced with crustal drilling on very young sea floor are probably due to a combination of factors, the most important of which are: (1) Lack of detailed drill site information (local slope, roughness, type of exposed rock, tectonic setting); (2) Inability to spud in due to buckling of an unsupported bottom hole assembly; (3) Very slow penetration rates and excessive core-bit wear due to the presence of fresh, glassy volcanic rocks that are extremely hard, very abrasive and highly fractured; and (4) Premature hole abandonment due to severe hole instability and frictional binding and torquing of the drill string in fractured, basaltic rubble.

Recognizing these problems, a number of new or previously untested systems were planned for use on Leg 106. These included the following:

1. A high-resolution, 360 degree, color-sonar tool for imaging the sea floor and aiding in re-entry operations;

2. A low light intensity black-and-white video camera system for visual observation of the sea floor and drilling operations;

3. A hard rock guide base (HRGB) to confine the bit during the initial spud-in operation;

4. A system for lowering the guide base to the sea floor, releasing it and cementing it;

5. Downhole drilling and coring motors to facilitate bare-rock spud-in and allow coring in the shallow part of the section;

6. A wire-line retrievable coring system compatible with the coring motors;

7. Special "hard formation" coring bits;

8. A modified re-entry cone with a gimbaled seat for deployment in the HRGB; and

9. A variety of special cements and muds.

From an engineering perspective, the main objective of Leg 106 was to test and evaluate these nine new systems, determine their feasibility for "bare-rock" crustal drilling, and make recommendations on system requirements for future drilling efforts of this kind.

Geologic and Tectonic Setting

The site chosen for the first "bare-rock" drill hole is in the rift valley of the MAR about 70 km south of the KFZ (Figure 2). This area was chosen for several reasons. First, this ridge segment seems to be typical of a slowly accreting (<2 cm/yr) plate boundary and is located far away from the potentially disturbing effects of hot spots like Iceland and the Azores. Petrological and geochemical studies of basalts from this area show them to be typical oceanic tholeiites (Melson et al., 1968; Bryan and Sargent, 1978; Bryan et al., 1981). Second, this area is one of the best surveyed portions of the MAR, having been the subject of a series of recent detailed geological and geophysical investigations (Purdy et al., 1978; Bryan et al., 1981; Karson and Dick, 1983; Detrick et al., 1985; Purdy and Detrick, in press). Third, the effect of transform faults on the crustal accretion process at slow-spreading ridges can be investigated here because of its proximity to the large-offset Kane Transform Fault. Finally, this area is attractive because of the generally favorable weather conditions which exist here year-round.

Site 648 is located on the smooth rim of the summit plateau of a small axial volcano about 70 km south of the KFZ (Figure 3). Named Serocki Volcano after the senior ODP engineer in charge of the "bare-rock" drilling project, it is about 800 m in diameter and stands about 50 m above the rift valley floor (Figure 4). It is one of a string of small, valley-parallel axial volcanoes, most with collapsed summit craters, identified on the Sea MARC I records. The western side of the volcano appears in the Sea MARC I records to be disrupted by several N-S trending faults or fissures which have been partially buried by later flows (Figure 5). Bottom photographs show the summit plateau to consist predominately of bulbous and tubular pillow lavas with a light to moderate sediment cover.

This site was considered an attractive drilling target because it has a relatively simple tectonic setting in the middle of the rift valley, far from the KFZ in an area with easily identifiable, symmetric magnetic anomalies. The summit plateau is also an exceptionally flat area with a relief of only a few meters. Dredge samples from this area show the basalts to be typical mid-ocean ridge basalts (MORBs). This site also offers the possibility of submersible sampling of the uppermost 50 m of the section, in the walls of the central crater and along the outer rim of the summit plateau.

Site Survey

Although excellent site survey data are available from this area, it was recognized early on that additional, extremely high-resolution surveying would be necessary on Leg 106 to find a location meeting the necessary engineering specifications. Two tools were acquired expressly for this purpose. The first is a high-resolution, low-light television camera, and the second, a color imaging sonar (Mesotech). Both the camera and sonar were mounted on a frame that was to be run up and down the outside of the drill string. Ideally, the camera provides real-time images of the seafloor up to 5-10 m in width, while the Mesotech insonifies an area up to 100 m in diameter.

Using these tools and the drillship's dynamic positioning system to offset from the navigation beacon, a 24 hour survey was carried out of the eastern summit plateau of Serocki Volcano. Figure 6 shows a geological map of Serocki Volcano based on the survey results. The summit plateau is extremely flat (<4 m relief) and consists almost entirely of bulbous and elongate pillow lavas up to 1-2 m in height with a light to moderate sediment cover. In a few places the pillows are almost completely buried by sediment. Sheet flows were found in only one location near the northeastern crater rim. Significant amounts of surficial rubble are present near the rim of the central crater, within the crater itself, and near the base of the eastern plateau scarp. The walls of the crater and the eastern edge of the summit plateau are precipitous. Post-eruptive N-S fissuring is common throughout the eastern summit plateau, although most of the fissures are relatively minor. The amount of fissuring was surprising given the smooth character of the eastern summit plateau on the Sea MARC I records and presented a problem in terms of choosing a site for deployment of the hard rock guide base.

The observations made during this survey are generally consistent with the interpretation of the Sea Beam and Sea MARC I records presented above. Serocki Volcano is the product of an earlier, but very recent, eruption and has been disrupted by an on-going extensional phase. A younger flow is observed burying older pillow lavas east of the summit plateau, which is consistent with the Sea MARC I evidence for some post-tectonic volcanism in this area. The age of Serocki Volcano is difficult to precisely estimate. It is located in the middle of the rift valley within the central magnetic anomaly, so an age of >700,000 years is unlikely. Up to one meter of sediment has buried pillow lavas on some parts of the summit plateau. If this sediment is entirely pelagic it could suggest the volcano is on the order of 10^5 years old (assuming a pelagic sedimentation rate of 1-10 mm/1000 yr).

Hard Rock Guide Base Site

A site was chosen for deployment of the HRGB approximately 206 m south-southwest of Beacon #2 (deployed prior to the cruise by the site survey team; Figure 2), about halfway between the central crater and the edge of the summit plateau ($22^{\circ}55.3'N$; $44^{\circ}56.8'W$; see Figure 6). Based on the survey, this area is characterized by flat, moderately sedimented pillow lavas without any evidence of surficial rubble. Several small N-S trending fissures are present in the area with an average separation of about 20 m.

Figure 7 shows a map of the area surrounding the HRGB constructed from video tapes recorded after it was deployed. The guidebase landed successfully with an initial tilt of less than 5 degrees. Subsequent shifting of the HRGB increased the tilt to about 10 degrees. One of the guidebase legs appears to be wedged into a small fissure, while the other legs are standing on moderately sedimented basalt. Several large bulbous pillows crop out nearby, while a larger N-S trending fissure is located about 6 m east of the HRGB.

Drilling Results

Hole 648A was spud in on bare pillowy basement using an unsupported drill string and a Navidrill positive-displacement downhole coring motor. Total penetration was 4.5 m below sea floor (BSF) with the recovery of three pieces of basaltic rubble, equivalent to a 1.6% recovery rate.

Hole 648B was drilled after successfully deploying the HRGB. The Navidrill positive-displacement drilling motors and the top drive were successfully used to reach a total depth of 33.3 m BSF with a total recovery of 6.2 m. The uppermost 6.2 m of the hole were deliberately not cored, and the first 8.4 m of the hole were cased with 16-inch casing after setting a gimbaled re-entry cone in the guidebase. The average recovery for the 26.7 m of cored hole is 23%. Cores 648B-2N, 648B-5N, and the top 2 m of Core 648B-3N represent rubble in-fill. Excluding these 0.6 m of basaltic rubble, the average recovery rate is about 20%.

Division of the cores from both holes into meaningful lithologic units is difficult because of the low recoveries and drilling records that indicate continual slumping of debris into the hole. Therefore, it was decided to divide the various cores into "rubble units" and "proposed cooling units" (probable). All of the basalts recovered from Site 648 are of one lithologic type: fresh plagioclase-olivine sparsely phyric basalt. The texture of the groundmass ranges from glassy, to subvariolitic, to intersertal, to intergranular indicating that most of the samples are probably derived from various parts of pillow lavas. The presence of plagioclase and olivine glomerocrysts, and the absence of chromian spinel suggest that the Site 648 basalts are typical, moderately evolved MORBs. They are petrographically quite similar to basalts dredged from the same general area of the MAR median valley, and to the basalts cored at DSDP Sites 395 and 396, 130 km west and 170 km east of this site, respectively. All of the latter have been interpreted as resulting from mixing of two or more, more or less "primitive" and "evolved" magma batches, which is a direct consequence of the episodic nature and intermittent replenishing of magmatic systems at the MAR. Vesicles, miarolitic voids and fractures are empty except in a few rare samples, and glassy pillow margins are unaltered. Incipient alteration is evidenced by the presence of occasional clay minerals coating sample surfaces, lining vesicles, and forming 2-4 mm thick black halos and streaks.

The average wet bulk density and grain density of the basalts from Hole 648B are 2.93 $\pm$ 0.03 gm/cc and 3.02 $\pm$ 0.02 gm/cc, respectively. The elastic wave velocities show no resolvable horizontal or vertical anisotropy and have an average compressional wave velocity of 5.69 $\pm$ 0.23 km/s. No downhole variability in physical properties was observed and all the results reflect the low porosity and high degree of freshness of the samples.

The mean magnetization intensity (118 $\pm$ 50x10^{-4} gauss) and the mean susceptibility (10.8 $\pm$ 6.1x10^{-4} gauss/Oe) of the samples from Hole 648B, are similar to dredged rocks from mid-ocean ridges. The carrier of NRM is titanomagnetite, varying in grain size between 1 and 50 microns. The titanomagnetite volume content ranges between 2% in Cores 648B-1N, 648B-3N, and 648B-5N, and 4% in Core 648B-6N, reflecting corresponding downhole variations in both NRM intensity and band susceptibility. The magnetostratigraphy of Hole 648B shows a short reversed interval between 11 and 21 m BSF which might correspond to the 100,000 yr old Blake event. However, since much of the recovered material appears to be rubble, the orientation of these samples is suspect and this interval of reversed magnetization may not be real.

SITE 649

Background and Objectives

Toward the end of ODP Leg 106, when deteriorating hole conditions forced us to terminate drilling operations at Site 648, a decision was made to spend the remaining site time (about 6 days) surveying and drilling the hydrothermal area described by Detrick et al. (1985) about 25 km south of the KFZ (Figure 2).

Although more than half a dozen active hydrothermal vents have now been observed along the intermediate- and fast-spreading centers of the eastern Pacific, until recently, extensive surveys revealed no evidence for such activity along the slow-spreading MAR. For example, in the TAG area, near 26°N, a number of studies over the past thirteen years found abundant evidence for low-temperature activity in the form of manganese-encrusted basalts and cemented breccias (Rona, 1980), but no indication of the high-temperature vents was found at faster spreading centers. In the FAMOUS area near 37°N, very detailed studies involving bottom-water temperature measurements from both deep-tow vehicles and submersibles found no evidence for water temperature anomalies attributable to hydrothermal circulation (Fehn et al., 1977). However, bottom photographs taken in May 1985, during a Sea MARC I survey of the rift valley south of the KFZ, revealed the presence of pockets of greenish white, mottled, hydrothermal sediment near the crest of a young, NNE-trending volcanic ridge located in the middle of the rift valley (Detrick et al., 1985; Kong et al., 1985). The sediment ponds were populated by crabs and small spindly worms that are indicative of recent hydrothermal activity. These photographs were the first convincing evidence for an active hydrothermal area on the MAR. In July 1985, just two months later, the first "black smokers" on the MAR were discovered in the TAG area at 26°N (Rona, pers. comm.). Little was known about either area prior to Leg 106, but these discoveries generated considerable scientific interest since they provided the first opportunity to study active hydrothermal processes at a slow-spreading ridge.

Objectives

A variety of important scientific questions can be addressed by drilling in an active hydrothermal area on the MAR. These include:

1. Establishing the character, extent and duration of hydrothermal activity at a slow-spreading ridge;

2. Determining the thickness, lateral variation, mineralogy, and oxidation history of the hydrothermal sediments deposited on the seafloor at different distances from an active vent;

3. Understanding the metallogenesis of massive sulfide ore bodies within the oceanic crust and their relation to magmatic activity;

4. Developing a better understanding of basalt-seawater interactions and their effect on the overall geochemical balance in the oceans;

5. Quantifying the physical parameters (crustal permeability, pore pressure, depth of circulation, flow velocities, etc.) that control the movement of hydrothermal fluids in the crust;

6. Improving geophysical models of the thermal structure of mid-ocean ridges; and

7. Investigating the effects of basic hydrothermal parameters (eg., solution composition, flow history, and temperature) on bacterial productivity and the biomass and character of the hydrothermal vent community.

Geologic Setting, Hydrothermal and Biological Activity

Site 649 is located about 25 km south of the KFZ on the crest of the young, NNE-trending volcanic ridge identified on Sea Beam maps in the northern part of the rift valley (Figures 2 and 8). This ridge stands several hundred meters high and is located near the middle of the central magnetic anomaly (Figure 9). The Sea MARC I survey revealed the presence of a small terrace near the crest of this ridge and the site survey team deployed a navigation beacon here (Beacon #3; Figure 2) to mark this area for possible drilling on Leg 106. Bottom photographs taken by the site survey team revealed a pocket of greenish white, mottled sediment populated by crabs and small spindly worms that is indicative of recent hydrothermal activity (Kong et al., 1985).

Survey of Hydrothermal Area

On arriving at Beacon Site 3, we began a 36-hr survey of the area east and south of the beacon using the video-camera system and the Mesotech color sonar. A navigation beacon was mounted on the camera frame so that the frame's position relative to the ship could be continuously monitored. This made it possible to accurately navigate relative to specific, identifiable seafloor features.

During the course of this survey, a major active hydrothermal vent field, later called the "Snake Pit Vent Area", was discovered about 140 m southeast of the navigation beacon near $23^{\circ}22.08'$N, $44^{\circ}57.00'$W. It contains numerous large (up to 11 m high) sulfide chimneys, "black smoker" vents, dark hydrothermal sediment, and a unique biological community. This is only the second time "black smokers" have been reported from the slow-spreading MAR ("black smokers" were also reported from the TAG Hydrothermal Area this past summer) and the first time an Atlantic vent area has been surveyed in any detail and monitored in realtime.

A geological map constructed from an analysis of the survey video tapes is shown in Figure 10. A narrow summit terrace, made up of pillow lavas and basaltic rubble, about 100 m wide and at least a few hundred meters long, was found bordered on the west by two narrow ridges and on the east by a steep scarp and slope which drops down toward the floor of the rift valley. Basaltic rubble covers the base of the scarps and the steeper slopes. Three small sediment ponds with light-colored, mottled sediment were found east and south of the beacon. Thinner sediments of the same type partly cover pillows over a larger area adjacent to the sediment ponds.

A NNE-trending fissure, up to several meters wide, was observed running down the center of the terrace. This fissure, later called the "Snake Pit Fissure", appears to mark the eastern boundary of a major, active hydrothermal vent field. To the east of this fissure, very young-looking bulbous and elongate pillow lavas outcrop. These basalts are largely free of sediment or any hydrothermal encrustations. West of this fissure, a major vent field stretches approximately east-west for a distance of at least 200 m, although the western limit of the vent area is not well constrained by our survey. The vent field consists of numerous chimneys and mounds, many displaying the spectacular dendritic, tubular structures and elaborate ornamentation observed in chimneys on the East Pacific Rise (EPR) and Juan de Fuca Ridge. Three types of chimney morphologies can be distinguished: a) mushroom type--large edifices up to 11 m high; b) tree type--smaller, delicate chimneys of about 3-4 m height; and c) finger type--mostly medium-sized vents 5-10 m high.

The largest concentration of vents seems to be within about 40 m of the Snake Pit Fissure, although most of these vents appear to be extinct. The largest and most active vents are in the central and western part of the field we mapped. A blanket of hydrothermal sediment, encrustations and chimney debris extends over a much wider area (Figure 10) and covers all basement rocks completely. An extinct vent surrounded by hydrothermally encrusted basaltic rubble is located as far away as 100 m south of the main vent field.

One very large "black smoker" vent was discovered about 130 m SSE of the navigation beacon in the middle of the vent area (Figure 10). Large plumes of "black smoke" were observed rising from the top of the chimney, with smaller amounts coming out of several secondary vents on the chimney walls. The flow rate of the "black smoke" appears to be lower than that observed at hydrothermal vents at the EPR. The sea floor in the immediate vicinity of the vent is covered with large numbers of LWBs (Little White Balls, see following paragraphs). The dimensions of this vent are difficult to estimate, but the chimney is at least 11 m in height and several meters in diameter. A large talus apron of debris at the base of the vent is at least 12 m thick, as indicated from the video and sonar survey and the drill hole data. The total size of the hydrothermal deposit related to this one active vent thus is at least 23 m in height and 30 m in width. Although only one "black smoker" was directly observed, there is evidence (turbid water, large concentrations of LWBs and other biological life) for at least two more active vents in the western part of the surveyed area (Figure 10). In summary, the number of vents and the extent of the hydrothermal sediment deposits indicate that this is a major and very active hydrothermal system.

The vent field is also associated with a diverse biological community that is surprisingly different from that observed at the Pacific vents. No clams or large sessile tube worms were observed near the vents. The most common forms of life spread over the whole Snake Pit Vent Area are large swimming crustacea, and long (30-60 cm) flat snake-like swimmers (possibly eels) that have given the vent field its name, the Snake Pit. Sessile LWBs (Little White Balls) that may be some type of sea anemone populate the talus slopes of the active hydrothermal vent. LWBs are restricted to this location and the slopes of the two probably active vents in the western part of the vent field (Figure 10). Slews of small shrimp-like animals were observed to congregate on rock surfaces very close to the active "black smoker" vent. Only a few crabs were observed, but more were seen in the still photos taken by the site survey team last May.

In general, the biological community observed here appears to consist of smaller, more mobile organisms than those previously found at submarine hydrothermal vents on the fast-spreading EPR. This might be an evolutionary adaptation to the shorter life and larger spatial separation of vents at the slow-spreading MAR, which favors the smaller, swimming organisms of the Atlantic over the large, sessile clams and tube worms of the Pacific vents.

Drilling Results

Ten shallow holes were drilled in the vent area at Site 649 to sample the hydrothermal sediments and the underlying basement rocks. These are the first holes ever drilled in an active, submarine hydrothermal area. Holes 649F, 649G, 649D, 649A and 649B were drilled at increasing distances away from the large active "black smoker" (Figure 11). Hole 649F is located at the very foot of the active vent, whereas Holes 649G, 649D, and 649A through 649C are 3, 10, and 17 m east of it, respectively. Hole 649C is located on a small inactive chimney. Hole 649E was drilled 20 m south of the "black smoker", and Holes 649H, 649I and 649J were spudded about 65 to 80 m west of this vent. The thickness of the hydrothermal deposits appears to rapidly decrease with distance from the active chimney; the deposits are at least 13 m thick at the base of the chimney (no hard formation was encountered in Hole 649F), and thin to 3-6 m or less, about 17 m away. Subaerial equivalents of these deposits are known for their variability in thickness and mineralogy. As a rule, the uppermost portion of the Snake Pit hydrothermal deposit consists of a few-meter-thick layer which is very soft and was unsampled since the drillstring always "washed" through this interval. The remainder of the section is made up of alternating soft and firmer formations composed of various proportions of fine-grained Fe, Cu and Zn sulfides (pyrite, pyrrhotite, marcasite, chalcopyrite, and sphalerite) disseminated in a clayey (talc or chlorite and possibly sulfate) matrix, with lenses of massive sulfides (pyrite, pyrrhotite and chalcopyrite).

All of the basaltic lava and glass samples recovered from Site 649 are essentially fresh, indicating that the hydrothermal solutions did not affect the basement rocks beneath the sulfide deposit. The basalt is aphyric with occasional olivine or plagioclase phenocrysts and typically contains 1-5% vesicles, although one sample contains 20% vesicles. The presence of glassy margins and shards indicates that the samples were recovered from pillow lavas. Site 649 basalts are different from those of Site 648 in that they have many fewer phenocrysts and contain more olivine, hence are probably more primitive. This observation is consistent with the nearby occurrence of very unfractionated basalts with 9-10% MgO dredged by Bryan and co-workers prior to Leg 106.

SUMMARY

Leg 106 has taken two very significant steps in the study of geological processes at mid-ocean ridges. At Site 648, the feasibility of "bare-rock" spud-in, drilling and coring in essentially "zero-age" crust was demonstrated, even though penetration and recovery rates were lower than hoped for. At Site 649, the first holes ever drilled to study an active submarine hydrothermal system were completed and, although recovery rates were low, the feasibility of drilling at least shallow holes in a vent area and precisely positioning these holes within a few meters of a high temperature "black smoker" vent was clearly proven.

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FIGURE CAPTIONS

Figure 1 Map of the North Atlantic showing the location of the Mid-Atlantic Ridge south of the Kane Fracture Zone drilled on Leg 106.

Figure 2 Bathymetric map of the Mid-Atlantic Ridge rift valley south of the Kane Fracture Zone showing the location of Sites 648 (at Beacon Site #2) and 649 (at Beacon Site #3). Also shown are DSDP Sites 395 and 396. Beacon Sites 1-4 show where beacons were deployed during the pre-site survey cruise. Contour interval 500m.

Figure 3 Detailed Sea Beam bathymetry map of the area around Site 648. Contour interval 10m. Serocki Volcano, on which Site 648 was drilled, is one of a group of small axial volcanoes which have been cut by valley-parallel faults and fissures.

Figure 4 Idealized depth profile across Serocki Volcano showing the location of Site 648 relative to the central crater and the summit plateau.

Figure 5 Sea MARC I record across Serocki Volcano, 5km swath width.

Figure 6 Geologic map of Serocki Volcano constructed from the video survey results. Inset shows tectonic interpretation of the area immediately surrounding Serocki Volcano based on available Sea Beam and Sea MARC I data (Ryan, W.B.F., pers. comm.).

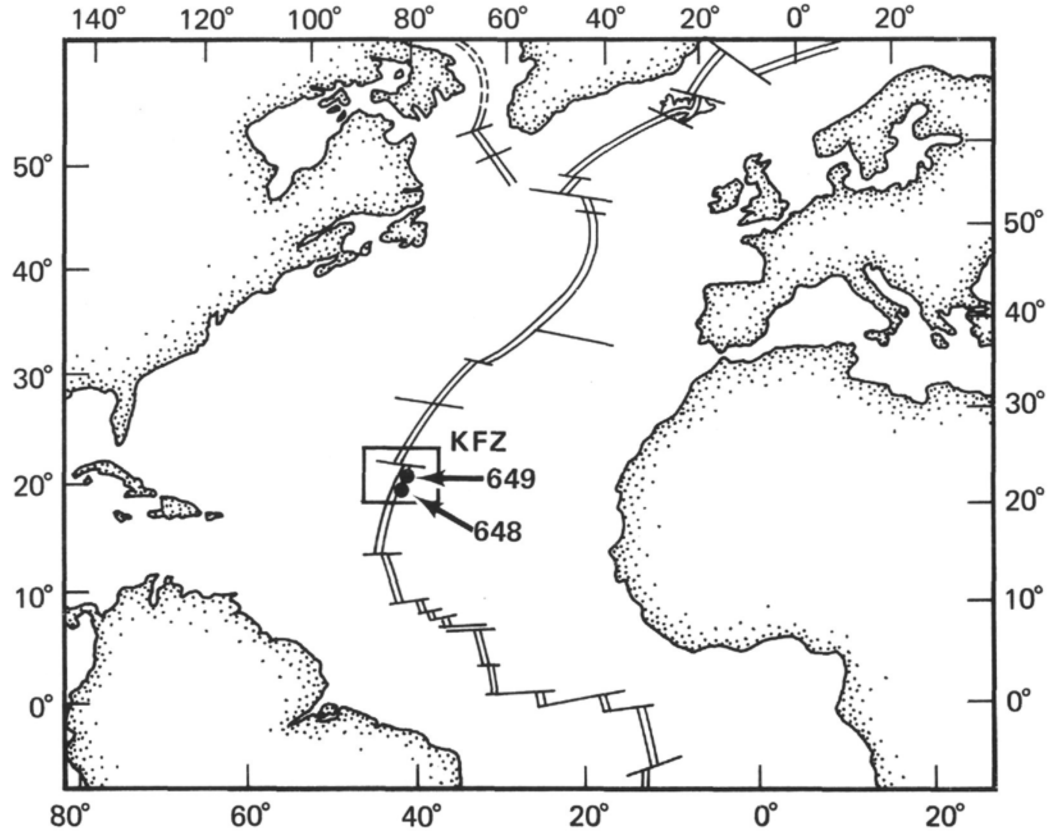
Figure 7 Map of the area around the HRGB constructed from video tapes recorded after the guidebase was deployed at Site 648.

Figure 8 Sea Beam bathymetry map of eastern intersection of the Mid-Atlantic Ridge rift valley and the Kane Fracture Zone showing the location of Site 649 (from Detrick et al., 1985).

Figure 9 Center beam Sea Beam bathymetry and magnetic anomaly profiles across the rift valley in the vicinity of Site 649 (from Detrick et al., 1985).

Figure 10 Geologic map of the Snake Pit Hydrothermal Area constructed from the video and sonar survey.

Figure 11 Location of Holes 649A-G in relation to an active black smoker. Figure shows simplified stratigraphy.



140°
120°
100°
80°
60°
40°
20°
0°
20°
50°
40°
30°
20°
10°
0°
KFZ
649
648
80°
60°
40°
20°
0°
20°

Figure 1

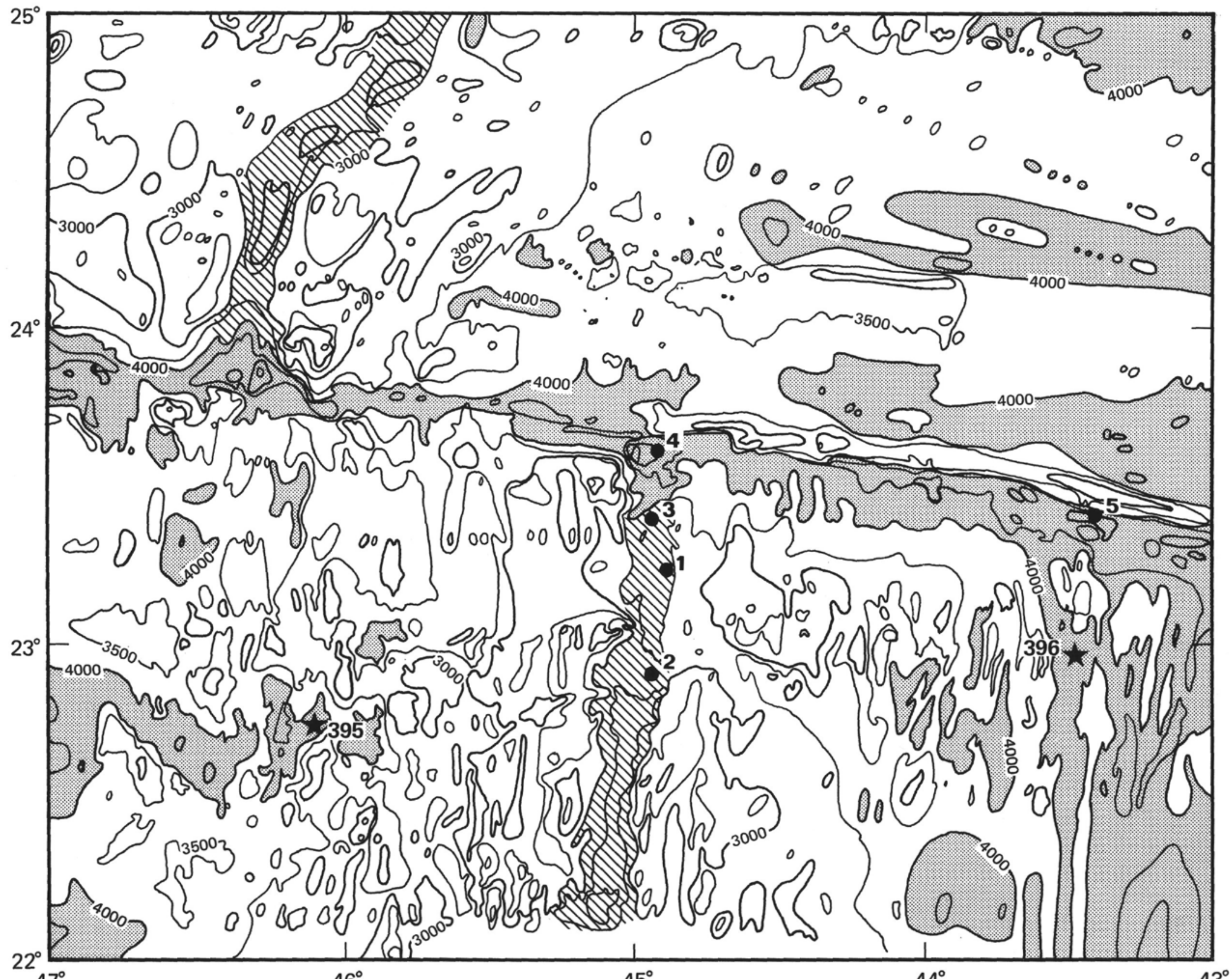
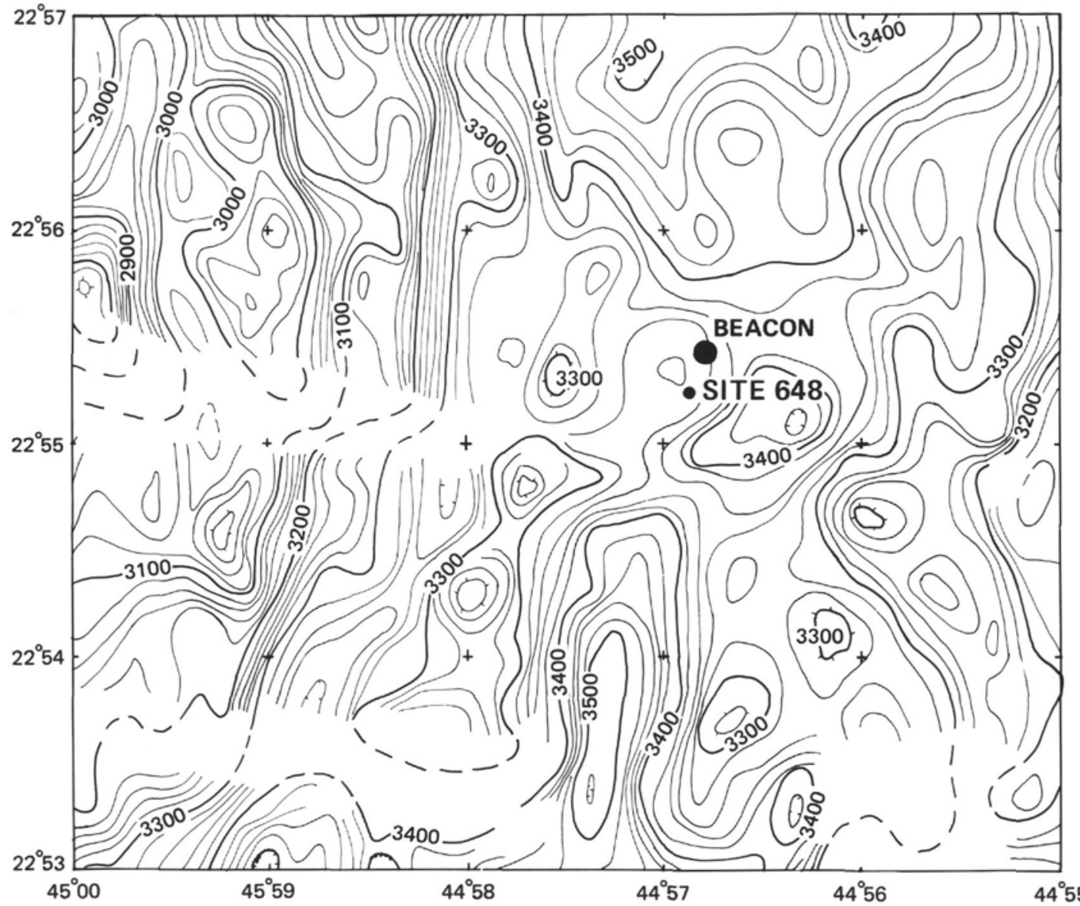


Figure 2



22°57
22°56
22°55
22°54
22°53
45°00
45°59
44°58
44°57
44°56
44°55
BEACON
SITE 648
2900
3000
3100
3200
3300
3400
3500

Figure 3

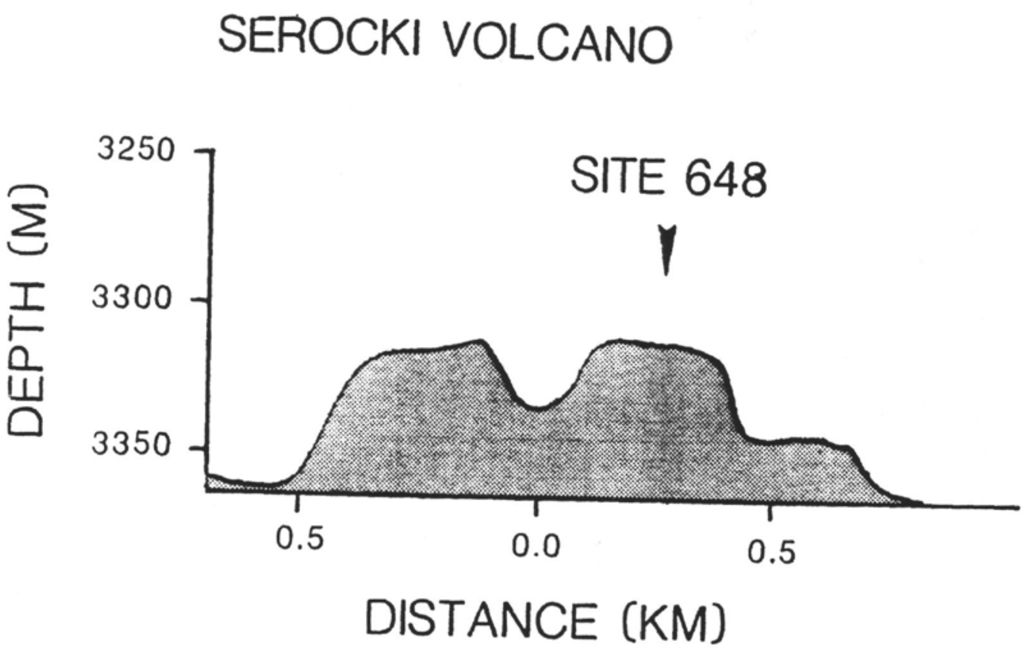

SEROCKI VOLCANO
SITE 648
3250
3300
3350
DEPTH (M)
0.5
0.0
0.5
DISTANCE (KM)

Figure 4

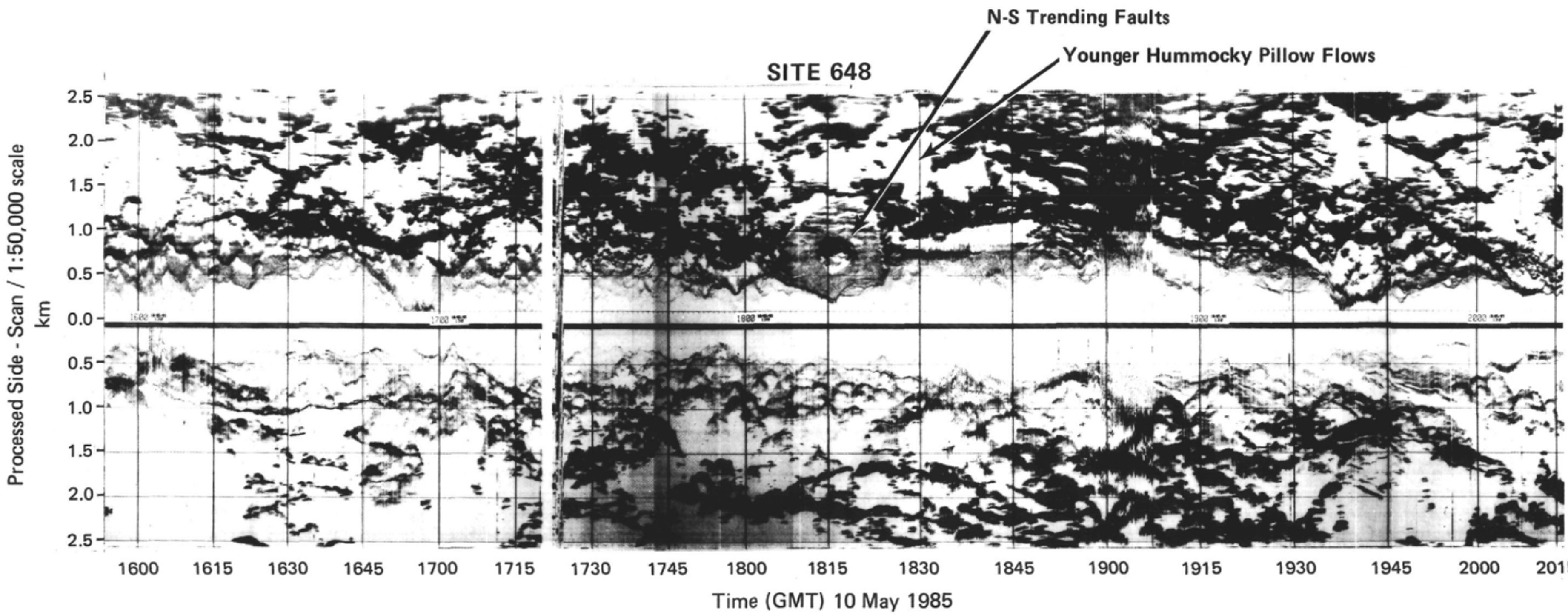
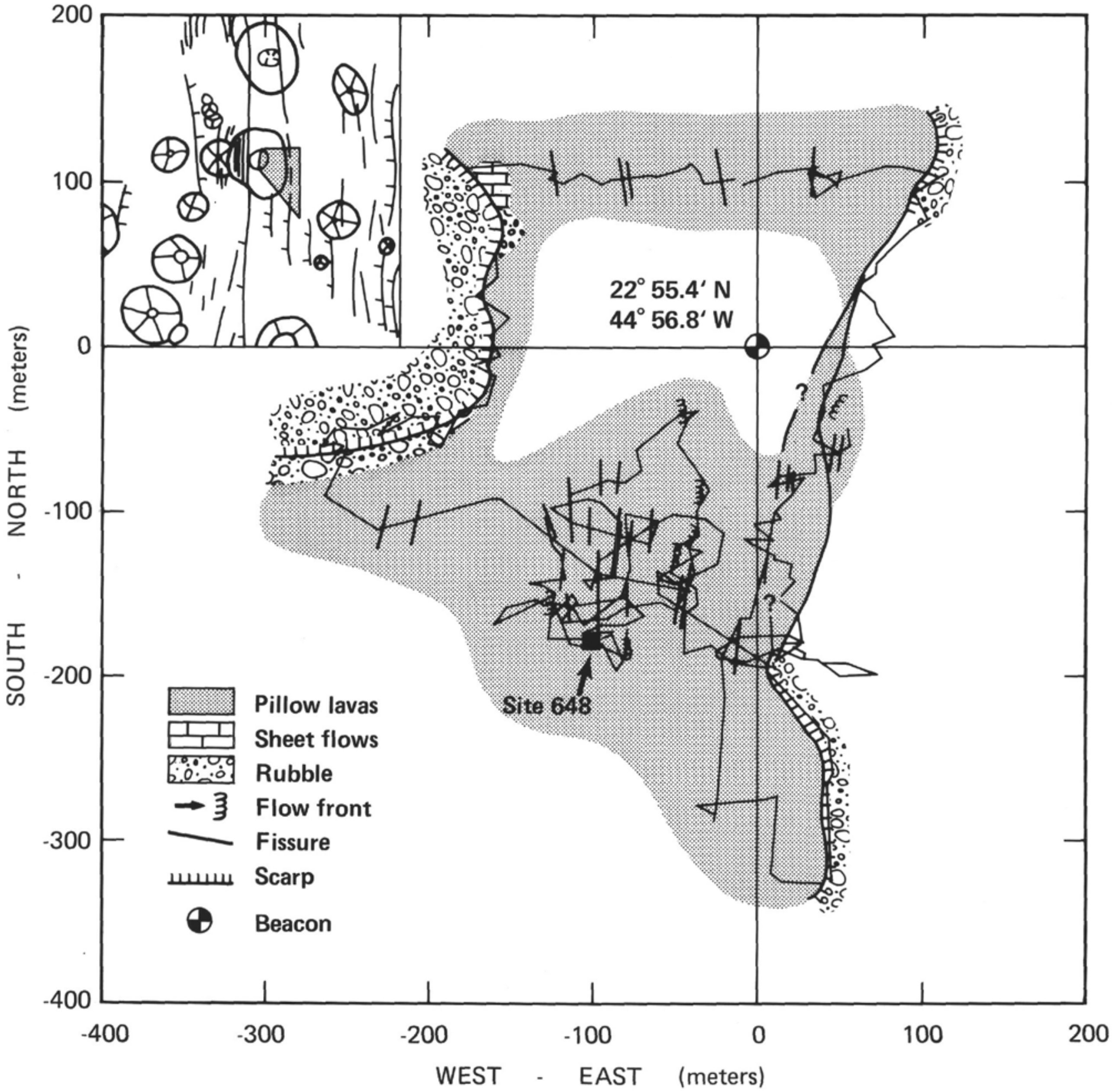

N-S Trending Faults
Younger Hummocky Pillow Flows
SITE 648
Processed Side - Scan / 1:50,000 scale
km
2.5
2.0
1.5
1.0
0.5
0.0
0.5
1.0
1.5
2.0
2.5
1600
1615
1630
1645
1700
1715
1730
1745
1800
1815
1830
1845
1900
1915
1930
1945
2000
2015
Time (GMT) 10 May 1985

Figure 5



200
100
0
-100
-200
-300
-400
SOUTH - NORTH (meters)
-400
-300
-200
-100
0
100
200
WEST - EAST (meters)
22° 55.4′ N
44° 56.8′ W
Site 648
?
?
Pillow lavas
Sheet flows
Rubble
Flow front
Fissure
Scarp
Beacon

Figure 6

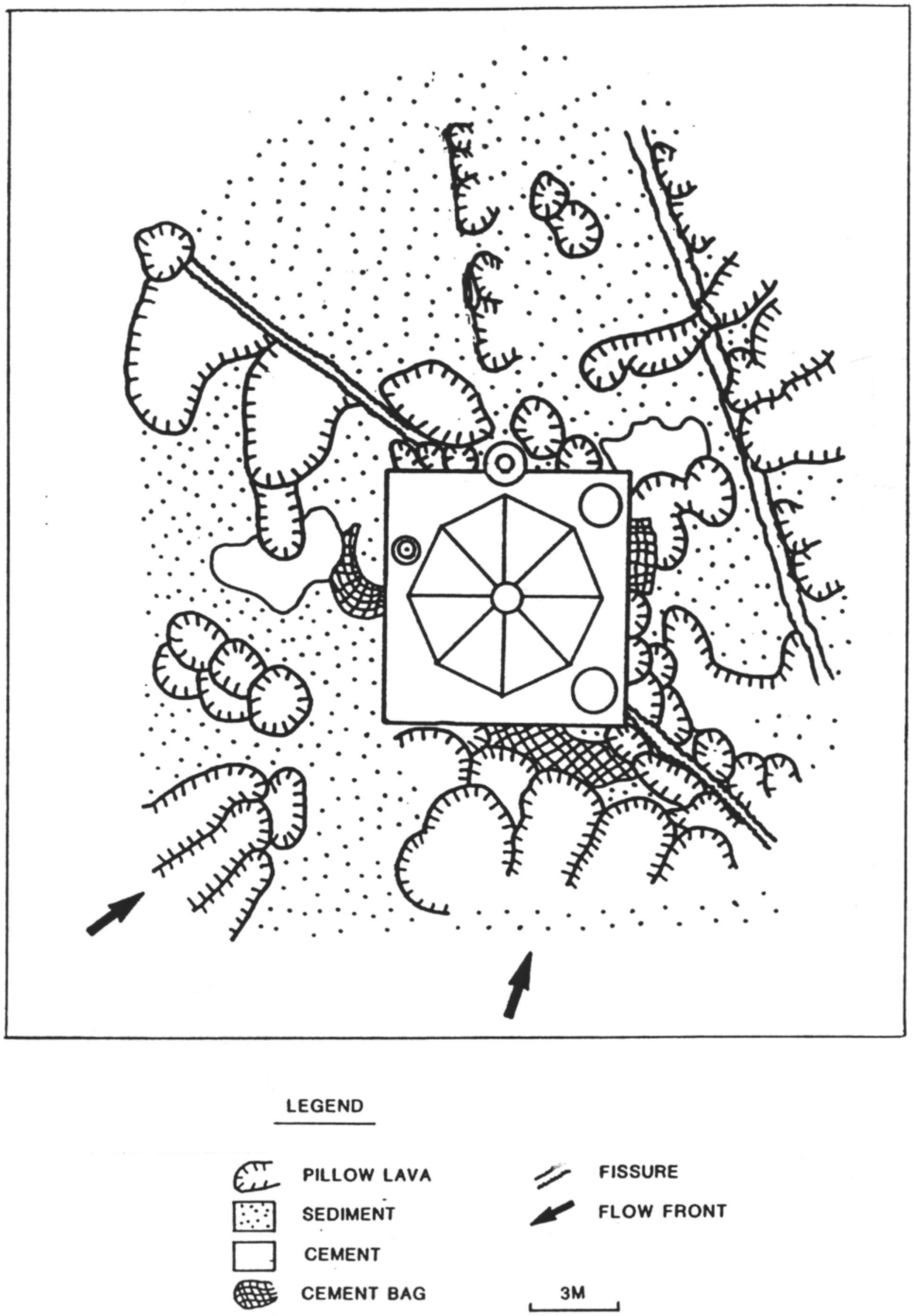

LEGEND
PILLOW LAVA
SEDIMENT
CEMENT
CEMENT BAG
FISSURE
FLOW FRONT
3M

Figure 7

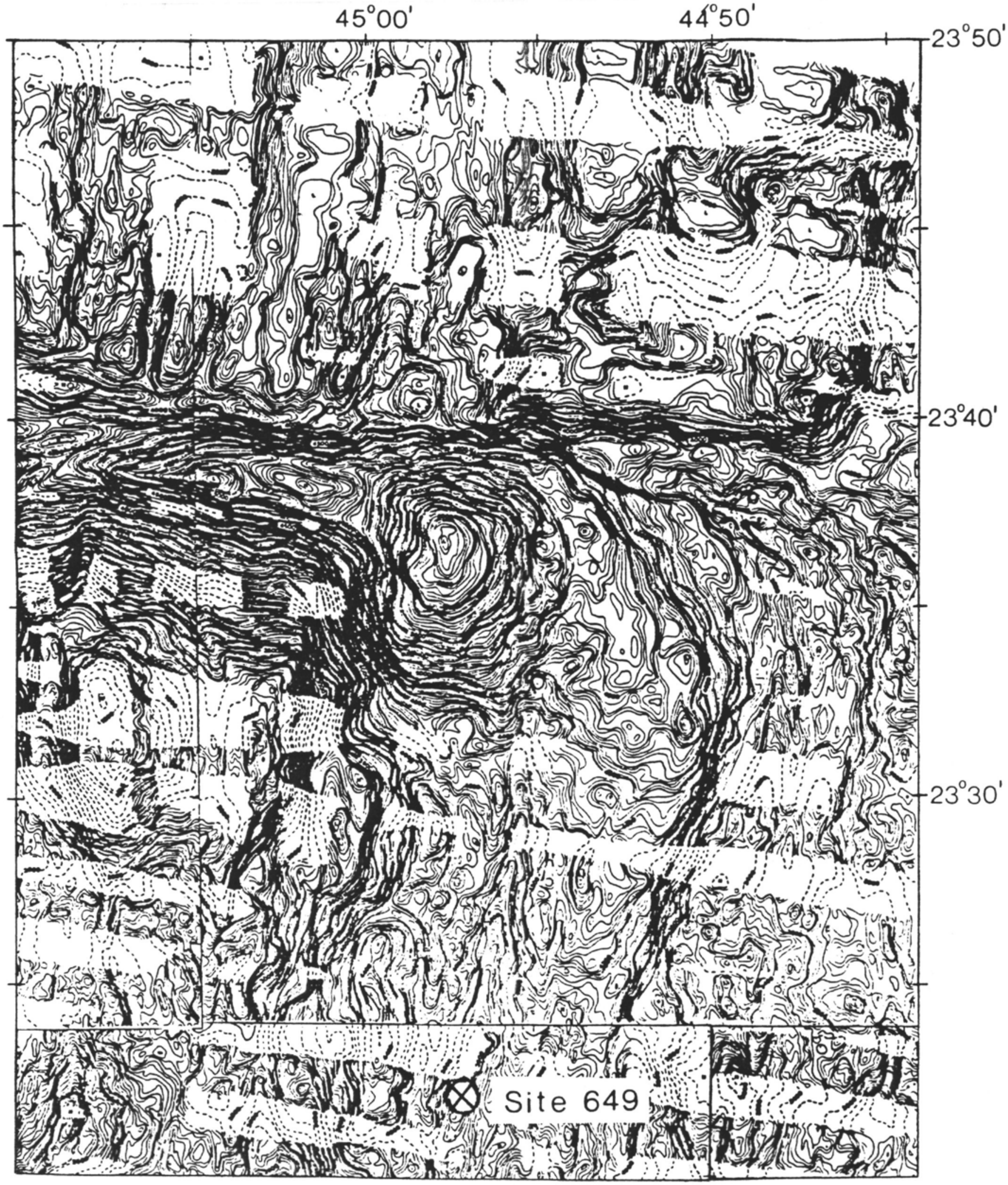


Figure 8

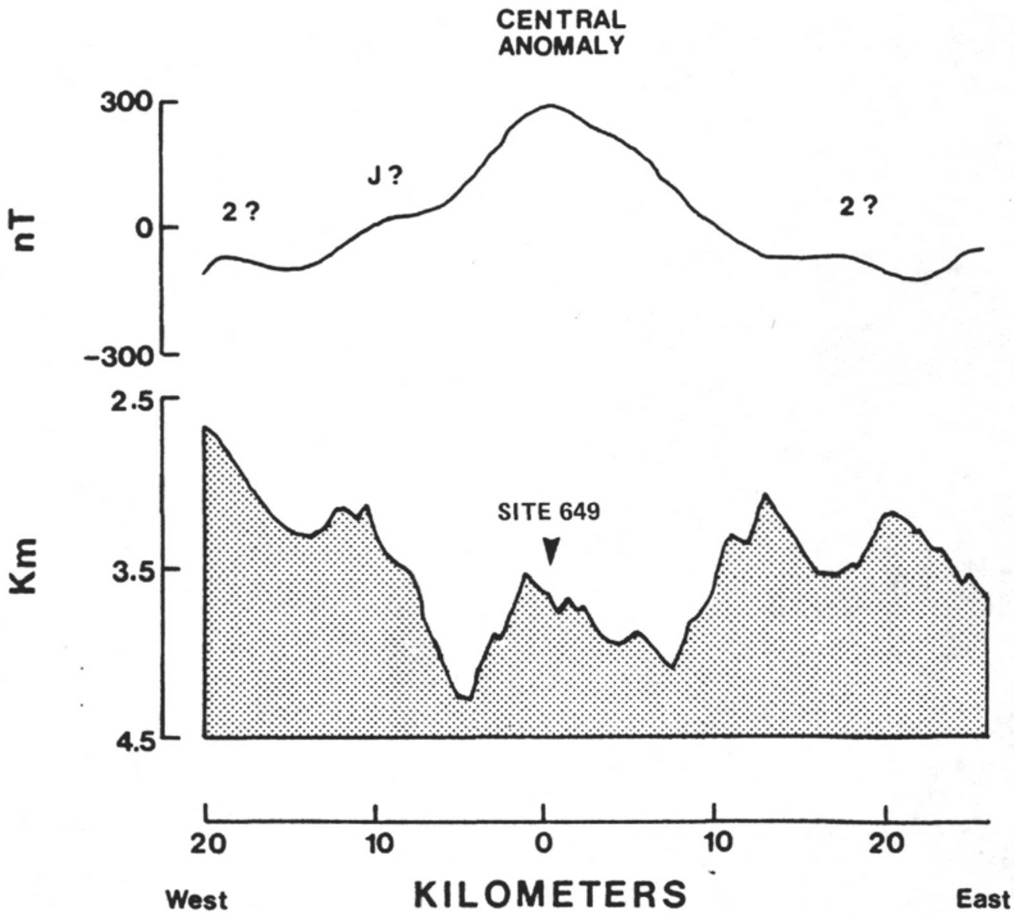
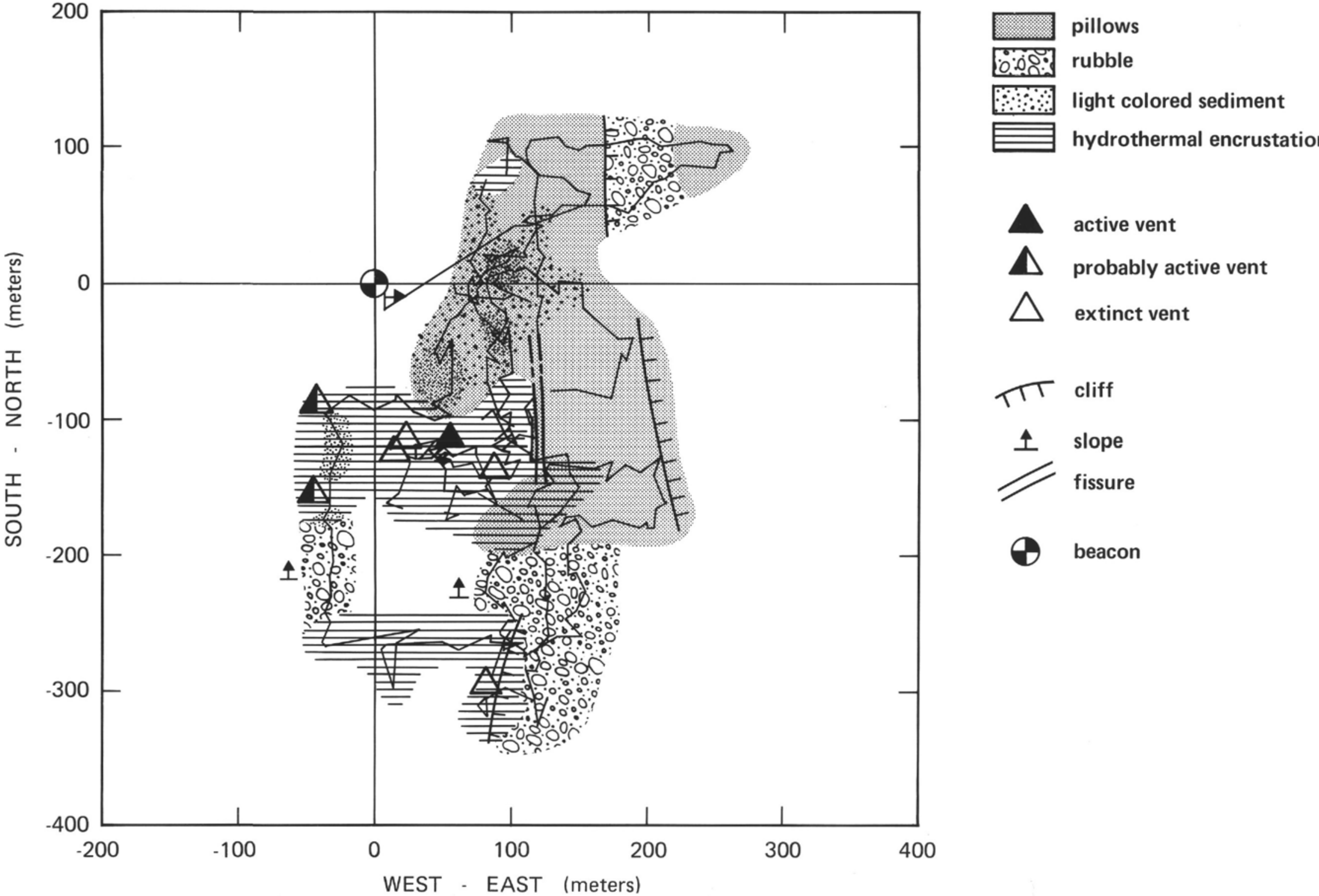
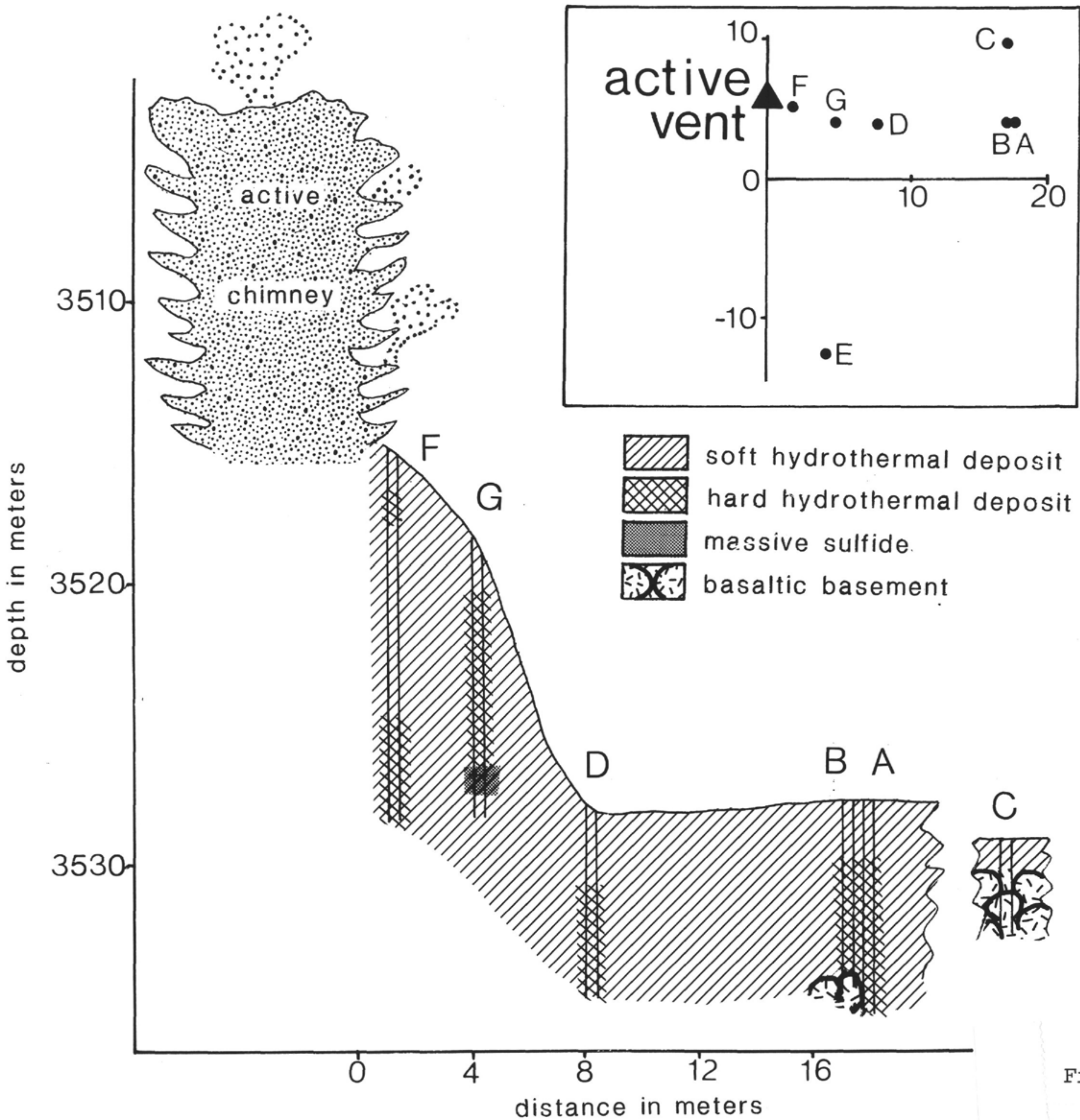

CENTRAL
ANOMALY
300
0
-300
nT
J ?
2 ?
2 ?
2.5
3.5
4.5
Km
SITE 649
20
10
0
10
20
West
KILOMETERS
East

Figure 9



pillows
rubble
light colored sediment
hydrothermal encrustation
active vent
probably active vent
extinct vent
cliff
slope
fissure
beacon
SOUTH - NORTH (meters)
WEST - EAST (meters)
200
100
0
-100
-200
-300
-400
-200
-100
0
100
200
300
400

Figure 10



active
vent
F
G
D
C
B A
E
10
0
-10
10
20
soft hydrothermal deposit
hard hydrothermal deposit
massive sulfide
basaltic basement
active
chimney
depth in meters
3510
3520
3530
distance in meters
0
4
8
12
16

Figure 11

OPERATIONAL REPORT

The ODP Operations personnel aboard JOIDES Resolution for Leg 106 of the Ocean Drilling Program were:

Operations Superintendent: Stan Serocki

Drilling Engineer: Steve Howard

Another drilling engineer aboard JOIDES Resolution was:

Terry Brittenham, Drilling Consultant (Southern International Inc., 4401 Northwest 4th Street, Suite 121, Oklahoma City, OK 73107)

INTRODUCTION

Leg 106 was selected for operational testing of the hard rock spud system. The system was designed to allow drilling into sediment-free, highly fractured sea floor basalts, a capability not previously available.

Work on the subsystems began in earnest in mid-January 1985 and the project was completed in time for the Leg 106 departure from St. John's, Newfoundland on November 1, 1985.

The principal sub-systems developed in the course of the work are as follows:

1. A gravity hard rock guide base (HRGB) structure 17 ft x 17 ft x 11 ft high, with the means to suspend the HRGB beneath the ship, lower to the sea floor, cement in place and release. It is designed to be set over boulders and on sloping sea floor. The structure receives a re-entry cone and casing after drill-out of the rock beneath the base.

2. Positive displacement coring motors, 9-1/2 inches in diameter, for 10-1/2-inch and 14-1/2-inch bits with the capability to provide 2-1/4 inch nominal wireline cores. The coring motors are driven by seawater pumped under high pressure. The drill string remains stable during use of the motors, since only the bottom 42 ft of drillstring rotates.

3. A low-light-level TV camera and Mesotech sonar system for detailed site surveys and for monitoring re-entry and other operations. Depth capability is 20,000 feet and the system is powered by coaxial cable.

A detailed description of the above sub-systems and performance is given in Engineering Reports by Mr. S. Howard and Mr. T. Brittenham.

MAJOR PORT ACTIVITY

Two hard rock guide bases were put aboard the JOIDES Resolution in St. John's. The crew made a practice HRGB dry run, moving the two halves of the HRGB into position in the moon pool area. The base was assembled and hydraulic system tested. The HRGB was then disassembled and stored.

The TV winch with 20,000 feet of coaxial cable was set in the moonpool area and the mezzanine was modified to accept the winch. Installation was completed at sea.

Underway to Site 648

JOIDES Resolution left St. John's, Newfoundland on November 1, 1985 for Leg 106 after taking on supplies and equipment including 519,500 gallons of fuel oil, 36.3 metric tons of bentonite, and 72 metric tons of barite.

SITE 648

After 5.5 days of cruising, the vessel arrived at Beacon Site 2 (Site 648) located at the MAR 70 km south of the KFZ. The site beacon was turned on and located at 3 km range. The ship was on location at Hole 648A at 2020 hours.

Preparations were made for a sea floor site survey using the "VIT" (vibration isolation tool) on which the TV camera and Mesotech sonar are mounted. The drill string was made up with a core barrel driven by a 9-1/2 inch positive displacement drilling motor. The drill pipe was lowered to 3121.5 m. Water depth was 3334.3 m. (The VIT incorporates a sleeve which is latched around the drill pipe. The VIT can be pulled up or lowered using the coaxial cable while the drill pipe acts as a "track" or guide.) With the drill pipe at 3121 m, we found the VIT camera frame could not be raised or lowered. It took a slow 12 hours to pull back the drill pipe, together with the VIT, unwrapping coaxial cable from the pipe by turning the drill pipe as it surfaced.

The TV camera took about 18 wraps around the lower 1000 m. When the cable head was removed, considerable torque was found in the cable. The TV/Sonar VIT frame was deployed again but without drill pipe to allow the cable suspending the TV/Sonar frame to de-torque. While approaching bottom, the floats from the site beacon were sighted by TV at 1925 hours at a water depth of about 3210 m.

The sea floor was sighted at 1945 hours, water depth 3334 m. The site survey continued with the DP vessel taking offsets to view the sea floor. Video and sonar presentations were high quality. The surveys were continued with the TV frame 6-8 m above sea floor. The "Mesotech" sonar was effective in helping maintain a "safe" elevation of the VIT frame above sea floor and in detecting nearby potential relief hazards.

After 28 hours of continuous site survey and mapping, a site was chosen for deployment of the guide base. The site was locally flat, consisting of pillow lavas 1-2 m in diameter.

After a somewhat unpromising start with cable torque problems the TV system proved in subsequent tests to be rugged, dependable, and able to provide high resolution black and white TV coverage. Particle backscatter was minor and in some cases it was possible to view the sea floor or re-entry cone at ranges up to 18 m (60 ft). The system was "up" every time it was needed.

Hole 648A

System tests were continued to determine if a hole could be drilled on bare rock without any guide structure or bit containment. For this test, a 9-7/8 inch bit and standard rotary core barrel were made up to a drilling motor and bottom hole assembly. This configuration did not allow for wireline coring, but a limited penetration with the standard barrel was acceptable.

The TV/sonar VIT frame was deployed on the drill pipe to observe the bit. The drill pipe was lowered and found the sea floor at 3310 m. After verifying the bit position, the TV/sonar frame was raised 100 m before resuming drilling to protect the frame from excessive vibration. The 9-7/8 inch bit cored from 3310.5 to 3315 m. The spud-in was checked by TV at 3312, 3313.5 and 3315 m. The VIT TV/sonar frame was recovered and the drill pipe "tripped" back to surface.

Though a limited test, results showed a hole could be drilled on hard rock without any lateral support. The pipe remains stable when only the lowermost 30-40 feet rotates. The motor made 4 m in 8.62 hours drilling in fresh pillow basalt to a total depth of 3316 m. Recovery was only 7 cm of pillow basalt and glass.

Hole 648B -- Hard Rock Guide Base (HRGB)

Assembly of the HRGB was started at noon 11 November. The lower half of the HRGB was secured in the moon pool area and the upper section landed and made up to the lower half. Lowering slings were attached, the release system tested and the cementing hose made up to the HRGB. Weather deteriorated with swells of 11 to 12 feet and the moon pool surging 8 to 15 feet. An unusually strong Bermuda high was producing strong northeasterly winds and swells in the area. The swells were forecast to become moderate to 6-foot in 96 hours. Weather conditions had moderated to 8 to 9-foot swells when the HRGB was deployed on November 16, reaching the sea floor at 0435 hours, November 17. The TV camera was deployed to monitor "landing" and the HRGB was landed successfully at 3342 m.

An 18-1/2 inch bit and a 9-1/2 inch drilling motor were made up to a bottom hole assembly to initiate drilling. The bit was run down to 3334 m and the hole was re-entered at 0915 hours, 18 November. The TV system was deployed, allowing the driller to position the bit above the HRGB and stab in for re-entry using a TV monitor at the drillers' station. The re-entry was made in winds of 30-35 knots, seas of 7-9 feet and easterly swells 12-16 feet, indicating downhole re-entry operations can continue in adverse weather conditions. The 18-1/2 inch hole drilling continued from sea floor at 3344 to 3347.5 m. The drill string was pulled out of the hole and a new 9-1/2 inch drilling motor and 12-1/4 inch bit were picked up. The smaller bit was selected in an attempt to increase the drilling rate.

The 12-1/4 inch bit was run to the top of the guide base and the ship positioned for re-entry using TV. The re-entry was made at 0450 hours, 20 November. The guide base was checked using TV and found in good condition. The 12-1/4 inch bit drilled from 3347.5 to 3348.5 m. The hole was swept with 30 barrels of high viscosity mud to flush out cuttings. Drilling and reaming the 12-1/4 inch hole continued to 3348.62 m. Hole conditions worsened while working pipe to unstall the drilling motor. Three high viscosity (100 to 200 vis) mud sweeps, 50 barrels each, were used to clear the hole. A maximum overpull of 40,000 pounds freed the stalled drilling motor. Drilling 12-1/4 inch hole at 3348.6 m was attempted. However, the motor was stalling and the bit was just able to get back to 3348.6 meters.

The 12-1/4 inch bit was pulled out of the hole, the drill motor laid down and the first drill motor picked up. The jet on the rotor was plugged to increase motor torque and a 9-7/8 inch core bit was selected for coring the pilot hole. The bit re-entered the guide base at 2345 hours, 21 November. The 9-7/8 inch hole was drilled from 3348.6 to 3358.3 m. Seven high viscosity mud sweeps were spotted (100-115 vis, weight 9.5 to 11.5 pounds per gallon). The drill motor stalled but was freed with a 70,000 lb overpull. The 9-7/8 inch bit with core barrel and drill motor were pulled out of the hole. Recovery was 3.7 meters of basalt. The bit was destroyed and the bit body was recovered with severe abrasive wear.

The drill rig went on a breakdown rate for 21 hours while making crown sheave repairs. The rig crew serviced and refit the unit to proper alignment.

A TV survey made on 22 November, found the guide base sitting on moderately cemented pillows with the southeast leg wedged in a small fissure which passes under the guidebase. A second fissure was located to the northeast of the guide base. Two small cement ponds could be seen on the east and west sides of the base.

On 23 November, an 18-1/2 inch bit and bottom hole assembly were made up, and run in the hole. Re-entry was effected at 0750 hours, 24 November. The 18-1/2 inch hole was opened up from 3350.81 to 3351.8 m. The 9-7/8 inch hole was opened to 18-1/2 inches in the interval 3351.8

to 3353.2 m. Fifty barrels of high viscosity mud was circulated to clean the hole. The bit was then pulled out of the hole to the top of the hard rock guide base and proceeded to wash out the cone. The 18-1/2 inch bit was pulled out of the hole and laid down.

On 25 November, a 14-3/4 inch bit was made up to a 9-1/2 inch O.D. drilling motor. The top drive and heavy wall drilling joints ("knobbies") were picked up and the hard rock guide base (HRGB) re-entered at 0833 hours using TV. Only one m of fill was found. The 14-3/4 inch bit opened up the 9-7/8 inch hole from 3353.2 to 3353.7 m. A 50 bbl and a 15 bbl slug of high viscosity (100-520 vis) mud were spotted. The 14-3/4 inch hole opening continued, enlarging the 9-7/8 inch hole in the interval 3353.7 to 3356.7 m. Seven 15 bbl "pills" of mud were used to clear the hole. Maximum overpull was 50,000 lbs. Opening of the 9-7/8 inch hole continued from 3356.7 to 3359.7 m, at which point preparations started for pulling the 14-3/4 inch bit and it was laid down on the derrick floor at 1200 hours, 26 November.

On 26 November, an 18-1/2 inch bit was picked up, without a mud motor, to drill using the top drive for rotation. The drill string was run in the hole making a TV-assisted re-entry at 2030 hours, 26 November. Hole bottom was tagged at 3356 m. The 14-3/4 inch hole was reamed to 18-1/2 inch from 3256 to 3357 m using top drive for torque. The hole was swept 7 times with highly viscous mud to clear cuttings. Maximum overpulls to 50,000 pounds were required to free stalled top drive.

Hole conditions worsened in the interval 3357 to 3358.5 m. Seven highly viscous mud sweeps (500+ viscosity) were pumped to clean the hole. Maximum overpull was 70,000 pounds.

A positioning beacon was deployed on 26 November, replacing the site survey "Hudson" beacon which was weakening after 22 days of operation. The guide base tilt beacon started to fail after 11 days.

Hole instability continued to hinder drilling operations. Reaming 14-3/4 inch hole to 18-1/2 inches continued to 3359 m. Five high-viscosity mud sweeps were pumped to ease hole problems. The drill pipe required overpulls to 70,000 pounds.

On 28 November, the open hole was cemented with 170 sacks of cement. The bit was pulled out of the hole and the guide base checked. The hole was re-entered with the 18-1/2 inch bit which tagged cement at 3345 m.

The 18-1/2 inch bit was then pulled out of the hole and a re-run 18-1/2 inch bit made up. It was run in the hole and made a TV assisted re-entry at 1830 hours. The cement was drilled out to 18-1/2 inch from 3349.5 to 3357.5 m. The hole was swept four times with viscous mud slugs. The drill pipe was run in the hole from 3349 to 3352 m, finding 2.5 m of solid fill. A 30-barrel slug of high viscosity drilling fluid was circulated to clean the hole.

On 30 November, the 18-1/2 inch bit was pulled preparatory to running 16-inch casing and a re-entry cone into the guide base.

The casing shoe was welded and the cone moved into the moon pool area where the gimbal was welded. The double "J" landing and releasing tool was made up. The cementing stinger was assembled and laid out on the pipe racker and the hangar and casing made up. The 16-inch casing hangar was latched into the re-entry cone. The running assembly was jayed into 16-inch hangar and the cone deployed on 1 December. The assembly completed the trip to 3337 meters. Pipe was spaced out for re-entry, the cementing assembly was rigged up and the cone landed in the guide base. Cementing was aborted due to apparent blockage. The cementing stinger assembly was released from 16-inch hangar and tripped out of the hole. The valve on the cementing head was found partially closed, apparently by impact from elevator bails during heave.

The drill string was tripped out of the hole, the TV frame removed, and a cementing stinger assembly picked up. The drill string and stinger were run in the hole, the TV frame latched to the drill pipe, and the string continued the trip to the re-entry cone. The drill pipe was spaced out for re-entry; the vessel repositioned and re-entry made at 0841 hours, 2 December. The casing was cemented through the stinger with 34.4 bbls of 15.8 pounds per gallon cement. The cementing stinger stuck briefly in the cone, possibly due to a slight vessel offset. While coming out with the stinger, the re-entry cone was inadvertently picked up about two meters and landed back to the original elevation. A TV camera check showed the cone and guide base in the proper attitude. The assembly pulled free and the cementing head was laid down.

The drill pipe and stinger were then pulled to 3337 m and the drill string flushed. The site was also surveyed with the drill pipe at 3337 m. The drill string was pulled to the surface with a stop to remove the TV frame. The trip out continued to surface and the stinger was laid out.

On 3 December, the ship was on a breakdown status for 12 hours while effecting repairs to the top drive. The top drive drilling motor armature grounded. Insulation broke down with windings blown at the junction to the commutator (this on 30 November). The top drive motor was replaced and rewired. Brake, air and hydraulic system lines were installed. Stress points were magnafluxed.

A 14-3/4 inch bit assembly for top drive operation was run in the hole and tagged cement at 3349 m. The bit was pulled back to 3346 m; the VIT was pulled to main deck and secured. In a top drive operation the VIT is taken out of the drill string as the entire string is rotated and the VIT TV/sonar may be damaged.

On 4 December, the cementing shoe and fill were drilled from 3349 to 3358.96 m. The hole was swept twice with 20 bbl sweeps of high viscosity drilling fluid. The cementing shoe was at 3352 m with 3 m of fill.

The VIT TV/sonar was installed and run in the hole to observe bit pull out from HRGB and cone. The 14-3/4 inch bit was pulled out of the hole, TV removed and a new BHA run in the hole with a 13-3/4 inch concave mill. The top drive and "knobbie" joints were picked up for space-out on re-entry. The hole was re-entered at 0215 hours. The VIT tool was pulled to main deck and secured. The drill string was run in hole from 3347 to 3356 m (3 m fill). Milling with top drive and the 13-3/4 concave mill continued from 3356 to 3361 m. The hole was unstable, with high torque and stalling. Four 20 bbl sweeps of high viscosity mud were pumped. The maximum overpull was 115,000 pounds (top drive in use). Bounce and vibration were noted from 3358.5 to 3359.5 m. From 3359.5 to 3361 m drilling was smooth, indicating the junk had been milled through. The mill, however, could not be worked back to bottom past 3360 m. High viscosity mud was circulated to clear the hole of cuttings. Overpulls reached 115,000 pounds during drilling.

The drill pipe was pulled to surface where the mill was found to be 95% expended, with little cutting life left.

A 9-7/8 inch core bit was run in the hole next with a top drive bottom hole assembly and standard core barrel. A TV-assisted re-entry was made at 0724 hours, 6 December. Three cores were taken in the interval 3357.8 to 3377.7 m. The drill string was then pulled to the surface, a new 9-7/8 inch bit picked up and the drill run back in the hole to continue coring. A TV assisted re-entry was completed at 1330 hours, 7 December. Two more cores were taken advancing the hole to 3377.8 meters, the deepest depth reached at Hole 648B. An 85,000 pound drag was noted on pullout.

The 9-7/8 inch bit was brought to the surface and exchanged for a 14-3/4 inch bit (top drive operations). The 14-3/4 bit re-entered 648B at 1230 hours, 8 December. Plans were to ream the 9-7/8 inch hole to 14-3/4 inch so that the 14-1/2 inch bit coring motors could continue the hole. Reaming to 14-3/4 inch hole continued to 3370.5 meters. Hole conditions were deteriorating and the 14-3/4 inch bit was pulled to the surface during reaming. Seventy-five barrels of high viscosity mud were pumped in the hole to clear cuttings while overpulls to 100,000 pounds were required to clear sticking pipe. At 3370 meters an additional 140 barrels of high viscosity drilling fluid was circulated to clear cuttings. The hole continued unstable with overpulls to 160,000 pounds required to free pipe. The 14-3/4 inch bit was pulled out of the hole.

At this point the rig crew made repairs to the top drive. The shaft was removed, inspected and reinstalled and the unit shimmed to alignment. The saver sub was found to be non-concentric and taken out of the string, further improving top drive concentricity.

A 14-3/4 bit was then run in the hole (top drive operations) with a TV-assisted re-entry made at 0129 hours, 10 December. The hole continued unstable with maximum overpulls to 160,000 pounds required to unstick drill pipe. High viscosity drilling fluid flushes were again used.

In an attempt to stabilize the hole it was open hole cemented with

31 barrels (100% excess). The cemented interval was 3369 m to seafloor. Cement was tagged at 3359 m and drilled out with a 14-3/4 inch bit from 3359 to 3363 m.

Drilling conditions were considered too severe to continue operations without drilling jars. Two hydraulic jars had been placed aboard the ship but both had been bent at the mandrel and were not in working order. In view of the lack of jars to combat stuck pipe, the unstable hole conditions, and the high priority assigned to keeping 648B open, a new site was occupied at Beacon Site 3, 25 km south of the Kane Fracture Zone.

Site 648B reached a total depth of 3377.8 m, or 33.4 m below seafloor. However, a total of 94.3 m were drilled fill and hole that was either reamed or cored. This is three times the actual penetration of 33.4 m. The hole was left with cement drilled out to 3363 m.

SITE 649

The drillship departed Site 648 at 0200 hours, 12 December. After a 27-mile cruise, beacon signals were picked up at 0545 hours and the vessel was on location at 0600 hours, 12 December.

Preparations began immediately for seafloor site surveying and tracking. The VIT frame was made ready with TV, "slim line" Mesotech, compass and a beacon for tracking. This arrangement provided the location of the TV frame with relationship to the vessel. The survey occupied 39.5 hours, terminating at 2250 hours, 13 December. The survey was done with the VIT frame only: no drill pipe was run. Concurrently, a 9-1/2 inch coring motor was made up, a core barrel checked and spaced out and surface flow tests were conducted. The VIT camera frame was retrieved and a 10-1/2 inch bit and coring motor were lowered.

Function tests and crew training on the tension latch, overshot and core barrel latch were completed. The VIT tool was installed in the drill pipe string and the top drive and knobby joints picked up.

Hole 649A

The drilling location for Hole 649A was selected after a one-hour TV site survey, spudded at 3528 m and cored to 3935 m with no recovery.

Hole 649B

Hole 649B was cored from 3528 to 3534.5 m (6.5 m penetration), recovering six meters of core and requiring 30,000 pounds of overpull to free the bottom hole assembly. The core recovered a broken-up hydrothermal sulfide deposit. The upper section was soupy silt and the lower section coarse sand and pebbles.

Hole 649C

Three and a half meters were cored. Recovery was 0.15 m of glassy basalt rubble.

Hole 649D

In this hole, 6.5 m were cored and recovery was zero. While pulling the inner barrel to the surface, the tube failed at a welded connection, requiring a round trip to continue coring operations. The knobby joints were laid down, the VIT TV frame was taken out of the string and the inner barrel recovered when the bottom hole assembly reached the surface.

A new 10-1/2 inch bit was made up. The VIT TV/sonar was put in the drill string and the pipe tripped to the sea floor.

Hole 649E

A core was cut from 3530.5 to 3539.4 m, but the inner barrel was apparently stuck and could not be pulled. The overshot was sheared off and the pipe tripped to the surface. About 10 cc of hydrothermal sulfide deposit was recovered. A pick-up sleeve was required to disengage a latch so that an inner barrel could be recovered. This sleeve was missing from the overshot retrieving assembly. Apparently, the sleeve disengaged from the overshot while travelling through the blocks and was found on top of the top drive unit. The latch was in good working condition and undamaged despite attempts to work the barrel free with Spang jars.

Hole 649F

Operations continued with the making up of an XCB bottom hole assembly, a 9-1/2 inch drilling motor and an 11-7/16 inch bit. The XCB has a spring-loaded inner barrel which extends some seven inches beyond the bit to protect soft core from washing away. When hard material is encountered the inner barrel retracts, allowing full washing and cuttings removal by the drilling fluid or water.

The VIT TV/sonar was installed in the drill string and the bit tripped to the sea floor. The XCB core was taken from 3515.5 to 3528.5 m. Five thousand pounds of drag were required to pull out of the 13 m deep hole. The drill string was pulled back to the surface after a stop to recover the VIT TV/sonar frame. Approximately 4 cc of hydrothermal sulfide deposit was recovered.

A new bottom hole assembly with a 10-1/2 inch bit and coring motor was made up, the TV VIT frame installed in the drill string and the bit was headed for the sea floor to core the next hole.

Hole 649G

This hole was cored from 3518.8 to 3527.8 m with recovery of 0.15 m, partly of massive sulfide deposit.

Holes 649H,I,J

Coring motor operations continued with the coring of three shallow holes, 649H, 649I and 649J. 3 m were cored in 649H, 2 m cored in 649I, and 1.5 m cored in 649J. The core barrel was not pulled between holes. The total recovery of 0.05 m was assigned to 649H. The approximately 1% combined recovery comprises highly disturbed hydrothermal sulfide deposits.

UNDERWAY TO ALGECIRAS, SPAIN

The drill string was tripped out of the hole and the vessel departed for Algeciras, Spain at 0900 hours, December 18, arriving at 1600 hours, December 25. The ship took on 532,732 U.S. gallons of fuel oil, and departed Algeciras at 1330 hours, December 26, arriving at Malaga, Spain, terminating Leg 106 with the first line at 2000 hours, December 26.

SPECIAL REPORTS

TV System

The TV/re-entry system was used successfully for 18 re-entries. It was also used for 60 hours of drill site surveying, recording sea floor structure and geology and monitoring drilling operations. System performance improved rapidly with experience. The maximum re-entry time was only 1-3/4 hours and many re-entries were made within 1/2 hour. By using a real-time video monitor at the driller's station, deliberate and positive re-entries can be made.

The principal elements of the system are a winch drum with 20,000 feet of coaxial cable, a frame (Vibration Isolation Tool or "VIT"), a low-light-level TV camera and a scanning sonar tool. The TV and sonar are mounted on the frame. The coaxial cable is used to deploy the frame. The frame can also be loosely latched around the drill pipe and raised or lowered along the pipe using the winch and cable.

During the initial VIT deployment the cable took 18 wraps around the drill pipe. The resulting cable friction prevented use of the drill pipe and VIT. The cable was released by recovering the VIT and drill pipe together and making 18 left-hand turns of the drill pipe. The fouling was apparently due to residual cable torque. The torque was removed by deploying the VIT without the drill pipe and repeatedly lowering the VIT 1000 m and raising it 100 m, allowing it to de-torque.

Bits

Leg 106 holes were cored using 9-7/8 inch, 10-1/2 inch, and 11-7/16 inch bits. Drilling bits used were 18-1/2 inch, 14-3/4 inch, and 12-1/4 inch. With light applied bit weights, penetration rates were slow, particularly for the larger bit sizes. Rates varied from 1.75 m per hour for a 9-7/8 inch core bit to about .3 m per hour for the 18-1/2 inch bit size. In general, abrasive wear on bit legs, shanks and shirt tails was abnormally high. Cutting-structure wear was not significant but fluid erosion was evident and could lead to insert loss. Additional detail is contained in Mr. Terry Brittenham's report titled "New Hardrock Drilling Techniques."

Coring Motor System

The results of Leg 106 showed that positive displacement motors could be used to spud into hard basalt sea floor. The coring motors were not used at Site 648B, primarily because of unstable hole conditions.

The coring motors were used at Site 649 but at lower than recommended flow rates. No motor-related problems developed. The core barrel latch and retrieval systems worked to design. The core barrels were weak at the laser-welded connections and several barrels parted at the connection during handling. Means of improving the core barrels by using an integral threaded connection is being investigated.

Hard Rock Guide Base (HRGB)

The HRGB worked to design and no major engineering modifications are planned. Minor modifications to reduce the amount of welding, and thus assembly time, should be studied. The existing unused guide base should be deployed before fabricating additional bases to ensure that HRGB evaluation is complete and all "bugs" are worked out.

Top Drive

On 3 December, the drillship went on a breakdown status to make repairs to the top drive. Insulation had broken down with the windings blown at the junction to the commutator. The top drive motor was replaced and re-wired. Brake, air, and hydraulic system lines were installed and stress joints magnafluxed. Electrical grounding was due to salt water penetration into the top drive motor assembly. To lessen exposure to salt water, improvements to the oil saver sub are planned and bolt-on top drive motor and quill shaft covers were installed.

After 1-1/2 days of rotation with the new top drive, excessive swivel motion was observed. On inspection, the quill shaft was observed to be out of centralization with the main shaft. The main shaft was reinstalled and centered using the lower guide dolly frame turnbuckles. After further adjustment the centralization was acceptable. A swivel sleeve is planned for installation on the main shaft to reduce excessive clearance.

Crown Sheaves

The starboard center sheave bearing would not accept grease, even under high pressure. No blockage was evident. Subsequently the cluster shaft was cleaned and inspected. It was concluded that shafts had been installed backwards by the manufacturer. Both starboard and port cluster shafts were removed, cleaned, inspected and reinstalled. There was little evidence of damage.

LEG 106 WEATHER SUMMARY

The ship departed St. John's, Newfoundland in a gale with north-easterly winds of 35-40 knots and seas to 20 ft. These adverse weather conditions caused us to deviate somewhat from our course to minimize the ship's motion. The lingering northerly swell produced by this gale resulted in an uncomfortable ride for the first three days at sea.

The cold front associated with the gale moved southward in advance of the ship. We had relatively good weather upon arriving at the site and the good weather held during the site survey. The cold front became an elongated east-west oriented area of low pressure to the south of the site and merged with the inter-tropical convergence zone. This low pressure trough, coupled with an abnormally strong Bermuda high pressure center to the north, produced near gale force east-northeast tradewinds of 24-35 knots with squalls gusting to 44 knots and seas to 14 feet, from 10 through 15 November.

The low pressure trough spawned a tropical storm just to the west of the site which later developed into hurricane "Kate." In addition, a small, intense low pressure center--probably a tropical storm--developed about 90 miles northeast of the ship and looped from northeast to southwest before moving away from the ship to the east. This storm produced winds of 35-45 knots with gusts to 52 knots and seas to 16 feet on the morning of 18 November.

The weather returned to normal after 18 November, and remained within the expected norms for the remainder of Leg 106.

The prevailing winds were east-northeast about 18 knots. The maximum sustained wind speed was 44 knots, and the highest gust was 52 knots. The seas averaged about 6 feet with a maximum of 16 feet at the site and 20 feet offshore Newfoundland. The air temperature ranged from 35°F at St. John's to a high of 79°F at the site. The sea water ranged from 42°F in Newfoundland waters to 75°F at the drillsite.

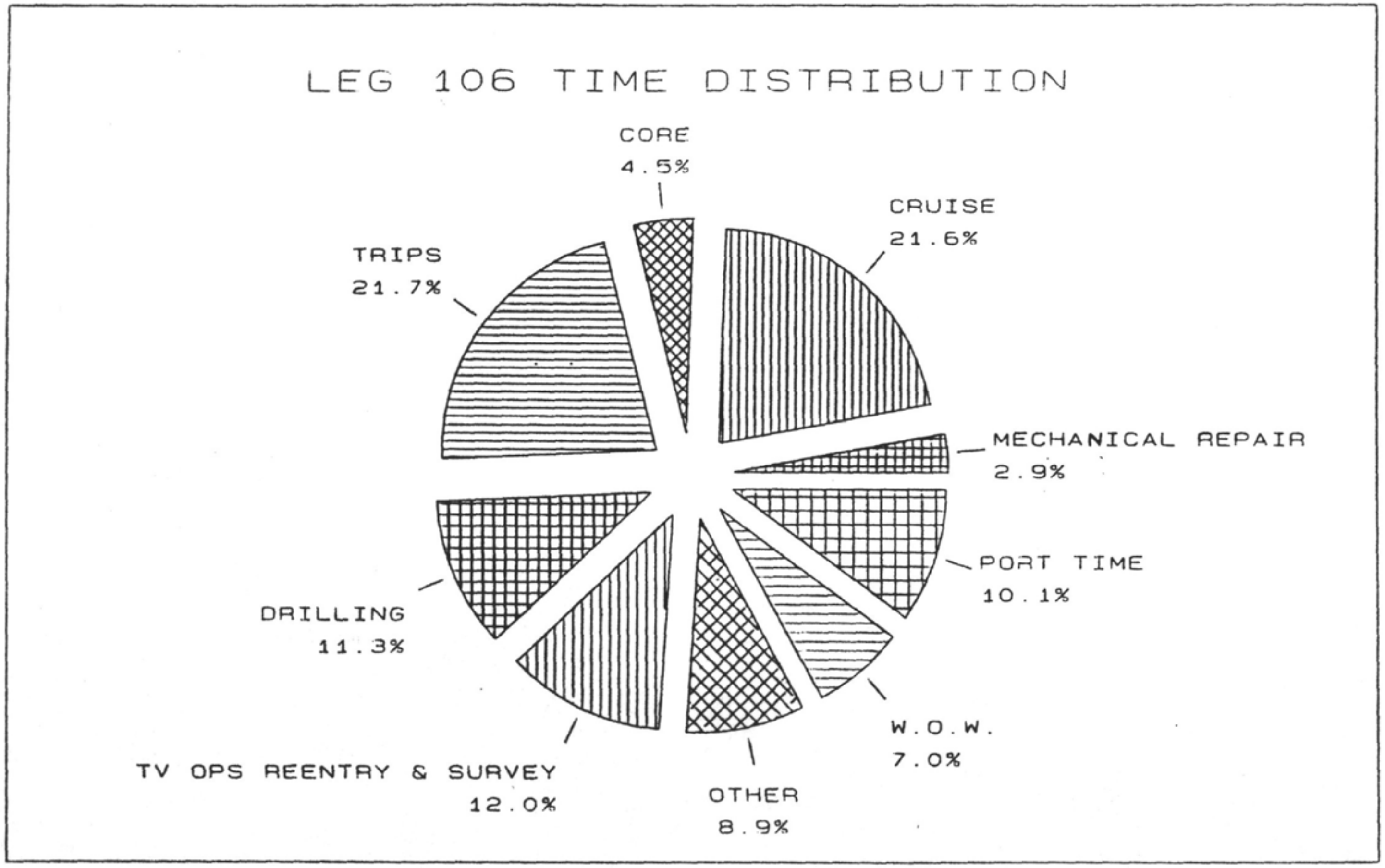
PERSONNEL

The low rate of penetration and borehole stability problems at Hole 648B were disappointing; nevertheless, morale was good and the ship's crew and science party maintained a positive attitude as participants in the development of the hard sea floor spud system. TV monitors were available throughout the ship allowing the science party and crew to observe operations. The SEDCO crew support in the assembly and deployment of the guide base and in the TV operations was outstanding. At Site 649, the discovery of a hydrothermal smoker and the recovery of sulfide deposits ended Leg 106 on a positive note.

OCEAN DRILLING PROGRAM
TIME DISTRIBUTION
LEG 106

Total Days (November 1, 1985 - December 26, 1985)	60.51
Total Days in Port	6.13
Total Days Cruising including Site Survey	13.09
Total Days on Site	41.29
Trip Time	13.13
Drilling Time	6.82
Coring Time	2.7
Logging Time	0
Reentry Time (TV)	4.37
Mechanical Repair Time	1.73
Wait on Weather	4.24
Other Miscellaneous	5.34
TV Surveys	2.88

Total Distance Traveled (Nautical Miles)	3865
Average Speed Knots	12.4
Number of Sites	2
Number of Holes Cored	12
Total Meters Cored	95.6
Total Meters Recovered	12.3
Percent Recovered	12.9
Total Meters Drilled	53.5
Total Cores Attempted	16
Total Meters of Penetration	99.3
Maximum Penetration	33.4
Maximum Water Depth	3530.5


LEG 106 TIME DISTRIBUTION
CORE
4.5%
CRUISE
21.6%
MECHANICAL REPAIR
2.9%
PORT TIME
10.1%
W.O.W.
7.0%
OTHER
8.9%
TV OPS REENTRY & SURVEY
12.0%
DRILLING
11.3%
TRIPS
21.7%

OCEAN DRILLING PROGRAM
SITE SUMMARY
LEG 106

HOLE	LATITUDE	LONGITUDE	DEPTH METERS	NUMBER OF CORES	METERS CORED	METERS RECOVERED	PERCENT RECOVERED	METERS DRILLED[2]	TOTAL PENET.	TIME ON HOLE	TIME ON SITE
648A	22°55.3'N	44°56,8'W	3310	1	4.5	.14	3.1	0	4.5	105.8	
648B	22°55.3'N	44°56,8'W	3344.4	5	29.7	5.77	19.4	53.5	33.4	740.6	846.4
649A	23°22.1'N	44°57.0'W	3528	1	7.5	0	----	0	7.5	69.6	
649B	23°22.1'N	44°57.0'W	3528	1	6.5	6.0	92	0	6.5	2.5	
649C	23°22.1'N	44°57.0'W	3529	1	3.5	.15	4.2	0	3.5	4.25	
649D	23°22.1'N	44°57.0'W	3528	1	6.5	0	----	0	6.5	11.0	
649E	23°22.1'N	44°57.0'W	3528	1	8.9	0	----	0	8.9	10.3	
649F	23°22.1'N	44°57.0'W	3515	1	13	.05	0.3	0	13	7.0	
649G	23°22.2'N	44°57.1'W	3518	1	9	.15	1.6	0	9	23.5	
649H	23°22.2'N	44°57.1'W	3522	1	3	.05	1.7	0	3	3.2	
649I	23°22.2'N	44°57.1'W	3522	1	2	[1]*----	----	0	2	.3	
649J	23°22.2'N	44°57.1'W	3518	1	1.5	[2]*----	----	0	1.5	9.8	141.5
	GRAND TOTALS			16	95.6	12.3	12.9	53.5	99.3		987.9

[1] *RECOVERY ASSIGNED TO 649H
[2] *INCLUDES REAMING, DRILLING FILL, DRILLING

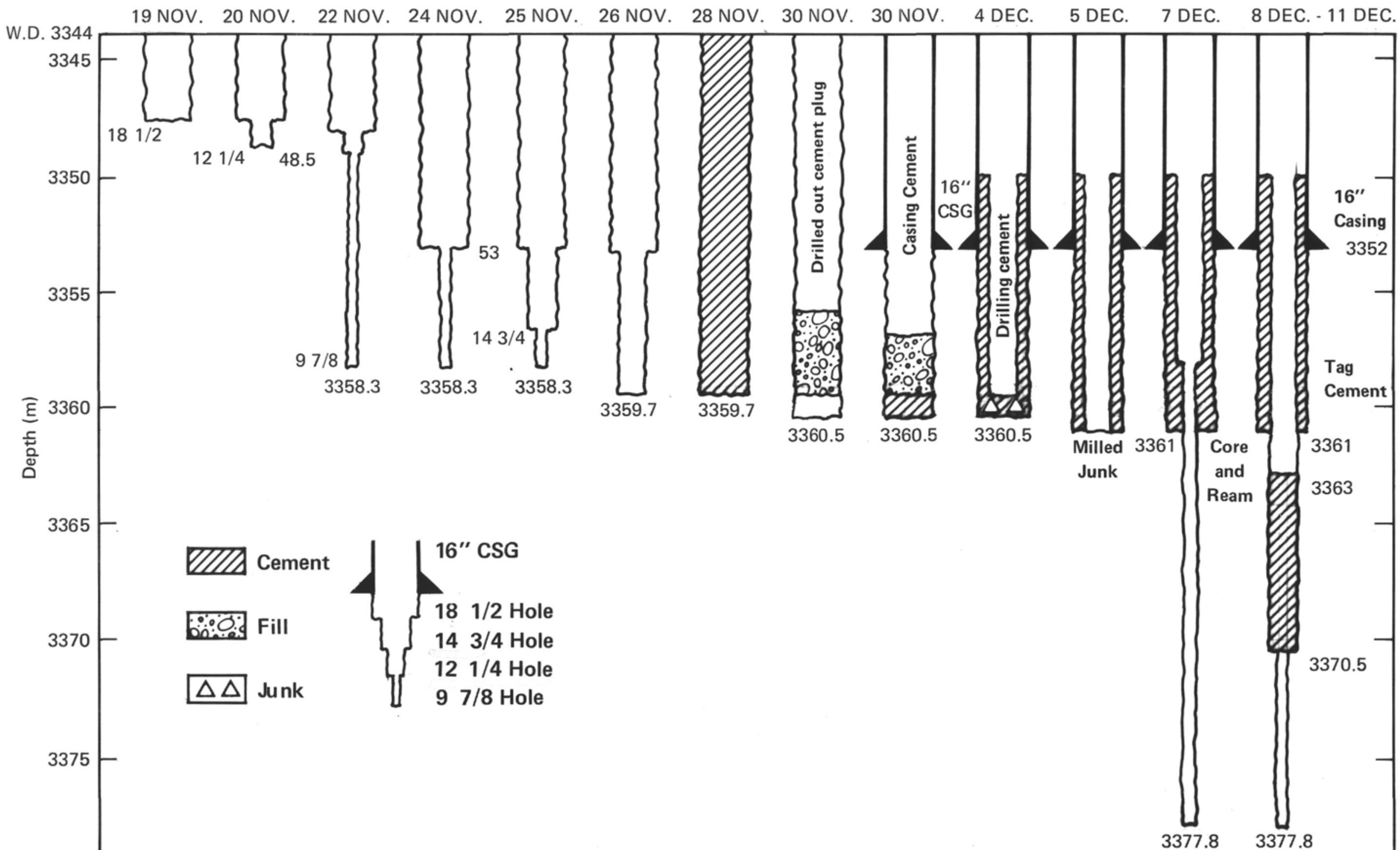
OCEAN DRILLING PROGRAM
BIT SUMMARY
LEG 106

HOLE	MFG	SIZE	TYPE	SERIAL NUMBER	METERS CORED	METERS DRILLED	TOTAL PENET	CUMULATIVE HOURS	HOURS THIS HOLE	TOTAL HOURS	CONDITION	REMARKS
648A	RBI	9-7/8	C4	AS003	4	----	4	4	8.62	16.12	T2-B4 1/8 #3CL	RR bit run on motor
648B	HTC	18-1/2	X77	KD884	----	3	3	3	17.16	17.16	T2-B4 SE 1/16 Shank wear	Pulled due to low ROP
648B	STC	12-1/4	Q7JS	EC4647	----	1.6	1.6	1.6	19.92	19.92	T2-B8 SE 1/16 #1CL Shankwear	Pulled due to hole problems.
648B	RBI	9-7/8	C4	AT131	10.75	----	10.75	10.75	6.16	6.16	Junk bit destroyed	Run on motor only body left.
648B	HTC	18-1/2	X77	KD884	----	2.39	2.39	5.39	24.66	24.66	T4B6SE 1/8 Shankwear	Pulled due to total op. hrs.
648B	REED	14-3/4	S62J	R21167	----	6.5	6.5	6.5	18.00	18.00	T2B6SE 1/16 Shankwear	RR bit pulled due to hours.
648B	HTC	18-1/2	X77	KD883	----	4.5	4.5	4.5	39.5	39.5	T4B6SF 1/8 Shankwear	Pulled due to hours.
648B	HTC	18-1/2	X77	KD884	----	12.5	12.5	17.89	32.41	32.41	T4B8SF 1/8 Shankwear	Pulled cement & rubble.
648B	REED	14-3/4	S13GJ	D05627	----	10	10	10	5	22	T4B 6 1/16	Drilled 16" shoe cleaned out rathole.
648B	RBI	9-7/8	C4	AT113	21	----	21	21	5.68	5.68	SFBTMT T8B8 1/16	Cored 12m fill Cored 9m new hole.
648B	RBI	9-7/8	C4	AT130	17.63	----	17.63	17.63	4.92	4.92	BTMTSE T6B6 1/16	Cored 10m fill Cored 7.63m hole
648B	SEC	14-3/4	H10JAP	115908	----	9	9	9	15	15	T4B6 I	Open 9-7/8" hole
648B	SEC	14-3/4	H8JAP	121685R	----	4	4	4	10	10	T4B6 I	Ream 14-3/4" hole; Drill 4m cement

HOLE	MFG	SIZE	TYPE	SERIAL NUMBER	METERS CORED	METERS DRILLED	TOTAL PENET	CUMULATIVE HOURS	HOURS THIS HOLE	TOTAL HOURS	CONDITION	REMARKS
649A	RBI	10-1/2	C-9	ATS15	7.5	----	7.5	7.5	0.67	0.67	Not surfaced.	7-1/2" PDCM
649B	RBI	10-1/2	C-9	ATS15	6.5	----	6.5	6.5	1.00	1.67	Not surfaced.	9-1/2" PDCM
649C	RBI	10-1/2	C-9	ATS15	3.5	----	3.5	3.5	2.17	3.84	Not surfaced.	9-1/2" PDCM
649D	RBI	10-1/2	C-9	ATS15	6.5	----	6.5	6.5	0.67	4.51	BT nose inserts T2B4SE I	9-1/2" PDCM
649E	RBI	10-1/2	C-9	ATS17	8.96	----	8.96	8.96	0.50	0.50	New condition T2B2SE I	9-1/2" PDCM
649F	RBI	11-7/16	APC XCB	AS813	13	----	13	13	1.50	1.50	New condition T2B2SE I	9-1/2" PDCM
649G	RBI	10-1/2	C-9	AT517	9	----	9	9	1.92	2.42		
649H	RBI	10-1/2	C-9	AT517	6.5	0	6.5	6.5	0.69	3.11	T2B2 SEI	

OCEAN DRILLING PROGRAM
BEACON SUMMARY
LEG 106

SITE NO.	MAKE	FREQ. KHz	SERIAL NUMBER	SITE TIME HOURS	WATER DEPTH	REMARKS
648B	Datasonics	Z	221	288	3344.4	Use on HRB as tilt meter, could not command to pinger function.
648B	Datasonics	Z	222	----	3344.4	Failed in moon pool surf action (tilt meter on HRB)
648B	Datasonics	17.5	232	345	3344.4	Dropped 11/27 free fall positioning beacon. Still pinging when site abandoned. 12/9/85
648B	Datasonics	15.5	225	14	3344.4	Deployed on cone for Leg 109 site 648B.
648B	Datasonics	16.5	XX	Died after 706 hours	3344.4	Left by "Hudson" survey vessel, turned on 9800 ft. from location with hull mount C.P. life 30 days.
649	Datasonics	15.5	XX	4.75	3528	Turned on at 2139 meters. From location with hull mount C.P. approx. 20 days life left in batteries. Beacon turned off.



Site 648B Drilling Sequence

TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard JOIDES Resolution for Leg 106 of the Ocean Drilling Program were:

Laboratory Officer:	Burney Hamlin
Laboratory Officer:	Bill Mills
Curatorial Representative:	Jim Butler
System Manager:	John Eastlund
Electronics Technician:	Michael Reitmeyer
Electronics Technician:	Dan Larson
Yeoperson:	Michiko Hitchcox
Photographer:	Kevin De Mauret
Marine Technician:	Mark Dobday
Marine Technician:	Matt Mefferd
Marine Technician:	Joe Powers
Marine Technician:	Dan Quoidbach
Marine Technician:	Kevin Rogers
Marine Technician:	Christian Segade
Marine Technician:	Katie Sigler
Marine Technician:	Don Sims
Marine Technician:	John Tauxe
Weather Observer:	Farrell Johnson

Another technician aboard JOIDES Resolution was:

Earle Derry, Schlumberger Logger (Schlumberger Houston, 8460 Gulf Expressway, Houston, TX 77023)

TECHNICAL REPORT

PORT CALL - ST. JOHN'S, NEWFOUNDLAND

The technical staff arrived in St. John's 25 October to meet JOIDES Resolution. The ship docked the morning of the 27th, at the fueling pier. Crossover continued throughout the day with most off-going technicians released by the end of the day. A Magnavox Transit/Global Positioning System (GPS) was installed in the Underway Geophysics lab. Marine techs with responsibilities in the chemistry and cryogenic magnetometer labs were held over to address problems and repairs.

Leg 105 samples and cores, equipment for service, and frozen organic samples were off-loaded and shipped. Three truck-loads of drilling equipment and consumables and two air-freight shipments supporting this leg were received and distributed. Included was the mezzanine structural members to be used to construct a second level in the casing hold.

Vendor services included Xerox, IBM, Hewlett Packard (GC), Phillips (XRD), DEC (XRD), and SOLA (U/W power). Cold-weather parkas were sent to be cleaned.

The G.R.A.P.E. source housing was given a "wipe test" and the sample returned to Texas A & M to comply with a request from the Radiation Safety Office.

The JOI Review Panel met with key technical personnel.

The public relations group co-ordinated an intensive three days of tours to highlight Canada's partnership in the Ocean Drilling Program. One hundred VIPs toured the ship the first day, followed by about 700 industry personnel and 700 students on the next two days.

The Canadian Minister of Mines hosted a dinner for ship and ODP officers and scientists.

A spruce Christmas tree was cut from the Newfoundland woods on Halloween night.

UNDERWAY TO SITE

The ship departed from St. John's harbor on 1 November 1985 at 0900 hours. Slow speeds and courses were selected to ease the movement of the ship through the rough sea conditions. Once out of traffic lanes, speed was increased, but no seismic gear was streamed because the ship's speed was in excess of ten knots. Bridge SATNAV fixes were recorded on the U/W PRO-350; pit log speed, heading and other parameters were recorded via the HIRES program on the transit to site. Smooth track plots were successfully generated with new software using the SATNAV data.

The GPS system that was installed in port performed well for up to a day at a time before various error signals would come on, terminating dead reckoning and other functions. A service call is anticipated in Malaga.

TELEVISION RE-ENTRY AND BOTTOM SURVEYS

The sub-sea television system was used extensively to survey the proposed drilling area and to give a high degree of confidence for each of the 17 re-entries. In the configuration used, the Mesotech gave precise ranges to bottom and an indication of slope and scarps; the TV gave detail of bottom features, fish, and the re-entry cone and guide base. The TV showed the smoothness of re-entry, and allowed inspection of the bit and cones, mud stingers, and drill pipe motion. Operators of the survey re-entry system have great confidence that by using the TV and Mesotech systems concurrently, holes without re-entry cones could be located and re-entered.

A makeshift metal mesh trap was constructed and fastened into the VIT frame for the last deployment to collect biological specimens. A deep sea fish, pink shrimp, and white blind shrimp-like crustacea were recovered, and are thought to be from the vent area. They have been taken to Woods Hole Oceanographic Institution for identification.

To get the signal to the computer room from Dynamic Positioning (DP), a coaxial line was run temporarily to a video outlet in the Tech Office. In the computer area the signal was connected to the lab's TV multiplexing system and distributed on channel 9.

The recreation and photo VCRs were used to record the surveys and re-entries on some 30 video cassettes. This equipment was also used in the photo lab to edit the films. SEDCO's electrical supervisor plans to acquire a larger equipment rack for the DP room to accommodate additional monitors and associated re-entry electronics, and to acquire two rack-mount VCRs that annotate the videos with time and date. It is also his intent to operate and support all of the re-entry and TV systems. Permanent editing equipment for the photo lab will have to be considered.

ON-SITE PROJECTS

In the first weeks of the cruise, considerable effort was put into the erection of a 16' X 44' deck in the casing hold, into lab and refrigerated storage modifications, into technical cross-training, and into service jobs.

Mezzanine Deck

The structural members for the casing hold mezzanine deck arrived in St. John's and were spotted in the casing hold to reflect the order of assembly. Selected planks in the oak flooring were removed and notches cut in the sleepers to expose the steel I-beams. Columns, cross beams, and joist hanger were assembled on the floor, raised with the overhead crane, and clamped into position. Joists were then fastened into hangers, stabilizing the structure. Another assembly was erected and tied into the free standing structure until the five bays were up.

SEDCO's welders arc-welded the column bases to the floor beams. Corrugated metal decking and tongue and groove 5/8 inch plywood were then fastened to the joists, and trim attached to the deck perimeter to finish the job.

The steel plate under the oak flooring had not been refurbished in the ship conversion and was in need of chipping, grinding, and paint protection. One third of the casing hold was cleared at a time for reconditioning and refinishing. The consumables, much of which had been moved to the refigerated core storage area before construction began, were shifted again and covered. Planking was re-layed as tight as possible; planks adjacent to the fuel tank and over the drain were not fastened.

Refrigerated Stores

With the hassle of folding up the basket landing platform, and the problem of handling the basket between the mezzanine and landing platform, it was agreed that it would be desirable to make the lower 'tween deck refrigerated core storage area the prime one. The supplies on the lower 'tween deck were removed, and the cages were disassembled and relocated in walk-in refigerator on the hold deck. The hold deck reefer is now cooled to 50^{O}F and accommodates all the photo chemicals, many of which are sensitive to a 40^{O}F lower limit. When the space has to be used for core storage, short-term storage of the cores at 45 or 50^{O}F is not thought to be detrimental.

Paleo Lab

This work space was gutted and refitted with a perimeter maple butcher block work surface that now accommodates the computers and peripherals, microscopes, and an extra work station. New shelving holds the reference volumes that were in the large floor cabinet.

SEM Lab

A bench was constructed that accommodates the printer and PRO-350, freeing the desk for papers and reference work, and augmenting the techs' work area. The Haskris water cooler was plumbed in, tieing into the chill water available in the XRF area; silver-soldered copper-insulated pipe was routed through the passageway overhead. A cabinet was constructed behind the SEM unit to house the Haskris water cooler, the SEM vacuum pump, and an isolation transformer. The specified electrical outlet was installed.

With permanent cooling water available and the unit on permanent stand-by, excellent specimen images were available within 5 minutes. The increased stability gained by leaving the unit on also contributed to sharper images up to 50,000X and good images up to 100,000X.

XRF/XRD Lab

The chemistry lab's HP 1000 was remounted to allow a table top and a file cabinet to be mounted over it. Some of the components were mounted on slides to ease access. The table top contributed much needed work space as it accommodated printers. A movable monitor mount was also installed.

Chemistry Lab

The yellow solvent cabinet and corrosives cabinet were exchanged to make the location of the solvents more convenient, and to remove them from the vicinity of the Claisse fluxer and furnace. Some intermediate shelving was installed to hold computer peripherals and instrument components. Plumbing and wire runs were organized. Two drying ovens were moved into the XRF preparation area and mounted on stacked shelves.

Core Lab

The physical properties vane shear electronics were rebuilt, the Scientech balance system installed, an aluminium rack for cut cores in the description area refined, the second dement coated Felker saw and mini-core station re-installed, and a cabinet built for pigeon-holing bagged samples.

Underway Geophysics Lab

The interior access to the battery room was removed and an exterior weather tight door installed to replace it. This allowed a reconfiguration of cabinets that gives more comfortable use of the VERSATEC plotter.

The weather covers on the fantail air exhausts weather covers were hinged upward. This cleared a passage aft and exposed the hydrophone winch controls to a greater degree. The vent diffusers were rotated to blow air aft, and to keep some of the hot air venting on the fantail off the work bench area.

LABORATORY ACTIVITIES

In spite of the lack of core on this leg, several labs were kept busy with shorebased projects.

Thin Section Lab

More than 300 polished sections were made for the East Coast Repository from DSDP samples. This completed the repository's collection, by replacing missing thin sections and augmenting those made before. In addition, rock specimens were brought aboard by scientists from which petrographic slides were made. Pyrite and other sulfide minerals recovered from the hydrothermal area required special attention, including epoxy impregnation and casting, before slides could be prepared. The yeoperson familiarized herself with the equipment and assisted in the preparation of some of the slides, as well as making slides from spare material.

XRD Lab

Physical properties specimens from Leg 104 were quantitatively analyzed with and without glycol treatment. Clays were extracted and identifications attempted. Samples from the hydrothermal sediments recovered at Site 649 were analyzed also. Other projects included the creation of reference pattern files, writing clay preparation and analysis procedures, and programming efforts directed towards speeding up use of the database.

XRF Lab

The majority of time available this cruise was spent attempting to overcome hardware and software problems. Progress was disappointing, very few successful scans were made. A service call from ARL is planned during the Malaga port call. Dr. Gary Brass, an XRF specialist, was aboard to refine our standard procedures and to fine tune and evaluate the machine. Dr. Brass also conducted several seminars on XRF theory.

Chemistry Lab

The CHN was run the entire leg, analyzing samples the scientific staff had brought with them. A ROCKEVAL operations cookbook was written. Ion suppressors were installed in the DIONEX unit for evaluation, but a defective anion unit curtailed completion. Several areas of the lab were reorganized to gain more counter space. A technician was trained to maintain and operate the inorganic chemistry systems, focusing primarily on the DIONEX ion analyzer.

Photo Lab

Although core photos were minimal, hundreds of photos were taken to document the engineering aspects of deploying the hard rock guide base and gimbaled cone. Thirty blank video cassettes and several recycled movies were used to record the deployment of the guide base, aspects of the drilling, and the sea floor site surveys. Numerous hours were spent editing the videos as directed by the scientists. Polaroid 4" x 5" photos were copied from a monitor to assist in geologically mapping the areas surveyed. Permission from shore was granted to make sets of the most significant photographs for each of the scientists.

LONG-TERM LAB PROBLEMS STUDIED

Several problems previously addressed were studied by SEDCO supervisors.

Underway Geophysics Air Conditioning

Blueprints revealed that four ducts had been planned for this area; only two had been installed, both smaller than specified. It was also suspected that the heat load for the area had been underestimated. Three solutions were identified, in order of preference:

1. Mount an auxiliary water cooled air conditioner in the aft port hole or through the aft bulkhead. Besides providing for the specific heat load it would offer redundancy if the ship

system ever failed or was shut down for servicing.

2. Use air from the Engine Control Room (ECR). This would be fairly straight forward using a floor level cool air duct, and a ceiling level warm air return penetrating the deck in the forward part of the lab near the plotter.

3. The ducting in the warehouse could be continued into the lab space and another air return vent penetration made.

The latter two solutions use air conditioning planned for other areas and could tax them under severe conditions.

XRF/XRD Air Conditioning

As the ship's chill water is available in the lab, a wall mounted air cooling heat exchanger would be practical. Catalogs aboard failed to illustrate anything suitable within the dimensions (1' X 4' X 4'), so when approved, shopping will be done ashore. The unit will have a thermostat and a multispeed fan control for fine control and comfort.

Lab Stack Power Imbalance

One problem with the labs' regulated power was attributed to a load imbalance on the three phases of power supplying the labs. Amperage measurements were made in the regulated power panel box on the fo'c'sle deck where the largest power users are located. XRF and XRD power loads were reassigned after finding them, and other heavy users, all on the same power circuit. Pulsing on the load was noted and traced to ovens in the CHN analyzer whose load was transferred to ship's power. Thermostatically controlled loads and large motors that cycle are possible sources that can induce noise into the regulated power circuits. (The load measurements are in the general information section of the L.O. book.)

Cyborex Regulated Power

This unit is to be augmented with a battery backup to assist in maintaining power standards. As regulations governing battery installations are quite rigid, and a large volume of batteries is impractical at most locations, a corner of the Schlumberger workshop has been proposed.

Fantail Levelwind Foundations

Levelwind units have been purchased for installation on two of the existing seismic and magnetometer winches located on the fantail poop deck. Drawings of the units were FAXed to the ship for the Drilling Engineer to make work drawings and a materials list. Although our aft deck request was included, none of our drawings of the proposed deck accompanied the FAX. Drawings were sent back to the beach and finals received before cruise end. It is anticipated that materials will be purchased in Malaga so the deck structure can be fabricated before the levelwind units arrive.

Rusty Water

The chief engineer is investigating sodium carbonate as a water additive to achieve a neutal pH. Chlorine is also added to inhibit iron-loving bacteria. These efforts are to reduce the rust in the water. Water filters are to be ordered for the lab stack water fountains.

Second-Look Lab Condensation

Baffles were installed in the lab stack air conditioning system in St. John's, and this has alleviated 95% of the condensation drips originating there. High heat and humidity have not taxed the system so far. Some of the equipment scheduled for the lab has been reinstalled as have a few pieces of XRF sample grinding equipment. A proposal has been drafted for consideration to make the area suitable for XRF powder preparation, including a positively pressurized clean hood.

The condensation from the air conditioning system now drips on the floor of the fan room and occasionally, when the drip buckets overflow, water runs under the wall to the top of the lower 'tween store room.

Safety

We elected to retain the same METS team as on Leg 104, with the possibility of rotating a member out in the future. We feel that with complete team rotation, training would be so infrequent as to be ineffectual if we are indeed expected to assist in an emergency. The fire drills conducted this leg were of considerable depth, and included most of the ship and METS team. With emergencies staged in likely locations, and with hands-on practice using the equipment, our appreciation of the problems that could be encountered was considerably expanded.

To contribute to the oncoming crew's emergency plans, one walkie talkie was stationed in the corelab entry way, with two others (yet to arrive), to be located on the new main deck and in the casing hold. A pair are located on the fantail and a pair in the technician's office.

The Marine Emergency Task Squad (METS) notebook was reviewed by the Leg 106 team. The base diagrams were redrawn for all lab decks. These diagrams were particularly useful during a walk through the lab with SEDCO personnel. When the diagrams are finalized, a copy will be posted on each deck.

UNDERWAY TO MALAGA

Seismic gear was streamed upon our departure from Site 649 on 18 December for the transit to Malaga, Spain. A speed of six knots was requested for the first three hours to test all aspects of the system and to assess a low towpoint for the starboard water gun. All seismic gear was deployed and functioned well after an initial period of trouble-shooting. However, the magnetometer signal deteriorated. Speed was increased to ten knots to finish the low tow point test and then reduced to pull in the gear.

At this time the problem with the magnetometer became obvious as the cable, but not the cable jacket, had parted five feet in front of the sensor. There was no apparent cause for the failure. The low tow point allowed the water gun to tow 2 meters deeper at six knots, and 1.5 to 2 meters deeper at ten knots. It will soon be determined whether the gain in depth and theoretical improvement to the record is worth the extra time needed to rig the guns for "deployment".