1. INTRODUCTION[1]

Shipboard Scientific Parties[2]

BACKGROUND AND OBJECTIVES

The northwest Pacific Ocean is the most active earthquake zone in the world. More than 20% of the world's seismic energy is released in the Aleutian–Kurile seismic zones, where the Pacific Plate is actively being subducted. Seismic systems placed on islands in the Aleutians and in Japan are on the overriding plate and are thus subject to the high noise levels and complexities of island arc structure. Islands on the Pacific Plate, such as Midway and Wake, tend to be seismically noisy and are relatively far from the sources of activity. Ocean bottom seismometers are temporary, subject to ocean current noise, and can be poorly coupled to the ocean floor.

It is highly probable that seismic instruments permanently emplaced in basement rock at the bottom of Deep Sea Drilling Project (DSDP) holes will be quieter and more sensitive to earthquakes than all but the best continental land stations. By placing these seismometers in strategic locations it should be possible to detect very small earthquakes and to discriminate between earthquakes and man-made events. Leg 88 was designed to emplace specially designed seismometers into boreholes in the Northwest Pacific because this area is near the Soviet Union, and because of the need for better discrimination between earthquakes and nuclear tests. Experiments on this leg were to supply the basic data necessary to decide whether the added costs of installing instruments in deep-sea boreholes are justified by the decrease in noise level and signal complexity.

The operation of seismometers in this part of the world also provides a rare opportunity to study earthquakes generated in subduction zones and to study the seismic structure of old Pacific Plate crust and lithosphere. In addition, the installation of two seismometers in the same vicinity would allow hole-to-hole experiments to be conducted for the first time.

A wide band, wide dynamic-range seismic system in a low ambient noise marine environment provides information capable of contributing to the following scientific objectives:

1. Obtaining data from a wide range of earthquake magnitudes, first motions, and focal depths which will help to clarify processes associated with subduction; these include identifying possible areas of tensional, compressional, and strike-slip faulting.
2. Determining the magnitude of changes of seismic properties of the oceanic crust with increasing age by establishing more accurate epicentral locations and by recording signals from events whose propagation paths are undistorted by seamount chains or island roots.
3. Measuring signal absorption and propagation characteristics of both long- and short-period body and surface waves.
4. Determining plate structure near the site using seismic refraction.
5. Evaluating source mechanisms within regional distances of an actively subducting plate boundary.
6. Measuring anisotropy of the crust and upper mantle and anisotropic variations within crustal layers. Independent evidence suggests that crustal and upper mantle velocities have azimuthal variations as much as 0.9 km/s near an active margin. Studies of variations in velocity fields may generate information pertaining to the magnitude, mechanism, and direction of convective motions at various depths. This is because surface wave-dispersion measurements and refracted body-wave traveltime from many directions within the same area are required for these studies.
7. Determining the relationship of seismic background noise beneath the seafloor as a function of such environmental parameters as bottom currents, tidal cycles, convection, heat flow, sediment thickness, and lithification.
8. Measuring elastic and rheological properties of converging plates.
9. Obtaining long-term borehole temperature measurements which will permit determination of steady state heat-flow rates or the amount and direction of water flow in the hole.

The prime objective of DSDP Leg 88 was to deploy two permanent borehole seismometers in the seafloor off the Kuriles. The first priority was to deploy a three-component seismometer, the Marine Seismic System (MSS), built by the Defense Advanced Research Projects Agency (DARPA), in a reentry hole at DSDP Site 581. The Hawaii Institute of Geophysics (HIG) seismic system was to be placed in a hole nearby and a hole was to be piston cored for paleoenvironmental studies. No logging was planned but tests on a wireline reentry system were made.

[1] Duennebier, F. K., Stephen, R., Gettrust, J. F., et al., *Init. Repts. DSDP*, 88: Washington (U.S. Govt. Printing Office).

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The objectives of the sediment studies were to access the Neogene sub-Arctic paleoceanography of the Northwest Pacific basin for comparison with other data from the area obtained on Leg 86 and with data obtained from the Southwest Pacific on Leg 90. The primary drill site (581) lies north of the modern sub-Arctic Front. The predicted sedimentation rate of about 40 m/m.y. would allow events with periods on the order of 10^4–10^5 yr. to be resolved. Regrettably, operational difficulties consumed the time allotted for piston coring and the principal paleoenvironmental objectives could not be met. Analysis of the sediments obtained in this leg is incorporated into the results of Leg 86.

In conjunction with the *Glomar Challenger* operations, the U.S.N.S. *De Steiguer* surveyed the area drilled, deployed 10 ocean bottom seismometers, and shot explosives to the seismic array for refraction and anisotropy experiments. A recovery cruise to change the HIG seismometer's data recording package was accomplished by the University of Hawaii's *Kana Keoki* in May 1983 (Cruise no. KK830116-5). In addition, the Soviet research vessel *Dimitri Mendeleev* was also in the area coordinating with the Leg 88 seismic experiment. Personnel aboard *Mendeleev* made five ocean bottom seismometer deployments and shot numerous reflection and refraction lines.

GEOLOGIC SETTING

Site 581 lies just south of the Hokkaido Trough in the Northwest Pacific basin (Fig. 1). Magnetic lineations to the south run roughly parallel to the Hokkaido Trough, but the regions to the north apparently lie in the Cretaceous quiet zone. The age of the crust at the site is slightly older than 110 m.y. based on magnetic anomalies. Reflection profiling data from Legs 86 (Fig. 2) and 88 shows a bottom roughness of 1/4 to 1/2 s with sediments generally draping evenly over the basement and possible outcrops on the steeper slopes. The results from the pilot hole (581) drilled on Leg 86 (Heath, Burckle, et al., 1985) indicate that the sediments are 345 m thick, of which the lowermost 75 m are composed of cherty layers. Sediment velocities of 1.7 to 1.9 km/s have been determined from refraction studies of the area.

EQUIPMENT AND OPERATIONS

Site 581 (the only site drilled on this leg) was reoccupied on 24 August 1982. Hole 581A (43°55.46′N, 159° 47.79′E) is about 300 m south of pilot Hole 581, drilled on Leg 86. A reentry cone and 72.15 m of casing were spudded and washed to 5552 m with difficulty. As the pilot hole had been washed to 90 m without difficulty, the problems in washing the casing to depth were surprising. Considerable torque and sticking were encountered in chert bands. Basement was encountered at 5840 m. For an unexplained reason, the pipe broke just above the bottom-hole assembly (BHA) during a hole-cleaning operation. As the proper tools for fishing out the hole were not on board, the hole was abandoned.

Hole 581B (43°55.66′N, 159°47.79′E) was spudded on 29 August with 72.27 m of 16 in. casing. Washing to casing depth was not accomplished and the cone was released with the top of the cone about 17 m above the mud line. Reentry with a 14 in. bit was accomplished

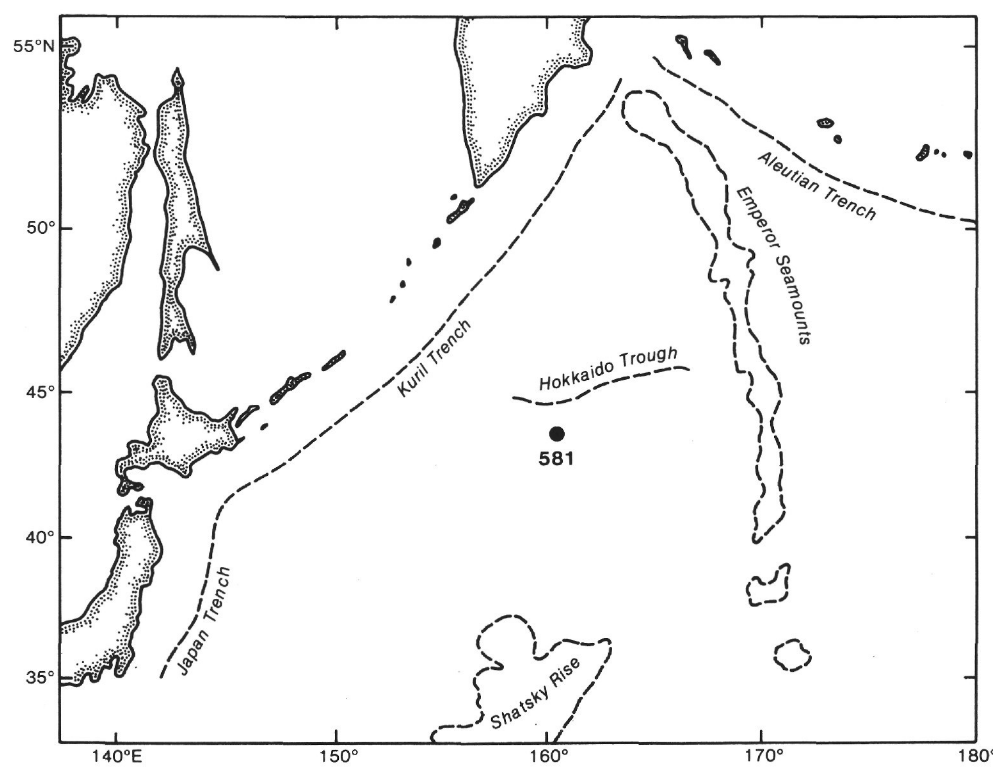

Figure 1. Location of Site 581 in the Northwest Pacific.

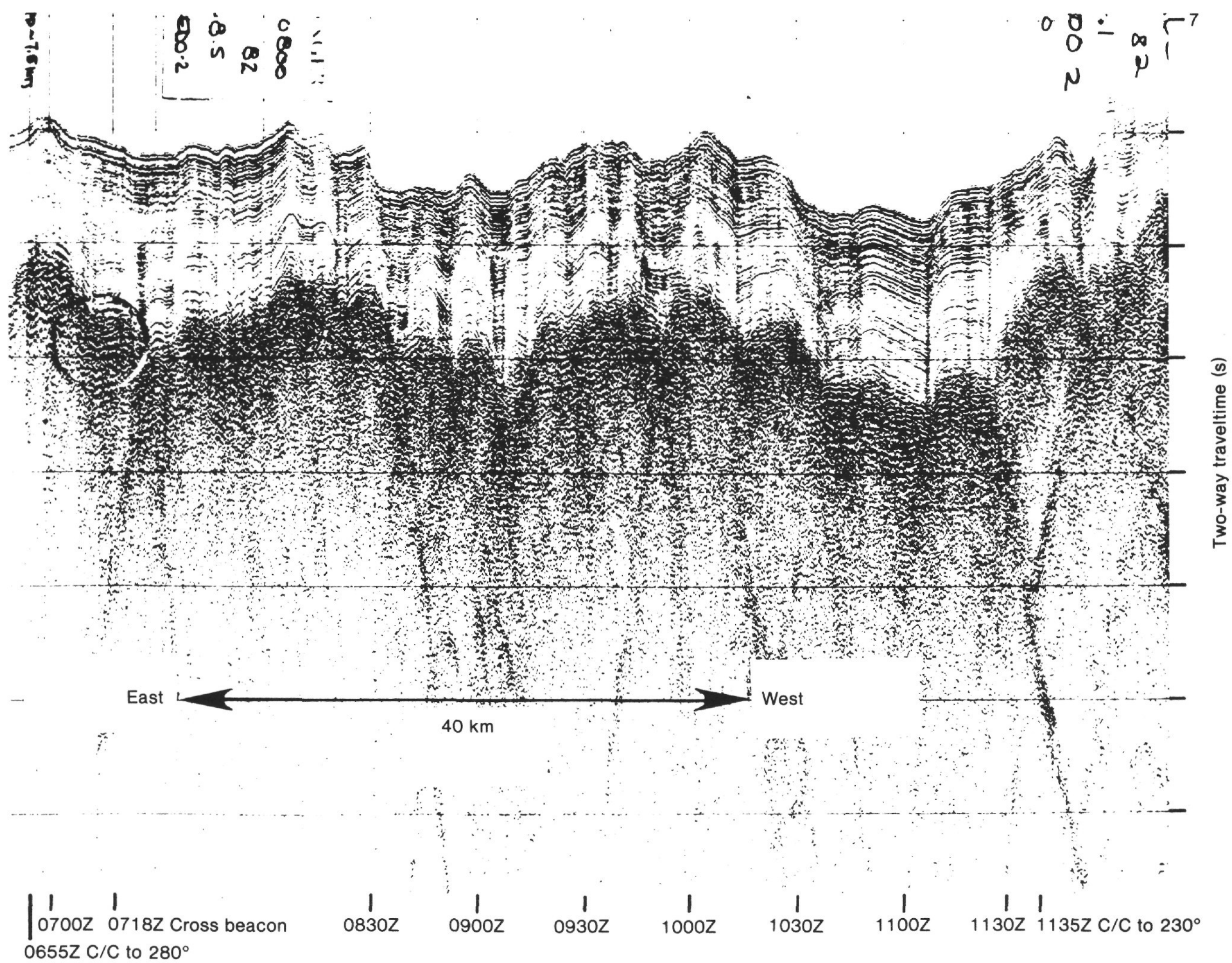

Figure 2. *Glomar Challenger* profile over Site 581 obtained during Leg 88.

and we drilled to basalt at 5830.5 m with considerable torquing and sticking in the chert layers. The longest 11 3/4-in. casing ever run by *Challenger* (39 joints) was set and cemented without apparent problem after considerable trouble with the EDO reentry tool. When attempts were made to release the casing, however, we found that it had not set correctly and was spinning in the hole. A measurement of pipe length indicated that the casing extended 9 m above the cone. With Typhoon Gordon approaching, and no way to release the casing, the pipe was blown above the BHA and Hole 581B was lost on 5 September 1982.

With several hours to spare before having to dodge the typhoon, a wireline reentry was attempted. See Stephen et al. (this volume) for a detailed description of this test.

Without another reentry cone, the EDO tools in poor shape, no 11-in. casing, and time growing short, there was no way that a hole could be drilled for the MSS during the remainder of Leg 88. Much discussion on board and with the shore led us to decide to emplace the HIG ocean sub-bottom seismometer (OSS) as quickly as possible to record the *De Steiguer* shooting, which was to begin on 9 September.

The start of Hole 581C (43°55.44′N, 149°47.84′E) was delayed 56 hr. by Typhoon Gordon, but the hole finally was spudded on 9 September. The hole was washed to basement with the familiar torque and sticking. The hole was completed 380.2 m below the mud line and 20.6 m into basalt. The bit was released and the hole completed at 1300 hr., 10 September.

For emplacement and operations during the HIG OSS experiment, please see other chapters in this volume. The anchor for the OSS was released on 13 September at 2245 hr. in gale force winds with no sign of a break in the weather that would allow piston coring. We then decided to leave the site and return to Yokohama.

SUMMARY OF CORING AND GEOPHYSICAL OPERATIONS

Leg 88's prime goals were unlike those of any other drilling leg prior to this time. They were to drill holes for instruments, not to obtain samples. Whereas few sediments were recovered on this leg, about 32 m of basalt cores were recovered. The sediments and basalts are described in the site report.

Most of Leg 88 was spent attempting to get a hole cased to basement for the DARPA Marine Seismic System. After two attempts ended in loss of the holes, and after passage of Typhoon Gordon, a single-bit hole was drilled successfully, and the HIG OSS was emplaced. The OSS recorded 185 shots fired by the U.S.N.S. *De Steiguer* while holding on to the end of the cable connected to the tool in the bottom of the hole. A recording package deployed after the shooting was recovered by the *Kana Keoki* on 25 May 1983 after recording seismic events, the passage of ships and of pods of whales for 64 days. At that time, 9 months after emplacement, the OSS was still operating perfectly and a second recording package was emplaced to record data continuously for another 60 days. Data obtained suggest that OSS IV, emplaced on Leg 88, is the quietest seismic station in the world in the frequency range from 5 to 20 Hz. Earthquakes were recorded at a rate of about one per hour during the whole 64-day recording period. In addition to three-component seismic data, tilt and hole temperature measurements were obtained continuously for the entire 64-day period.

Although we unfortunately failed to place the MSS into a hole during Leg 88, the instrument was successfully deployed on Leg 91, as reported in the second part of this volume.

The failure of the EDO tool used in the wireline reentry attempt on Leg 88 was frustrating. Later wireline reentry attempts have had similar problems. Nevertheless, many scientists who have attempted ocean borehole instrument experiments believe that this method of emplacing borehole tools is very promising, and possibly the only cost-effective method.

EXPLANATORY NOTES

This volume presents the results of Legs 88 and 91, both concerned primarily with downhole seismological experiments in the Pacific, under one cover. All results pertaining to Leg 88 are presented in the first section of the volume, and to Leg 91 in the second. Conventions regarding coring procedures, sediment descriptions, and rock descriptions for both Legs 88 and 91 are provided in an appendix to the introductory chapter of the Leg 91 portion of the volume, because of the greater emphasis on coring during Leg 91.

We have divided the Leg 88 portion of the volume into five parts: I, Introduction and Site 581 chapter; II, Underway Geophysics; III, Instrumentation; IV, Results of Seismic Experiment and Synthesis. The Introduction and site report were written by the combined scientific parties of *Glomar Challenger* and U.S.N.S *De Steiguer*. Sections on sedimentary and igneous rocks in the site report were written by Audrey Meyer and James Natland, respectively.

REFERENCES

Heath, G. R., Burckle, L. H., et al., 1985. *Init. Repts. DSDP*, 86: Washington (U.S. Govt. Printing Office).

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