38. GEOPHYSICAL OBSERVATIONS TAKEN UNDERWAY ON *GLOMAR CHALLENGER* — LEG 55

H. Gary Greene, U. S. Geological Survey, Menlo Park, California

INTRODUCTION

The D/V *Glomar Challenger* left Long Beach, California on 14 July 1977 for its fifty-fifth DSDP cruise. It arrived in Honolulu, Hawaii on 22 July 1977 for a short port stop before sailing on to the region of the Emperor Seamounts. The cruise ended in Yokohama, Japan on 5 August 1977. We collected geophysical profiles covering over 7600 nautical miles, including 12 kHz, 3.5 kHz, and air-gun continuous seismic reflection profiles, and earth's-total-field magnetometer measurements. Site number, progressive distance in hundreds of nautical miles along the track, dates (day/month), and hours are shown on Figures 1 and 2. We located the track by means of underway navigation information and plots prepared by the Geological Data Center, Scripps Institution of Oceanography, using the FIXPI computer program. Satellite fixes and course and speed changes were encoded on the ship from data in the underway geophysical log. The data were key-punched on shore and run through a navigation smoothing program, edited on the basis of reasonable ship drift velocities; a deck of corrected navigation points was merged with the depth and magnetic data. Satellite navigation errors are generally less than 1 nautical mile (Talwani et al., 1966).

Figures 3 to 15 show magnetic anomaly profiles and bathymetric profiles. Figure 17 (back pocket) shows photographic reproductions of original air-gun seismic reflection records. Depths in two-way reflection times (seconds) are along the edges of the seismic profiles. Times in days and hours, speeds, and headings are at the bottom of each figure. Distances along the ship's track (in hundreds of nautical miles) and site locations are marked at the top of each figure.

The sound sources used to obtain these records were two air-guns with interchangeable 10-, 20-, and 40-in.^{3} chambers. Incoming signals were filtered through a Bolt filter-amplifier system and then recorded on dry-paper EDO recorders. During transit across deep water, fire rate and sweep were maintained at 10 seconds. In shallower water over the seamounts, however, fire rate and sweep varied from 10 to 5 seconds; in some localities a 5-second fire rate and a 2.5-second sweep were used.

A 3.5-kHz system assisted in locating unconsolidated sediment ponds on the seamounts. Initially, we used it only for the site surveys made before drilling; but after installation problems were corrected, we ran it continuously as part of the underway geophysical data collection program. Selected 3.5-kHz profiles collected during the site selection surveys are shown by Greene et al. (this volume).

In Figures 3 to 15, the upper profile is of magnetic anomalies versus distance, and the lower is of depth versus distance as determined from the 12-kHz fathometer system. Horizontal scale indicates time and date, distance in nautical miles from the start of record collection, and latitude and longitude; the vertical scale gives gammas and uncorrected depth in meters. We derived the magnetic anomalies by removing 1975.0 IGRF from the total field measurements. The magnetic data produced at sea by the Geometrics Magnetometer were recorded in the underway geophysical logbook at 5-minute intervals. The depths, taken from echo sounders (calculated at 1500 m/s calibrated sound velocity), were recorded in the underway geophysical logbook at 5-minute intervals. Both types of data were edited on shore by the Geologic Data Center, Scripps Institution of Oceanography. The solid black line at the base of Figures 3 to 15 indicates the existence of air-gun reflection profiler data.

MAGNETIC AND BATHYMETRIC PROFILES

The ship's track from Long Beach to Honolulu is restricted to the area between the Murray and Molokai fracture zones, and obliquely crosses the magnetic anomaly lineations of the Cenozoic reversal epoch (Figure 16; Atwater and Menard, 1970; Peter et al., 1970; Naugler and Wageman, 1973). The magnetic anomaly patterns are irregular throughout the northern part of the Baja California Seamount Province. From latitude 27°6.9 'N, longitude 139°21.3 'W, 1100 nautical miles from the beginning (Figure 4), bathymetry shows less relief and the magnetic anomalies become more irregular and pronounced than in the preceding profiles. Few magnetic anomaly lineations have been found in this area (Figure 16; Pitman et al., 1974; Hilde et al., 1976). Near the end of the traverse from Long Beach to Honolulu, at about latitude 23°44.6'N, longitude 149°46.8 'W, 1700 nautical miles distance (Figure 5), the magnetic anomaly profile dampens to a nearly flat line. This section of the traverse is in the west central part of the Cretaceous quiet zone (Figure 16; Pitman et al., 1974; Hilde et al., 1976).

The track between Honolulu and Ōjin Seamount is north of the Hawaiian Ridge, within the Cretaceous quiet zone. Magnetic anomaly profiles are uniform, except for local magnetic variations associated with the Hawaiian Ridge and a few scattered seamounts. We crossed the Mendocino fracture zone between nautical miles 3400 and 3500, near 33°4.2 'N latitude, 178°51.7 'E longitude; this can be identified in the bathymetry as a nearly flat-floored depression with local flat-topped

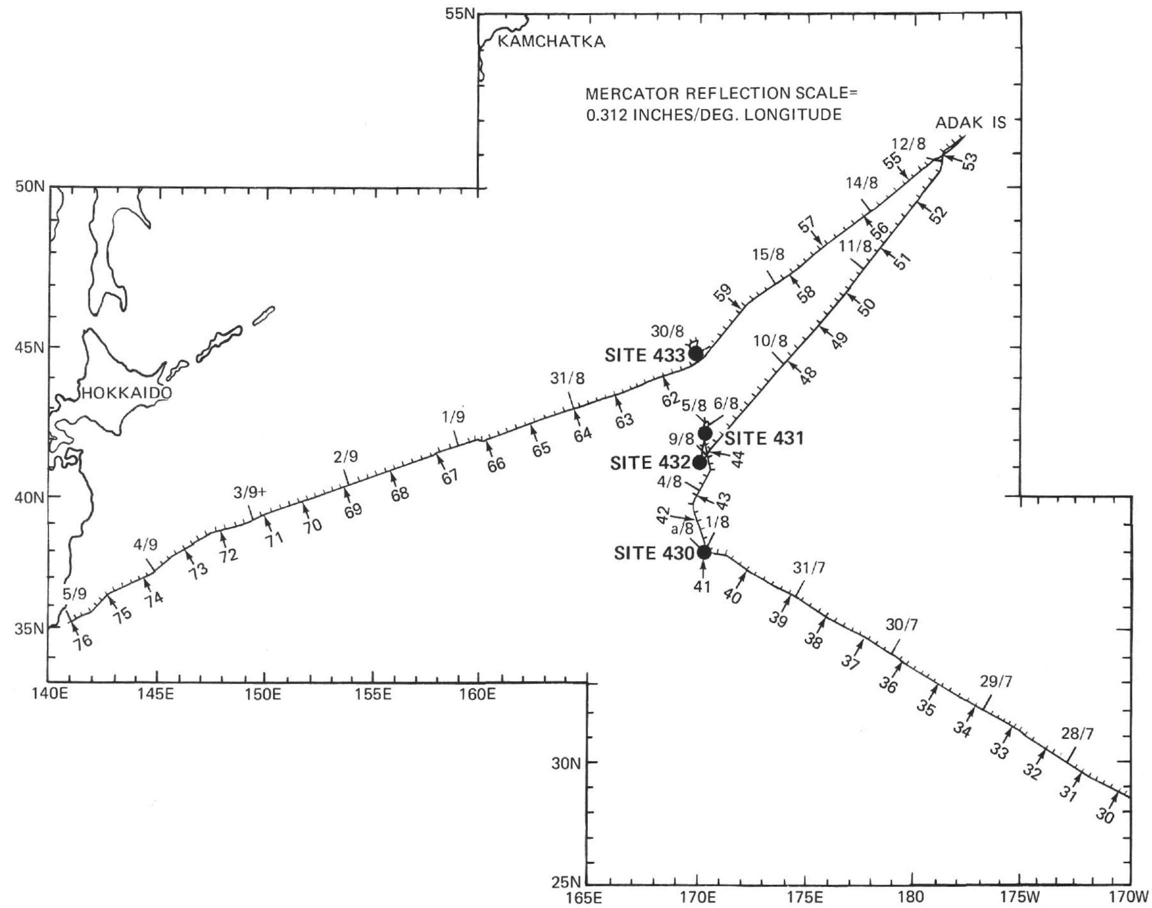

Figure 1. *Track chart for Leg 55 of* Glomar Challenger *from Honolulu, Hawaii to Yokohama, Japan. Dots and larger numbers are drill site locations. Smaller numbers are days and months along track and small ticks represent hours along track.*

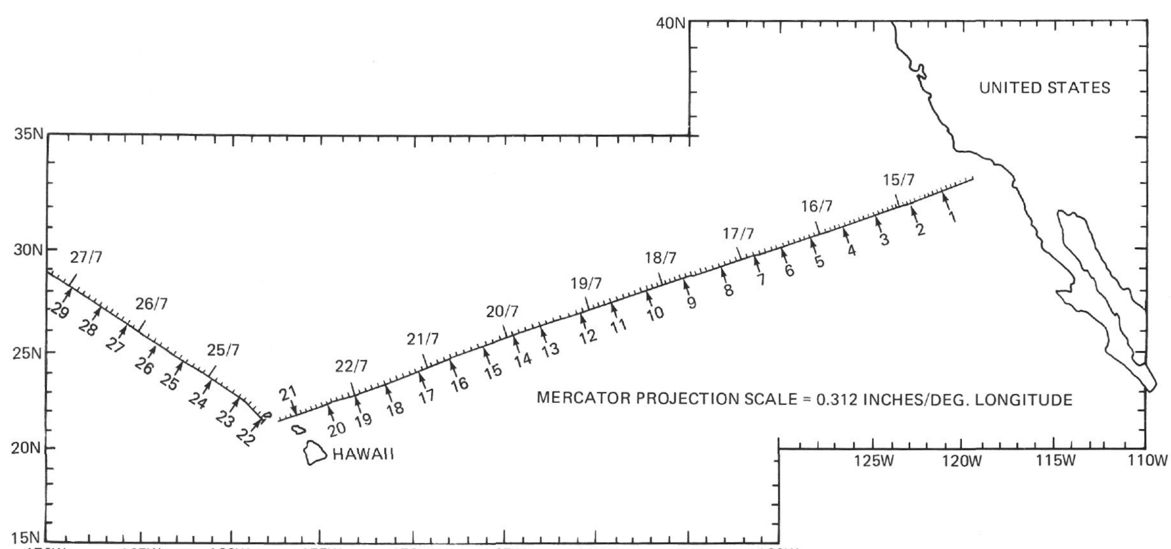

Figure 2. *Track chart for Leg 55 of* Glomar Challenger *from Long Beach, California to Honolulu, Hawaii. Numbers are days and months along track and small ticks represent hours along track.*

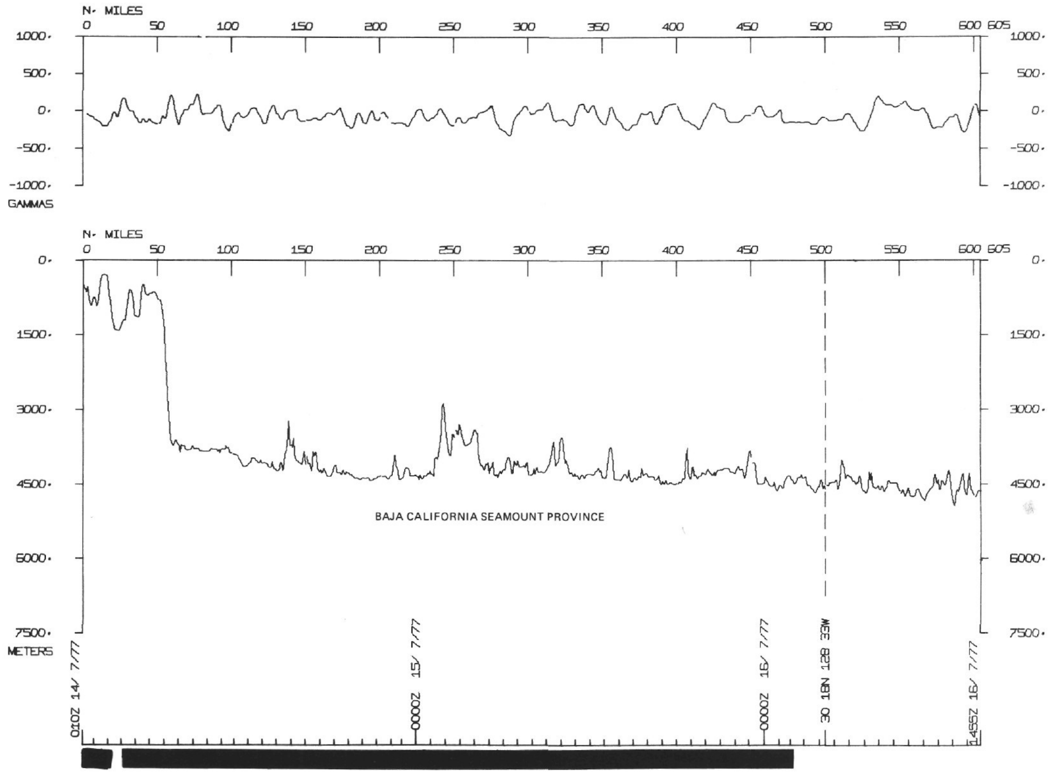

Figure 3. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

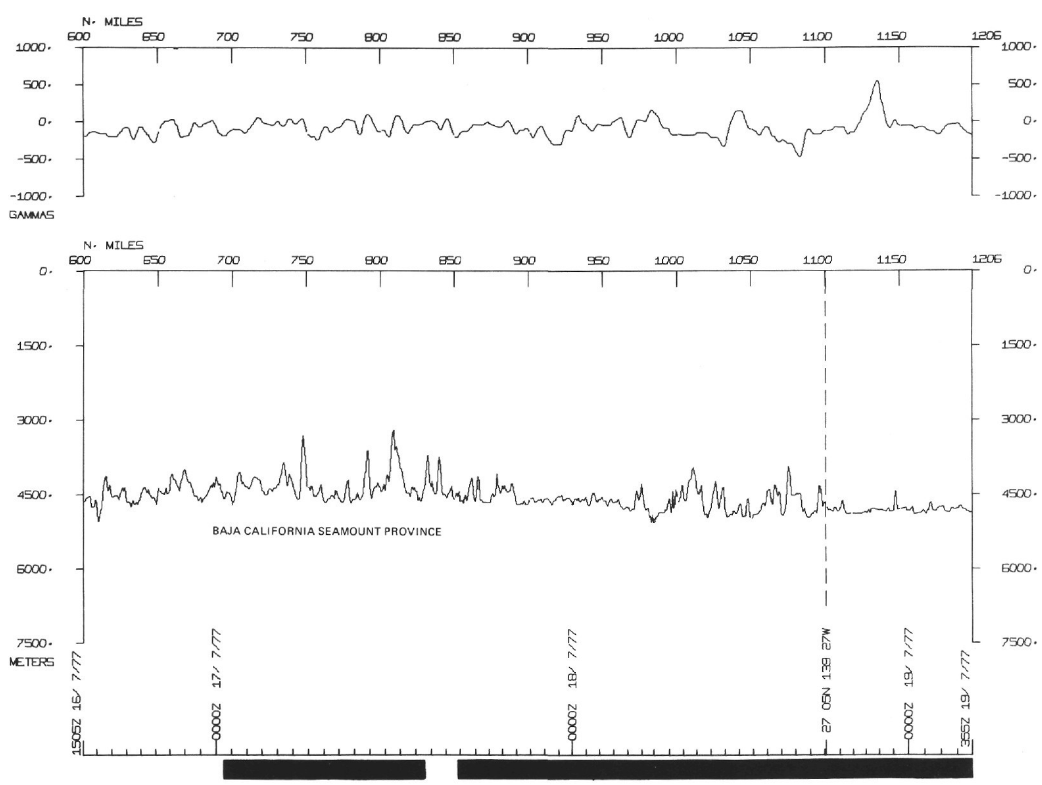

Figure 4. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

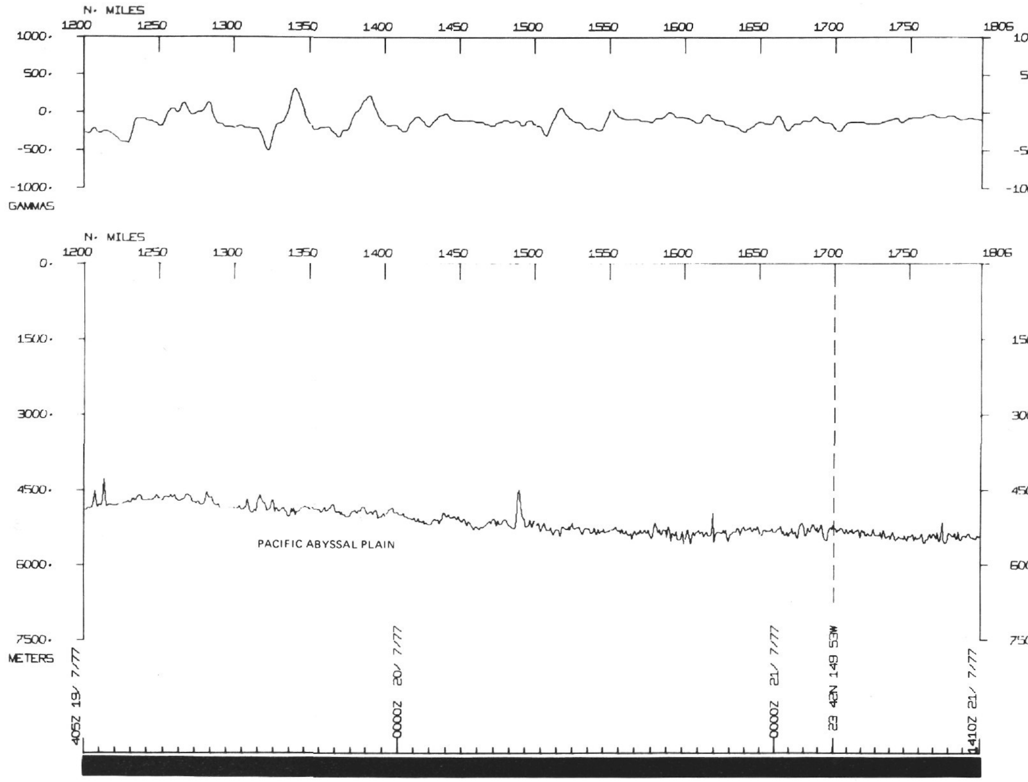

Figure 5. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

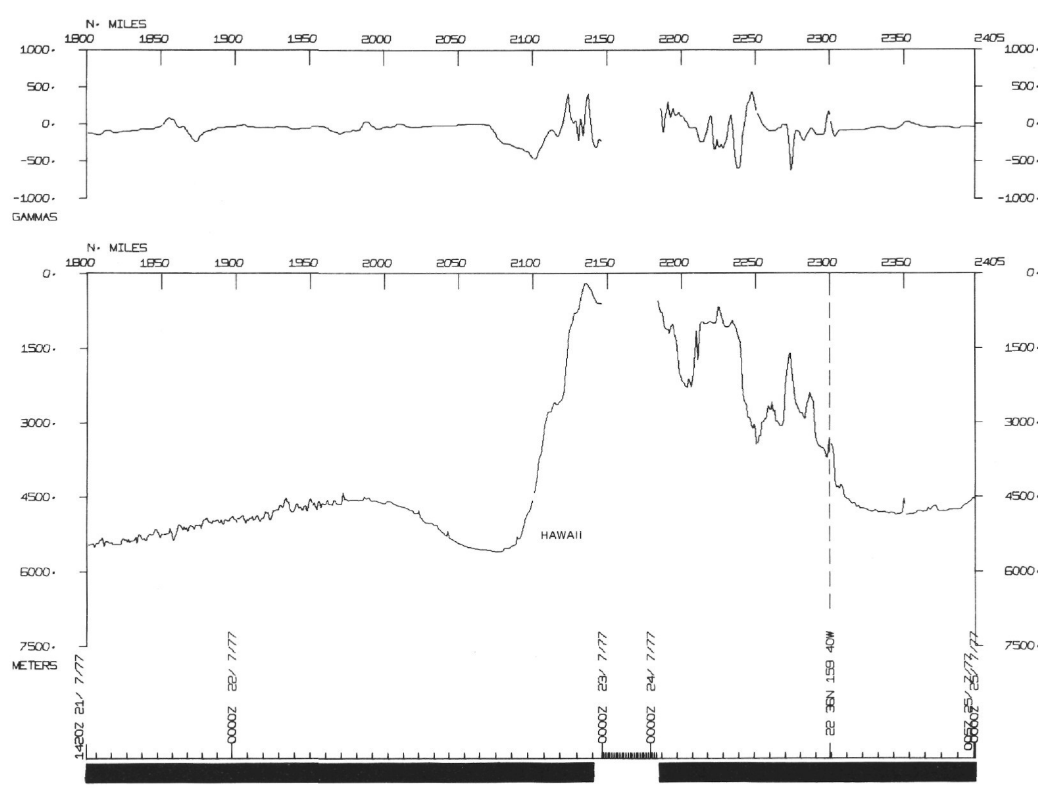

Figure 6. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

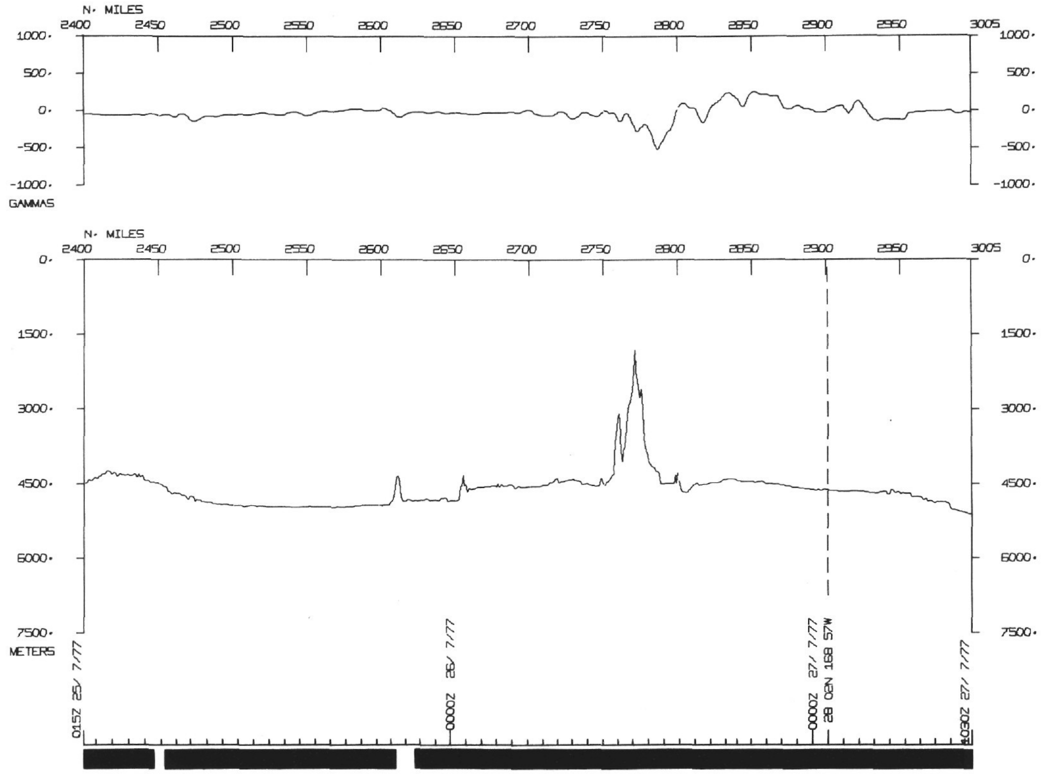

Figure 7. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

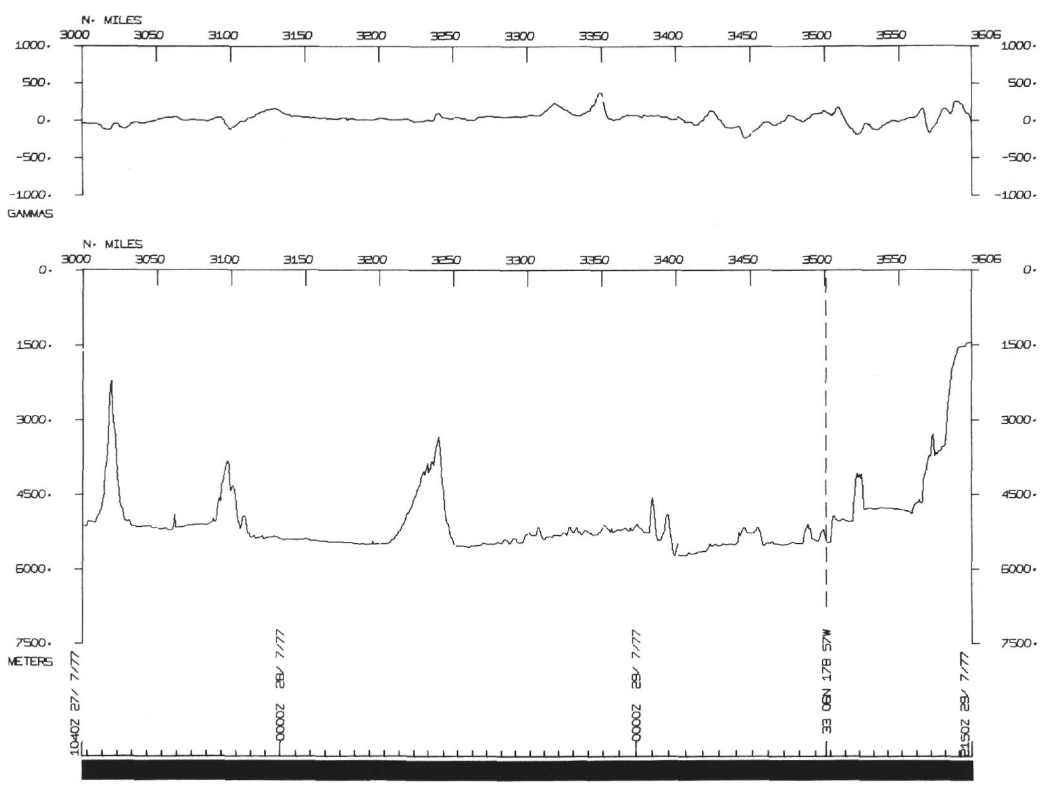

Figure 8. *Magnetic anomaly and bathymetric profiles along track of Leg 55* Glomar Challenger. *Plots and scales explained in text.*

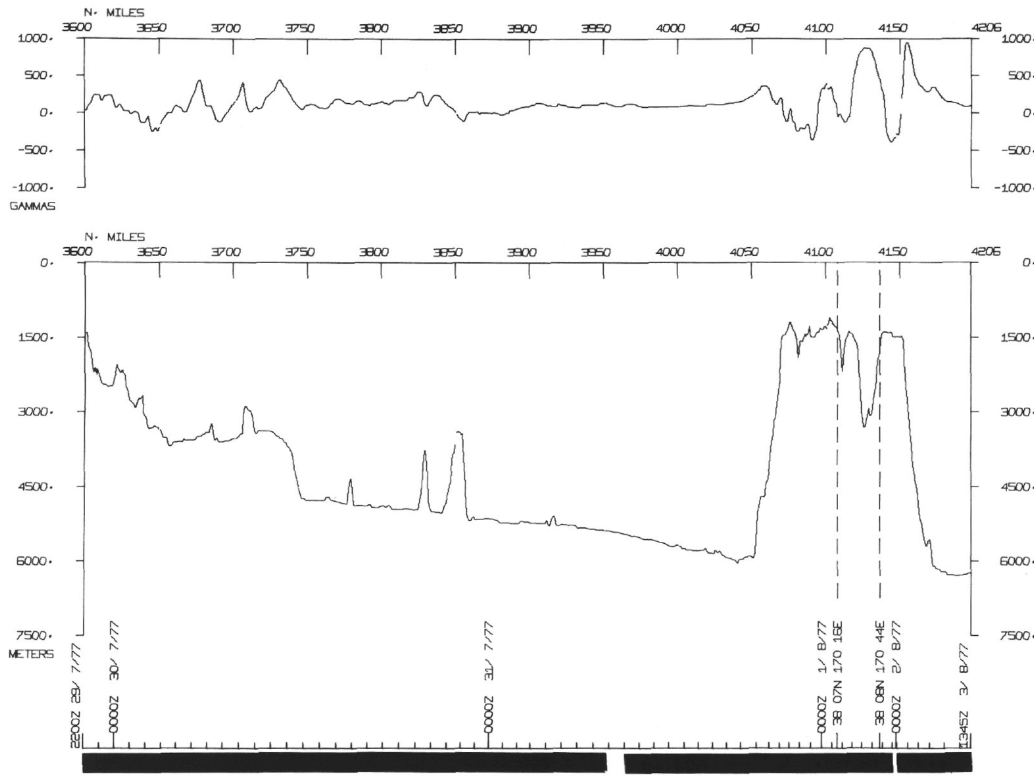

Figure 9. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

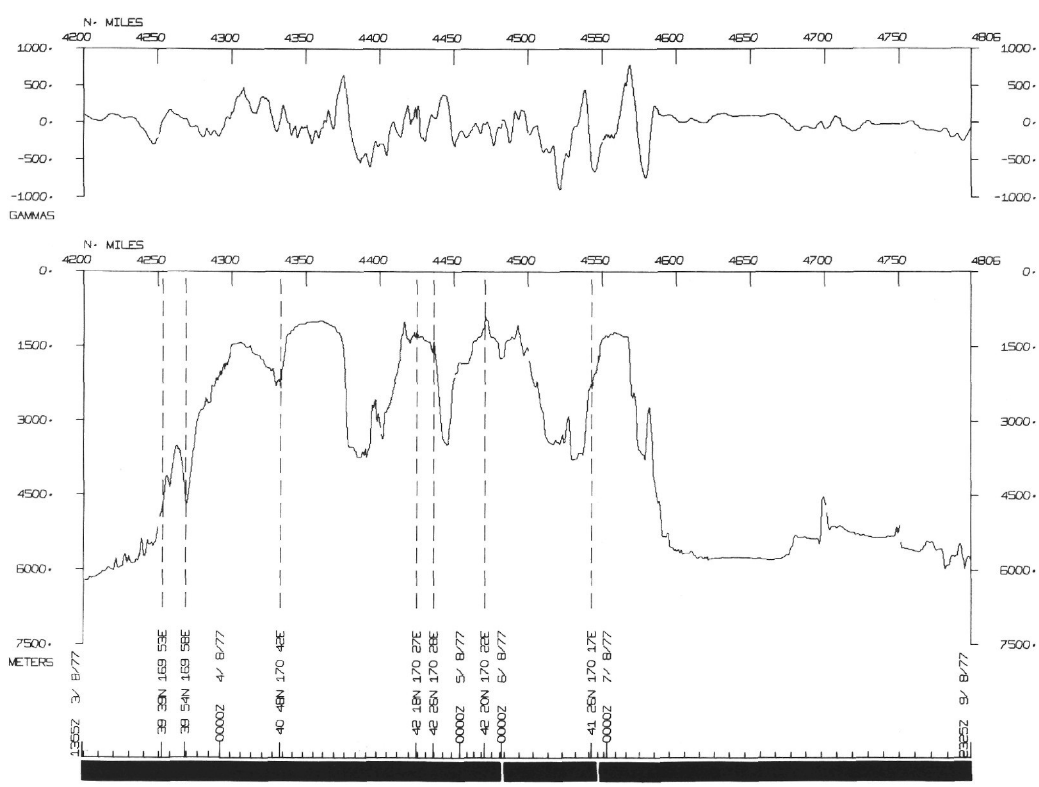

Figure 10. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

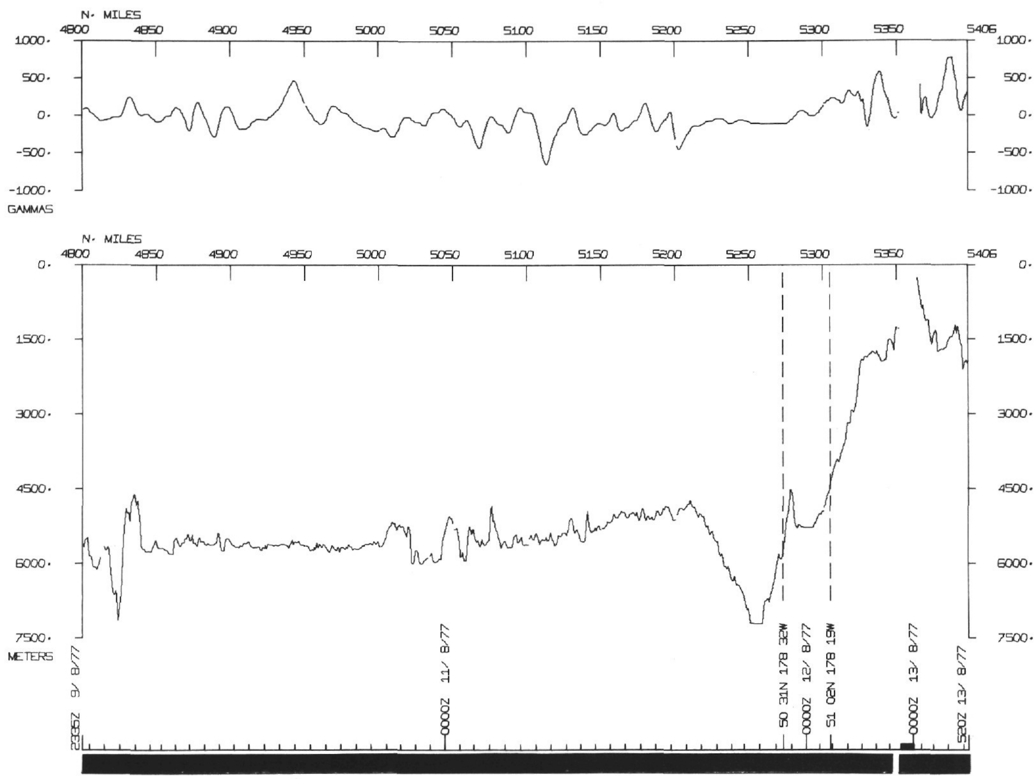

Figure 11. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

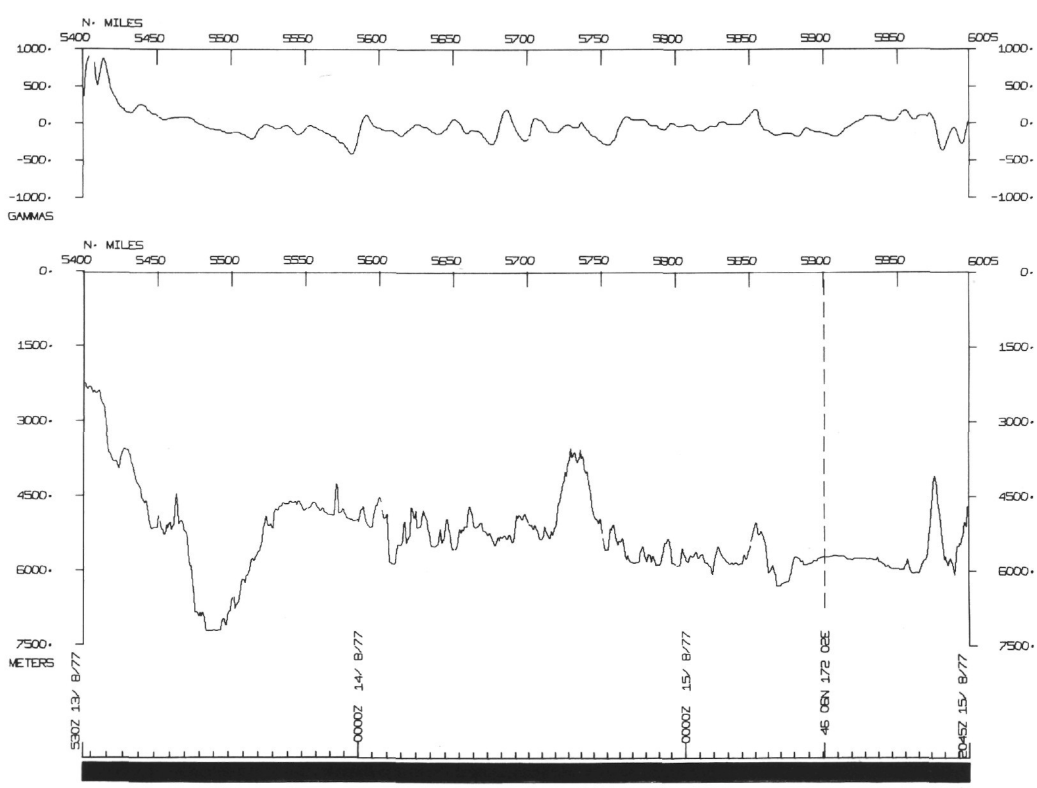

Figure 12. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

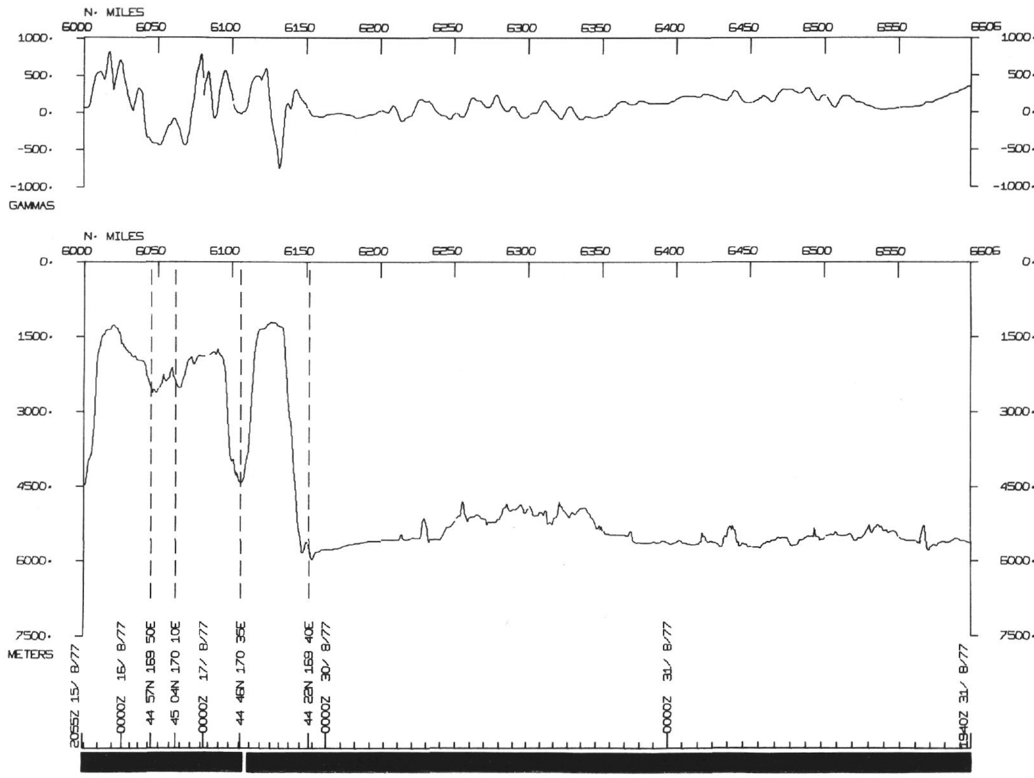

Figure 13. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

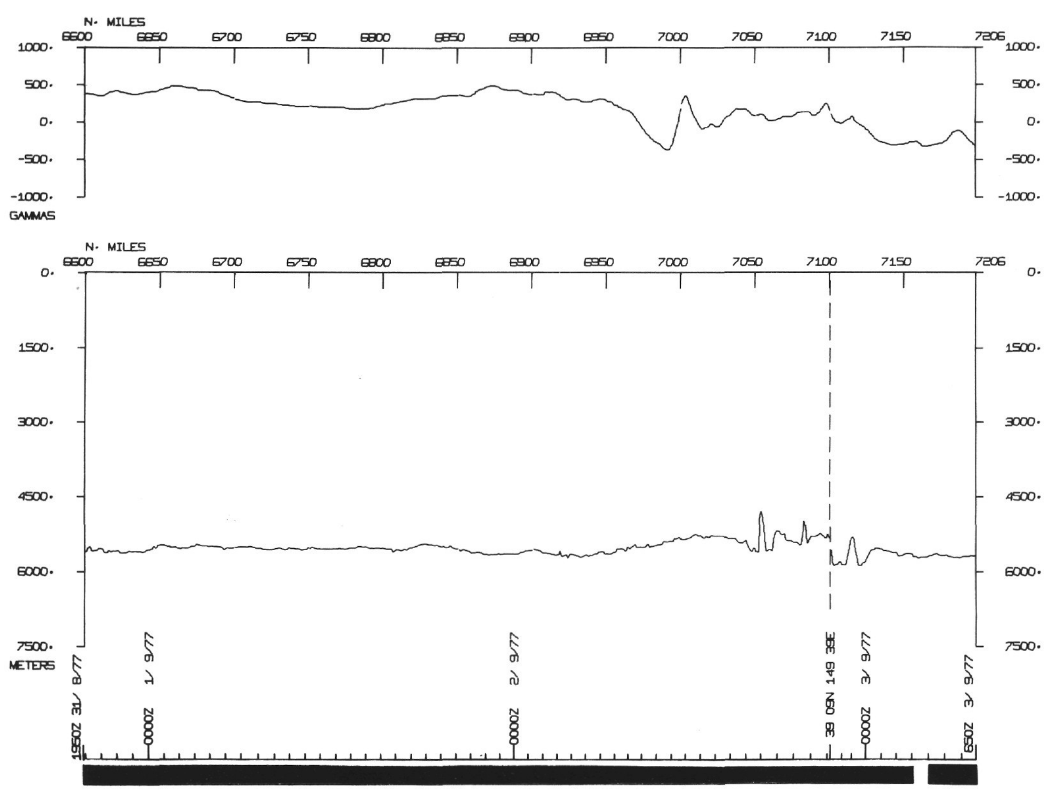

Figure 14. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

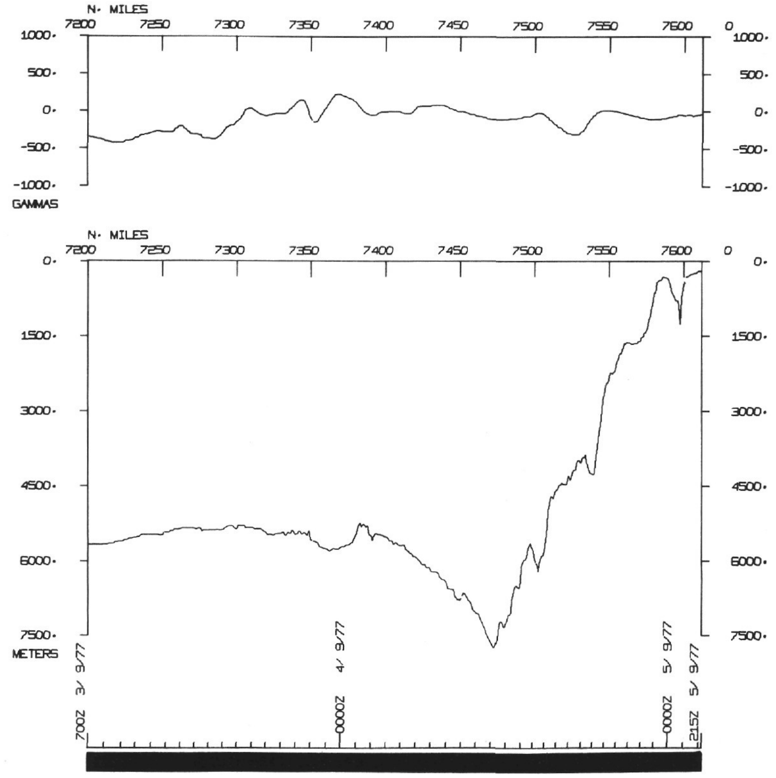

Figure 15. *Magnetic anomaly and bathymetric profiles along track of Leg 55 of* Glomar Challenger. *Plots and scales explained in text.*

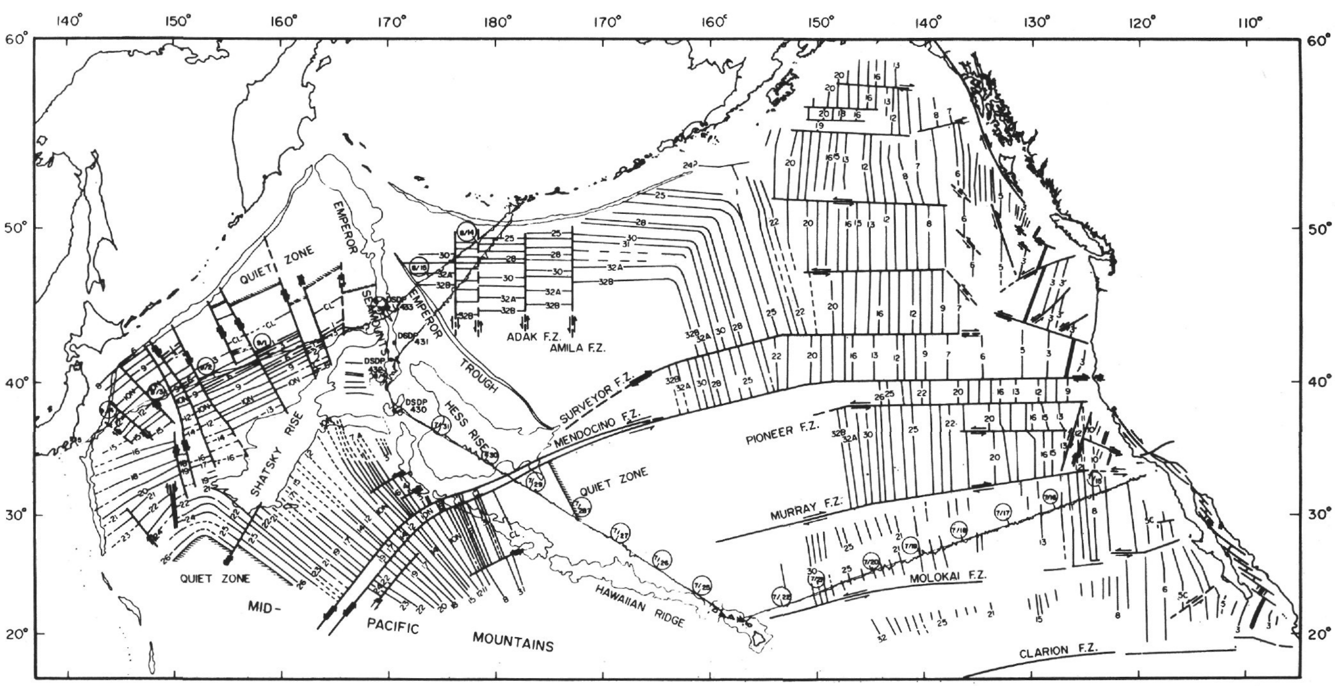

Figure 16. *Magnetic anomaly lineations in the North Pacific by Hilde (1976). Magnetic anomaly profile along track of Leg 55 of* Glomar Challenger *is superposed on map. Numbers in circle represent month and day along track. Dots are Leg 55 drill sites (modified after Hilde, 1976).*

ridges (Figure 8). The magnetic profile in this area is irregular.

We crossed Hess Rise between nautical miles 3350 and 3750, soon after traversing the Mendocino fracture zone. The rise climbs steeply upward from the Mendocino fracture zone, and produces large-scale variations on the magnetic anomaly profiles (Figure 9). These variations disappear northwest of Hess Rise, where the track crosses the flat sea floor of the quiet zone.

In the area of the Emperor Seamounts, the ship's track crosses the seamounts between DSDP Sites 430, 431, and 432. The profiles reflect the differences in bathymetric relief and in magnetic properties among these sites (Figure 10).

The *Glomar Challenger* stayed within the Cretaceous quiet zone from Site 432 on Nintoku Seamount to the Emperor Trough at 44°22.4 'N latitude, 173°58.3 'E longitude, between 4800 and 4850 nautical miles distance. From the Emperor Trough to Adak and back, the track obliquely crosses late Cenozoic lineations and fracture zones west of the Adak fracture zone (Figure 16). The Aleutian Trench is crossed at 5250 nautical miles and 5500 nautical miles; however, no indications of the trench or lineations ar evident in the magnetic anomaly profiles (Figures 11 and 12). Approaching Site 433 on Suiko Seamount, we again crossed the quiet zone.

The track from Suiko to Yokohama, Japan is nearly parallel to the magnetic anomaly lineations of the Japanese late Mesozoic magnetic sequence between the Shatsky Rise and the Japan and Kuril trenches (Hilde et al., 1976). Magnetic and bathymetric profiles in this region are nearly flat, except for irregular magnetic variations and distinct, alternating bathymetric relief between nautical miles 7000 and 7150 (Figure 14). In this area, an unnamed fracture zone offsets lineations (Figure 16; Hilde et al., 1976), and an unusual seafloor channel has been seen (Mammerickx, personal communication, 1977). The remaining bathymetric and magnetic profiles from the traverse into Yokohama appear uneventful. Although bathymetry shows the presence of the Japan Trench, the magnetic anomalies do not.

SEISMIC REFLECTION PROFILES

The first part of the track, from Long Beach to Honolulu, crosses the southern California borderland and the Baja California Seamount Province. San Nicolas Basin, Santa Rosa–Cortes Ridge, Tanner Basin, and the Patton Escarpment can be seen, in that order, between 0300 and 0700 hours, 14 July 1977 (Figure 17, back pocket). Tanner Basin contains sedimentary fill with a thickness of nearly 1.0 second (two-way travel time). We saw little or no penetration in the seismic reflection profiles, except in the first 200 nautical miles, where a westward thinning layer of acoustically transparent sediment overlies an irregular acoustic basement. The maximum thickness of the transparent layer is 0.25 second near the base of the Patton Escarpment. From the Patton Escarpment to the Hawaiian Islands, we found many steep, peaked seamounts (Figure 17.).

The seismic reflection profiles across the northern flank of the Hawaiian Ridge show basins and seamounts; sediments are ponded in the interseamount basins. Off the Hawaiian Ridge, the sea floor is flat for nearly 1000 nautical miles, except for a few protruding seamounts (Figure 17, 1200, 26 July 1977; Figure 17, 1230 27 July 1977) or faulted seafloor offsets (Figure 17, 0300, 25 July 1977; Figure 17, 1400, 26 July 1977). Seismic penetration was poor, probably because of a poor noise-to-signal ratio rather than of a non-penetrable, lithologically hard surface. Close examination of the profiles reveals a thin layer (0.25 s) of well-bedded sediment, the base of which cannot be distinguished. Farther along the track, near 0530, 27 July 1977, this sedimentary layer thickens to nearly 0.5 second and appears to lie upon the irregular surface of the acoustic basement. Many small basins associated with the bases of seamounts contain locally ponded sediments (Figure 17, 1200, 26 July 1977).

Hess Rise, crossed between 1700, 30 July 1977 and 1200, 31 July 1977 (Figure 17), is a structural feature elevated above the flat seafloor in faulted steps. On its shallow, south central side are several acoustic basement ridges and peaks and interspersed basins containing ponded sediments nearly 0.25 second thick in some areas. Strata in these basins are generally flat-lying and well-bedded. Covering the northwestern crest is a relatively thick (approximately 0.5 s) layer of well-bedded sediments that overlies an irregular acoustic basement. Sediments on the flat ocean floor south and north of the rise increase in thickness to over 0.75 second thick along the base of the rise. This flat sedimentary unit is a thin (0.1 s) acoustically transparent layer, probably of pelagic sediments, conformably overlying a thicker, well-bedded layer; it continues to the Emperor Seamounts, broken occasionally by a seamount.

Seismic reflection profiles across the drill sites and along the Emperor chain between sites show the seamounts and sedimentary basins that make up the chain (Figure 17). Interpretation of these profiles is discussed by Greene, Clague, and Dalrymple (this volume).

The subsurface characteristics are similar in the seismic profiles taken between the Emperor chain (Site 432) and Adak, Alaska, and those taken from Honolulu to the Emperor chain. Between the chain and the Emperor Trough the seafloor is flat, except for a few seamounts and minor faults (Figure 17). The tracks from the Emperor chain to the Emperor Trough and from the second half of the Honolulu–Emperor traverse are both in the Cretaceous magnetically quiet zone (Figure 16). Although acoustical penetration and definition are poor in the chain-to-trough profiles, a two-layered sedimentary unit, consisting of an upper acoustically transparent layer conformably overlying a lower, well-bedded layer of unknown thickness, overlies an irregular, acoustic basement surface. In places, the transparent layer is about 0.25 second thick.

Equipment failure prevented us from obtaining seismic reflection profiles across the Emperor Trough going to Adak. On the return track, however, the trough appears as a structurally controlled feature, probably a graben (Figure 17, 0530 to 0800, 15 July 1977). It is flat-floored and has irregular basement ridges on either side. Over 0.5 second of acoustically transparent, flat-lying sediments fill the trough. Between the Emperor Trough and the Aleutian Trench, many acoustic basement ridges and peaks project above the two-layered sedimentary unit. The upper, transparent layer is generally thinner here (about 0.25 s), and the base of the well-bedded layer is difficult to locate.

Near the southern boundary of the Aleutian Trench, the surface and subsurface structures are very hummocky (Figure 17). Both the sedimentary unit and the acoustic basement have been disturbed considerably by tectonic activity. Along the upper south wall of the trench, slumping of the sedimentary unit probably is ongoing. The topography of the north side of the trench is complex. Many faulted basement ridges create buttresses, which collect detritus from the Aleutian Ridge. Sedimentary structures in the marginal basins are contorted by folding and slumping.

After leaving Suiko Seamount (Site 433), we replaced the onboard filter-amplifier system with a spare portable Khron-Hite filter; the record quality improved considerably. Consequently, the seismic reflection profiles from Suiko Seamount to Yokohama have a good noise-to-signal ratio. Seafloor and subsurface structures from Suiko to about 1700, 31 August 1977 (Figure 17) are generally irregular, and include many faulted ridges and acoustic basement knobs and spikes protruding above the sedimentary cover. An acoustically transparent sedimentary layer covers more consolidated well-layered sedimentary and basement rocks. This layer locally thickens to nearly 0.5 second. A graben at 0730, 30 August 1977 (Figure 17), and a faulted bedrock rise between 1230 and 1500, 31 August 1977 (Figure 17) may indicate fracture zones.

The subsurface has no distinct structure, and the seafloor is unusually flat between 1700, 31 August 1977 and 1400, 2 September 1977 (Figure 17); after this interval, acoustic basement peaks and ridges again protrude through the flat-lying sedimentary unit. However, minor disruption of the sea floor and subsurface strata in the vicinity of 0730, 2 September 1977 (Figure 17) suggests a fracture zone. Another fracture zone may be at 2100, 2 September 1977 (Figure 17), where the sea floor is displaced nearly 600 meters in a nearly vertical west-facing scarp that exposes basement rocks. This fault appears to be the west boundary of a horst; the east boundary is a gentler scarp that has much less vertical displacement. The surface of the acoustic basement on the horst is bowed and filled with acoustically transparent sediments. A small basement peak in the center of the bowl-shaped horst projects above the sediments. Over 0.5 second of sediments abut the horst's basal scarps.

Just west of the horst is the channel, described by Mammerickx (personal communication, 1977), which appears to be associated with a fracture zone and may be a graben (Figure 17). It is faulted on its east side, where a thick (0.5 s), acoustically transparent sedimentary layer is dropped down to the east along several nearly vertical faults. The east margin of the channel has a gentle rounded basement dome. At least 0.25 second of acoustically transparent sediments fill the channel and are buttressed against the dome.

From the channel to 1700, 3 September 1977, the seafloor is flat and has no significant subsurface structure (Figure 17). The acoustically transparent layer thins to the west and disappears at 1700, 3 September 1977, where acoustic basement appears to crop out. This may be near another fracture zone, since the acoustic basement and a well-layered sedimentary unit are faulted.

West of the basement outcrop, the sea-floor and subsurface structures are slightly irregular, and a thin layer (0.1 s) of transparent sediments is present locally. Between 0100 and 0200, 4 September 1977 (Figure 17), a gentle basement ridge bows up the seafloor and is faulted on the west side. A thick unit (0.5 s) of nearly acoustically transparent sediments overlies a well-bedded sedimentary sequence and acoustic basement. To the west, the seafloor descends gently into the Japan trench. The sediments thicken toward the trench and are faulted into step blocks, most of which are dropped down toward the trench; these are tensional structures associated with the downbowing and subducting of oceanic crust. From the axis of the trench, the sedimentary unit continues under the contorted, hummocky, steep west wall of the trench.

The continental margin of Japan from the western trench wall or trench axis to the narrow shelf is an uneven slope composed of two distinct platforms (Figure 17). The deeper eastern platform comprises basement exposures and some small basins that have locally ponded thin sedimentary deposits. Basement rocks buried beneath sedimentary rocks are more than 1.0 second thick. Just west of the shelf, a narrow, steep-walled, V-shaped submarine canyon cuts through the sedimentary rocks (Figure 17). No basement rocks are exposed in this canyon.

SUMMARY

Geophysical profiles covering over 7600 nautical miles were obtained on the fifty-fifth cruise of the *Glomar Challenger* between 14 July and 5 August 1977. Twelve-kHz bathymetric, air-gun seismic reflection, and magnetic measurements are the principal data types, although some 3.5-kHz profiles were obtained, mostly from the Emperor Seamounts. The data were collected in the North Pacific, along four major transects: (1) a western track between the Murray and Molokai fracture zones, from Long Beach to Honolulu; (2) a northwest track from Honolulu across the Hess Rise to the Emperor Seamounts; (3) a northeast-southwest track from the Emperor Seamounts across the Emperor through and Aleutian Trench to Adak and back; and (4) a western track from the Emperor Seamounts to Yokohama.

Magnetic, bathymetric and air-gun seismic reflection profiles from transect one are very irregular; this is characteristic of the seamount province and the magnetic lineations of the Cenozoic reversal epoch between the Murray and Molokai fracture zones. Along transect 2, which lies within the Cretaceous magnetically quiet zone, relief is less and magnetic anomalies are fewer than along the other transects. Hess Rise and a few isolated seamounts piercing the well-layered sedimentary cover are the only disturbances in an otherwise flat ocean floor. Great diversity is apparent in the geophysical profiles from transect 3. Between the Emperor Seamounts and the Emperor trough, the profiles are characteristic of the Cretaceous magnetically quiet zone and similar to profiles from transect 2. However, between the Emperor trough, which is a graben, and the Aleutian Trench, the profiles have distinct magnetic anomalies associated with the Cenozoic magnetic lineations. The presence of the Aleutian Trench is not indicated by the magnetic profiles. However, the seismic reflection and bathymetric profiles show it to consist of a gently dipping south wall and a steep and hummocky north wall. Transect 4 is a sub-parallel to or obliquely crosses the late Cenozoic magnetic lineations and several fracture zones. Because of the angle between the track and the magnetic lineations, no distinct anomalies are identified. The sea floor is generally flat in this region, and major structures identified in the seismic reflection profiles are grabens associated with the fracture zones. Seamounts occasionally pierce the flat-lying sedimentary cover along this transect. The sedimentary cover thickens toward the Japan Trench, and is faulted into step blocks that drop down toward the trench axis and under the contorted, hummocky steep west wall of the trench.

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