OCEAN DRILLING PROGRAM

LEG 126 PRELIMINARY REPORT

BONIN ARC-TRENCH SYSTEM

Dr. Kantaro Fujioka
Co-Chief Scientist, Leg 126
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164, Japan

Dr. Brian Taylor
Co-Chief Scientist, Leg 126
Hawaii Institute of Geophysics
University of Hawaii at Manoa
2525 Correa Road
Honolulu, Hawaii 96822

Dr. Thomas Janecek
Staff Scientist, Leg 126
Ocean Drilling Program
Texas A&M University
College Station, Texas 77840

Philip D. Rabinowitz
Director
ODP/TAMU

Jack G. Baldauf
Assistant Manager of Science Operations
ODP/TAMU

Louis E. Garrison
Deputy Director
ODP/TAMU

June 1989

Preliminary Report No. 26

First Printing 1989

Copies of this publication may be obtained from the Director, Ocean Drilling Program, Texas A&M University Research Park, 1000 Discovery Drive, College Station, Texas 77840. In some cases, orders for copies may require payment for postage and handling.

DISCLAIMER

This publication was prepared by the Ocean Drilling Program, Texas A&M University, as an account of work performed under the international Ocean Drilling Program, which is managed by Joint Oceanographic Institutions, Inc., under contract with the National Science Foundation. Funding for the program is provided by the following agencies:

Canada/Australia Consortium for the Ocean Drilling Program
Deutsche Forschungsgemeinschaft (Federal Republic of Germany)
Institut Français de Recherche pour l'Exploitation de la Mer (France)
Ocean Research Institute of the University of Tokyo (Japan)
National Science Foundation (United States)
Natural Environment Research Council (United Kingdom)
European Science Foundation Consortium for the Ocean Drilling Program
(Belgium, Denmark, Finland, Iceland, Italy, Greece, the Netherlands, Norway, Spain, Sweden, Switzerland, and Turkey)

SCIENTIFIC REPORT

The scientific party aboard JOIDES Resolution for Leg 126 of the Ocean Drilling Program consisted of:

Kantaro Fujioka, Co-Chief Scientist (Ocean Research Institute, University of Tokyo, 1-15-1, Minamidai Nakano, Tokyo 164, Japan)
Brian Taylor, Co-Chief Scientist (Hawaii Institute of Geophysics, 2525 Correa Road, Honolulu, HI 96822)
Thomas Janecek, Staff Scientist (Ocean Drilling Program, Texas A&M University, College Station, TX 77840)
Jonathan Aitchison (University of New England, Department of Geology and Geophysics, Armidale, New South Wales 2351, Australia)
Stanley Cisowski (University of California, Santa Barbara, Department of Geological Sciences, Santa Barbara, CA 93106)
Albina Colella (Dipartimento di Scienze della Terra, Universita Della Calabria, 87939 Castiglione Cosentino, Scalo, CS, Italy)
Patricia Ann Cooper (Hawaii Institute of Geophysics, 2525 Correa Road, Honolulu, HI 96822)
Kathleen Dadey (University of Rhode Island, Graduate School of Oceanography, Narragansett, RI 02882)
Per Kristian Egeberg (Department of Geology, P.O. Box 1047, Blindern N-0316, Oslo 3, Norway)
John Firth (Florida State University, Department of Geology, Tallahassee, FL 32306)
James Gill (University of California at Santa Cruz, Department of Earth Sciences, Santa Cruz, CA 96064)
Yvonne Herman (Washington State University, Department of Geology, Pullman, WA 99164)
Richard Hiscott (Memorial University, Earth Sciences Department, St. John's, Newfoundland, Canada A1B 3X5)
MaLynn Isiminger-Kelso (Antarctic Research Facility, Florida State University, Tallahassee, FL 32306)
Kunio Kaiho (Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Aoba, Sendai 980, Japan)
Adam Klaus (Hawaii Institute of Geophysics, 2525 Correa Road, Honolulu, HI 96822)
Masato Koyama (Shizuoka University, Institute of Geosciences, 836 Oya, Shizuoka 422, Japan)
Henriette Lapierre (Université d'Orléans, Laboratoire de Géologie Structurale, 45067 Orléans Cedex 2, France)
Michael Lovell (Leicester University, Geology Department, Leicester LE1 7RH, United Kingdom)
Kathleen Marsaglia (University of Texas at El Paso, Department of Geology, El Paso, TX 79968)
Akira Nishimura (Geological Survey of Japan, 1-1-3 Higashi, Tsukuba-shi, Ibaraki 305, Japan)

Philippe Pezard (Lamont-Doherty Geological Observatory, Borehole Research Group, Palisades, New York 10964)
Kelvin Rodolfo (University of Illinois at Chicago, Department of Geological Sciences, P.O. Box 4348, Chicago, IL 60680)
Rex Taylor (University of Southampton, Department of Geology, Hampshire SO9 5NH, United Kingdom)
Kazue Tazaki (Shimane University, Department of Geology, Matsue, Shimane, Japan)
Peter Torssander (University of Stockholm, Department of Geology, S-106 91 Stockholm, Sweden)

ABSTRACT

The Izu-Bonin intra-oceanic island arc is a product of the subduction of Pacific lithosphere since the Eocene. The focus of Ocean Drilling Program (ODP) Leg 126 was to study three important and poorly understood aspects of this system, namely (1) the origin and evolution of the forearc, investigated by drilling a series of holes through the sediments and into the basement of the forearc basin (Sites 787 and 792-793); (2) the process and products of arc rifting, investigated by drilling holes into the center (Sites 790/791) and eastern footwall (Sites 788/789) of the Sumisu backarc rift; and (3) recycling of subducted lithosphere and evolution of the mantle, investigated indirectly from the composition of the volcanic rocks recovered from all sites.

The principal drilling results of Leg 126 show that the forearc basin formed between 31 and 34 Ma by separation of the formerly contiguous frontal and outer arc highs. Igneous basement beneath the center of the forearc basin includes high-Mg series andesites, andesites with boninitic affinities, and low-Mg series lavas with tholeiitic affinities. Following a minimum of volcanic output between 24 and 13 Ma, there has been a steady increase in explosive volcanic activity in the forearc with a dramatic increase in the late Quaternary. Paleomagnetic evidence shows that the forearc has been translated about 15°N since 30 Ma. Benthic foraminiferal data suggest 1-2 km of basement uplift has occurred since the middle Oligocene. Pore waters in the Oligocene volcanogenic sediments of the forearc basin are the most extensively altered pore water of sea-water origin ever sampled by DSDP/ODP. Low-temperature alteration of the volcanogenic sediments has produced fluids extremely enriched in calcium and depleted in magnesium, silica, and sulfate.

The present stage of rifting in the Sumisu Rift at 31°N began between 3.56 and 1.1 Ma with both present-day and pre-rift volcanism along the volcanic front dominated by rhyolitic pumice eruptions. The footwall of the Sumisu Rift has been uplifted 200-1700 m, and rift basement depth prior to 1.1 Ma exceeded 2 km. The basement of the rift is formed by early rift basaltic lavas and intrusives, as well as by arc pyroclastics metamorphosed to zeolite or lower greenschist facies. Intra-rift basaltic eruptions and rhyolitic eruptions were common but explosive arc volcanic activity dramatically increased 250 Ka. Unlike the forearc region, fluids other than sea water are not circulating locally through the sediments in the Sumisu Rift.

TECTONIC SETTING AND EVOLUTION OF THE IZU-BONIN-MARIANA REGION

The present-day tectonic configuration of the Izu-Bonin-Mariana region (Fig. 1) comprises, from east to west: the trench; the forearc terrane, made up of an inner trench wall, an outer-arc high, a forearc basin, and a frontal-arc high; the active Izu-Bonin and Mariana island arcs; the Izu-Bonin backarc rifts and the actively spreading Mariana backarc basin and its remnant arc, the West Mariana Ridge; the Shikoku and Parece Vela marginal basins; and the Kyushu-Palau Ridge, the westernmost remnant arc. Mesozoic Pacific oceanic lithosphere is being subducted to the west-northwest beneath the arcs at rates of 20 mm/yr in the south to 65 mm/yr in the north. The velocity at 31°N is 60 mm/yr along a direction of 288° (Seno et al., 1987).

The evolution of these arcs and backarc basins is thought to have begun in the early-middle Eocene with the onset of westward subduction of Pacific lithosphere beneath the Philippine Sea plate (Karig, 1975). Development of the system continued through the early Oligocene, forming an intraoceanic volcanic arc on top of a 200-km-wide forearc composed of volcanic rocks primarily of tholeiitic and boninitic affinities (Natland and Tarney, 1981). In the Mariana area, this arc formed on or near the edge of the West Philippine Basin, whereas in the Bonin area it formed on the edge of the Amami-Oki Daito province, a series of island arcs and intervening basins of Cretaceous (Santonian) to Paleocene age. Mid-Oligocene rifting split the arc, and late Oligocene to early Miocene backarc spreading in the Shikoku and Parece Vela basins isolated a remnant arc (the Kyushu-Palau Ridge) from an active Izu-Bonin-Mariana arc (Kobayashi and Nakada, 1979; Mrozowski and Hayes, 1979). The initiation of this backarc spreading event was not synchronous along the length of the Oligocene arc. Spreading began at about 31 Ma in what became the central Parece Vela Basin and propagated both north and south, giving the basin its bowed-out shape. A second spreading episode began by 25 Ma in what became the northernmost Shikoku Basin and propagated south. By 23 Ma the two systems had joined at what is now approximately 25°N, and both basins shared a common spreading axis until spreading ceased at 17-15 Ma.

A repetition of this cycle of events began in the late Miocene when the southern part of the arc split again. Subsequently, 6 m.y. of spreading in the Mariana backarc basin isolated the active Mariana arc from, and increased its curvature with respect to, a remnant arc, the West Mariana Ridge (Karig et al., 1978; Hussong and Uyeda, 1981). Spreading in the Mariana backarc basin may now be propagating to the north, "unzipping" the Mariana arc from the West Mariana Ridge (Stern et al., 1984). The Bonin arc is still in the early rifting stage of backarc-basin formation, undergoing extension along most of its length (Honza and Tamaki, 1985). The major zone of rifting lies immediately west of the active volcanic chain, but some volcanoes near 29°N are surrounded by grabens (Taylor et al., 1985, in press). Volcanism is continuing along both the active and "remnant" arcs, and volcanic centers also have developed in the rift basins. The latter contain lavas with a bimodal basalt-rhyolite composition. The basalts have major- and trace-element abundances that resemble the basalts of the Mariana backarc basin rather than the basalts of the adjacent Izu-Bonin island arc (Fryer et al., 1985; Hochstaedter et al., in press).

The backarc rifts are semicontinuous along strike, segmented by structural highs and chains of submarine volcanoes extending westward from the island arc volcanoes (Taylor et al., 1985; in press). Similar volcanic cross-chains are located west of the Mariana volcanoes, and older chains extend westward into the Parece Vela and Shikoku basins from the West Mariana Ridge and the Izu-Bonin arc (Taylor et al., 1985, in press).

The differences in backarc evolution between the Mariana and Izu-Bonin systems are associated with corresponding differences in their forearcs. These differences are further accentuated by the fact that seamount chains and aseismic ridges on the subducting plate have collided only with the Mariana and southernmost Izu-Bonin arc. Compared to the Mariana forearc, the Izu-Bonin forearc has experienced little deformation since subduction began (Honza and Tamaki, 1985). It has developed a broad forearc basin, filled with volcaniclastic and hemipelagic sediments, behind an outer-arc basement high (Fig. 2). Biostratigraphic dating of the strata that lap onto this high, both submarine and on its subaerial expression in the Bonin Islands (Hanzawa, 1947), suggests that this high has been a positive topographic feature since the middle Eocene. Several mature, dendritic submarine canyon systems have developed across the Izu-Bonin forearc basin and the outer-arc high by mass wasting and headward erosion. These canyons have incised as much as 1 km into the 1.5-4-km-thick sedimentary section (Taylor and Smoot, 1984).

The Izu-Bonin arc is being subducted to the north beneath Honshu. Deformation of the northern Izu-Bonin arc is focused on the leading edge of the downgoing plate where subduction-related thrusting at the Nankai Trough is stepping seaward to the south side of Zenisu Ridge, the northernmost volcanic cross-chain of the arc (Le Pichon et al., 1987). Terranes of Izu-Bonin arc crust have been accreted onto southern Honshu during the last 15 m.y.; the latest terrane to be accreted was the Izu Peninsula in the early Quaternary (Matsuda, 1978; Huchon and Kitazato, 1985; Taira et al., in press).

DRILLING OBJECTIVES

The Izu-Bonin and Mariana regions are the best-studied intraoceanic arc-trench systems. They are the type examples with which older or less well-studied systems are compared. Yet fundamental questions about their evolution remain with regard to (1) arc rifting, (2) arc/forearc magmatism and structure, and (3) arc/forearc stratigraphy and vertical tectonics. To address these questions, Leg 126 in the Izu-Bonin arc had the following objectives:

Arc-backarc (Sites 788-791) Objectives

1. The differential uplift/subsidence history of the rift basin and adjacent arc margin.
2. The nature of volcanism and sedimentation in the rift and on the arc.
3. The duration of rifting and the nature of the rift basement.
4. The chemistry of fluids circulating in the rift basin.

Forearc (Sites 787, 792, and 793) Objectives

1. The uplift/subsidence history across the forearc to provide information on forearc flexure and basin development as well as the extent of tectonic erosion.

2. The stratigraphy of the forearc with its record of (a) sedimentation, depositional environment and paleoceanography; and (b) the variations in intensity and chemistry of arc volcanism over time.

3. The nature of igneous basement forming the frontal arc, outer-arc high and beneath the intervening basin, to answer questions concerning the initial stages of subduction-related volcanism, the origin of boninites, and the formation of the 200-km-wide arc-type forearc crust.

4. The microstructural deformation and the large scale rotation and translation of the forearc.

DRILLING RESULTS

Leg 126 sailed from Tokyo, Japan, on 19 April 1989 and drilled 7 sites, 3 in the forearc basin and 4 in the region of the Sumisu Rift (Figs. 2-4). During the 57.6 days of Leg 126 operations, 53.4 days were spent on site whereas underway time added up to 4.2 days (Table 1).

Site 787

Site 787 (proposed site BON-5C; 32°22.51'N, 140°44.64'E; 3259.0 m water depth) is located on the eastern edge of the Izu-Bonin forearc sedimentary basin, about 95 km east of the arc volcano Aoga Shima and 135 km west of the axis of the Izu-Bonin Trench (Fig. 2). It is located in the axis of Aoga Shima Canyon; the canyon has incised and removed up to 1 km of the sedimentary section. The principal objectives of this site were to determine (1) the stratigraphy of the forearc basin and hence both the temporal variations in sedimentation, depositional environment, and paleoceanography and the history of the intensity and chemistry of the arc volcanism; (2) the uplift and subsidence history across the forearc to provide information on forearc flexure and basin development as well as on the extent of any vertical tectonic activity which may have taken place since the formation of the forearc terrane; and (3) the microstructural deformation and the large-scale rotation and translation of the forearc terrane since the Eocene. Site selection was based on multichannel seismic records and a short shipboard seismic survey; the site chosen lies on *Fred Moore* 3505, line 2, at 0710 UTC (Fig. 3a).

Hole 787A was spudded as a jet-in test with a rotary core barrel (RCB) system, washing 34.5 meters below sea floor (mbsf) with 6 m recovery. Hole 787B was continued with an RCB, coring 320.1 mbsf with 50.0% recovery (73% between 127 and 282 mbsf), penetrating to a depth equivalent to the depth of the first strong seismic reflector before the pipe stuck, probably from hole collapse. The pipe had to be severed with explosives 10 m below the mud line, leaving the bottom-hole assembly (BHA) in the hole.

Four lithostratigraphic units were defined at Site 787 (Fig. 5):

Unit I (0-21.4 mbsf) is lower Pleistocene sandy gravel, gravelly sand, gravel, and silty sand, all scoriaceous and pumiceous;

Unit II (21.4-40.3 mbsf) is Pliocene and upper Miocene lithic-vitric-rich nannofossil ooze and nannofossil-bearing volcanolithic silty clay;

Unit III (40.3-118.9 mbsf) is upper Oligocene vitric-rich claystone, nannofossil chalk, and pumiceous and scoriaceous sandy claystone, with a lower 2.6-m-thick welded crystal-lithic lapilli tuff;

Subunit IVA, (118.9-281.7 mbsf) is upper Oligocene interbedded graded vitric silty sandstone, bioturbated silty claystone, and nannofossil silty claystone, with volcanic ash distributed throughout;

Subunit IVB, (281.7-320.1 mbsf) is upper Oligocene gravel-rich and pebbly coarse sandstone and nannofossil silty claystone.

Units I and II are biostratigraphically dated using nannofossils, foraminifers, and radiolarians. Units III and IV are well dated by nannofossil biochronology and excellent magnetostratigraphy (Chrons 6CN-9R). Sedimentation rates during the late Oligocene ranged from 35 m/m.y. (28.2-29.5 Ma) to 102 m/m.y. (26.6-28.2 Ma) to 17 m/m.y. (23.7-26.6 Ma) (Fig. 6a).

Units I and II are unconsolidated whereas Units III and IV are lithified. All sediments consist of mixtures of volcanogenic and biogenic, mainly nannofossil, materials that were deposited in water depths below 2000 m and above the carbonate compensation depth (CCD). Smectite is the dominant clay mineral in Units III and IV. The volcaniclastic sands and gravels of Unit I represent early Pleistocene canyon fill. Unit II is bounded both above and below, and is separated internally, by unconformities and records intermittent hemipelagic deposition during canyon erosion. The lithification of the Oligocene section requires significant former overburden; we infer that canyon formation did not remove this overburden until the late Miocene or Pliocene. The clastic component in Unit III results from distal turbidite deposition and volcanic ash fall as well as one andesitic submarine pyroclastic flow. Subunit IVA represents basin-plain volcaniclastic turbidite deposits interbedded with fine-grained hemipelagic sediments. The biogenic component of the hemipelagic sediments decreases upsection. Subunit IVB is probably a channel deposit, although the seismics suggest that this higher velocity coarse material is regionally distributed. All bedding is horizontal, except near a syndepositional slump unit at 189-195 mbsf, which is 75% overturned. The upper Oligocene section is strongly burrowed. Extensional microfaults, conjugate fracture sets, low-angle shear planes, clastic injections, and dewatering veinlets all evidence post-depositional extensional deformation.

Physical-property measurements indicate that (1) carbonate content is a maximum in Unit III and varies inversely with clastic dilution from 0-65%, (2) average bulk densities increase downhole from 1700 to 2200 kg/m^3, (3) sonic velocities average 1.8 km/s in Unit III and 2.2 km/s in Unit IV with the exception of some thin coarse layers in both units with velocities of 2.7 to 3.5 km/s, and (4) magnetic susceptibility is a maximum in Units I and IV and a minimum in Unit III. Magnetic inclination data cluster around $\pm$40°, indicating 8° of northward motion since the late Oligocene.

Analyses of sediment and fluid geochemistry indicate that the interstitial waters are of marine origin and are modified by low-temperature alteration of volcanogenic material in the sediments. Concentration trends of K, Ca, and Mg below 275 mbsf may be interpreted as the result of seawater circulation in a deeper layer. Uniformly high concentrations of sulfate, along with hydrocarbon gas levels below detection limits, are evidence of very low bacterial activity. The concentration of sedimentary organic carbon varies from 0 to 0.54%.

The principal results of this site are (1) characterization of hemipelagic and turbidite deposition in this deep-water forearc basin in the late Oligocene, (2) documentation of continuous arc volcanism during the previously purported Bonin-Mariana volcanic minimum in the late Oligocene, (3) recognition of moderate to high sedimentation rates in the late Oligocene and extrapolation of average rates greater than 100 m/m.y. back to the presumed middle Eocene basement, (4) paleomagnetic evidence that there has been Neogene translation of this site about 8° to the north, (5) microstructural evidence of extensional deformation, (6) constraints on the time of major submarine canyon formation in this area to the (probably late) Miocene-Pliocene, and (7) pore-water indications of a possible seawater aquifer within the basin.

<u>Sites 788 and 789</u>

Sites 788 (proposed site BON-2; 30°55.4'N, 140°00.2'E; 1113.0 m water depth) and 789 (30°55.2'N, 139°59.8'E; 1128.5 m water depth) are located on the eastern margin of the Sumisu Rift between the active Izu-Bonin arc volcanoes Sumisu Jima (58 km north) and Tori Shima (55 km south-southeast) (Fig. 2). The sites are just over 0.5 km apart and are situated on the summit of the rift flank footwall uplift, which is cut by high angle normal faults dipping away on both sides from Site 788. The principal objectives of these sites were to determine (1) the vertical motion history of the rift margin, (2) the time of initial rifting, and (3) the nature and history of volcanism and sedimentation between the major arc volcanoes. Site selection was based on multichannel seismic records and a short shipboard seismic survey; the sites chosen lie on *Fred Moore* 3507, line 4, at 2138 UTC (Site 788) and at 2133 UTC (Site 789) (Fig. 4a).

Hole 788A was spudded with an RCB, coring to 45.3 mbsf with 1.24 m of recovery. After offsetting 100 m northwest, four RCB cores were taken in Hole 788B, penetrating 35.6 m with no recovery. Hole 788B began to cave in and so was abandoned. Hole 789A was spudded with an RCB, coring 54.1 m with only 0.1 m recovery. Hole 788C was spudded with an advanced hydraulic piston corer (APC), coring from 4 to 248.2 mbsf with 60% recovery. The hole was continued with the extended core barrel (XCB) system to 262.5 mbsf with 1% recovery before the pipe became stuck. The pipe was freed and the drill string was tripped. Hole 788D was spudded with an RCB and drilled with a center bit to 219.6 mbsf. Coring continued to 374 mbsf with 8% recovery. With the primary scientific objectives met, this hole was terminated so as not to jeopardize the BHA.

Two lithostratigraphic units were defined at Site 788 (Fig. 5):

Subunit IA (0-230 mbsf) is upper Pleistocene and Pliocene sandy, granule- and pebble-sized, pumiceous gravel locally interbedded with vitric sands and rare vitric silts.

Subunit IB (230-249 mbsf) is a Pliocene transition unit comprised of the same material as in Subunit IA, but which has been lithified to conglomerate.

Subunit IIA (249-278.6 mbsf) is lower Pliocene interbedded nannofossil-rich claystone and vitric sandstone, silty claystone, and siltstone, moderately burrowed.

Subunit IIB (278.6-374 mbsf) is lower Pliocene interbedded pumiceous conglomerate and vitric sandstone, siltstone, and silty claystone. Site 789 recovered 0.1 m of Pliocene-Pleistocene pumice from the surficial core.

Units I and II are dated using nannofossils, foraminifers, and paleomagnetics. There is an unconformity at about 30 mbsf between pumice less than 275 Ka and pumice 2.35-3.56 Ma. Pliocene sedimentation rates are >140 and <240 m/m.y. in Unit I and average 140 m/m.y. in Unit II, varying between 40 m/m.y. in Subunit IIA and 240 m/m.y. in Subunit IIB (Fig. 6b). Benthic foraminifers indicate a depositional water depth of 1500-3000 m for Subunit IIA.

The sediments are dominantly arc-derived volcaniclastics, mostly pumiceous gravel and conglomerate. No igneous rocks were recovered. The silt/clay component and all biogenic materials are virtually absent in the coarse clastics (carbonate is <0.5% in Unit I), probably as a result of winnowing. Carbonate-rich sections such as in Subunit IIA and lower Subunit IIB reflect slower deposition during volcanic minima lasting up to 300 k.y. Upward-coarsening intervals in Unit I represent four large eruptions, or four periods during which volcanism built up to climaxes, three in the Pliocene and one in the late Pleistocene. The pumice is mainly rhyolitic, although the lower two cycles have more diverse clast types, including high-silica andesite.

Bedding is horizontal in Unit I to subhorizontal in Unit II. A zone of 30°-60° normal faulting occurs near 297 mbsf. Lithification by compaction and pressure-welding is apparent in Subunits IB and IIA, plus carbonate and local zeolite cementation in Subunit IIB. The degree of compaction suggests that formerly the overburden was greater than at present.

Physical-property measurements indicate that (1) average bulk densities increase from 1.5 g/cm^3 in Unit I to 2.0 g/cm^3 in Unit II, (2) porosities range from 50-90% (average 73%) in Unit I to 45-70% (average 60%) in Unit II, and (3) sonic velocities average 1.6 km/s in Unit I, 2.7 km/s (range 2.4-3.3 km/s) in Subunit IIA, and 2.8 km/s (range 2.0-3.4 km/s) in Subunit IIB.

The principal results of these sites are (1) the arc margin footwall of Sumisu Rift has been uplifted 200-1700 m; (2) the footwall uplift, and therefore the initiation of rifting, occurred since 2.35-3.56 Ma; (3) present-day and pre-rift volcanism and sedimentation along the volcanic front is dominated by rhyolitic pumice eruptions; and (4) unlike other arcs such as Japan and the Cascades, there is no evidence at this site of igneous vents or lava flows between the large frontal-arc volcanoes during the last 5 m.y.

Sites 790 and 791

Proposed site BON-1A became two drill sites. Site 790 (30°54.96'N, 139°50.66'E, 2223 m water depth) and Site 791 (30°54.97'N, 139°52.50'E, 2268 m water depth) are located near the center of Sumisu Rift, a backarc graben west of the Izu-Bonin island arc volcanoes Sumisu Jima and Tori Shima (Fig.2). The sites are 2.4 km apart and are situated on the western side of the eastern inner-rift half graben. The syn-rift sediments dip to the east with regional basal dips of 15° and are cut by 45°-60°, dominantly west-dipping normal faults. The principal objectives of this site were to determine (1) the vertical motion history of the rift basin, (2) the nature of volcanism and sedimentation in the rift, (3) the duration of rifting and the nature of the rift basement, and (4) the chemistry of fluids circulating in the rift basin. Site selection was based on multichannel seismic records and a short shipboard seismic survey; the sites chosen lie on *Fred Moore* 3507, line 4, at 1933 UTC (Site 790) and at 1953 UTC (Site 791) (Fig. 4b).

Hole 790A was spudded with an APC, coring 35.7 m with 96% recovery. Potential entanglement with fishing line required a pipe round trip. Hole 790B recored the mud line and continued with an APC to 100.3 mbsf with 88% recovery before switching to XCB and coring a further 38.6 m with 2% recovery. A top drive electrical short terminated the hole. Hole 790C overlapped the poorly recovered basal section of Hole 790B, recovering 98% of the interval 85-155.2 mbsf with APC and continued with XCB to 271.1 mbsf with 50% recovery. XCB recovery in the basal 106 m of Hole 790C to 387.1 mbsf total depth was 0.5%. Operations in Hole 790C ended after the lockable flapper valve (LFV) jammed open and short trips showed repeated hole filling, making logging unsafe. Hole 791A was spudded with an APC, coring 207.9 m with 83% recovery. The hole was continued with XCB to 457 mbsf with 3% recovery. Hole 791B was spot-cored and washed down to 416.3 mbsf, then RCB-cored to 1145 mbsf. Recovery between 457 and 834 mbsf was 23% and in the basement below this was 9%. Extensive hole conditioning in preparation for logging was terminated when the pipe stuck at 825 mbsf. After geochemical logging of the sedimentary section through the pipe was completed, the pipe was severed at 46 mbsf.

Three lithostratigraphic units were defined at Sites 790 and 791 (Fig. 5):

Unit I, deposited in the last 0.25 m.y., is vitric silt and sand, pumiceous gravel and vitric silty clay at Site 790 (0-165 mbsf), and is pumiceous gravel and sand, vitric silt, pumiceous pebbly sand and vitric silty clay at Site 791 (0-473 mbsf);

Unit II, deposited 0.25-1.1 Ma, is burrowed nannofossil-rich clay, silty clay and clayey silt at Site 790, 165-271 mbsf, and is nannofossil-rich, burrowed claystone and sandy mudstone, and vitric silt at Site 791, 473-834 mbsf;

Unit III is scoriaceous basalt at Site 790 (271-387 mbsf), and is, in order of first occurrence downsection, basalt breccia, basalt, diabase, basaltic "mousse," and mafic to felsic tuff and lapilli tuff at Site 791 (834-1145 mbsf). A vitric siltstone occurs at 329 mbsf at Site 790 and a coarse sandy silt occurs at 975 mbsf at Site 791. Both sedimentary layers are Pleistocene.

Units I and II are well dated using nannofossils, foraminifers, radiolarians, and paleomagnetics. Eight chronostratigraphic datums at each site show that sedimentation rates increase exponentially from 80 and 300 m/m.y. at 1 Ma to 1000 and 2250 m/m.y. in the last 100 k.y. at Sites 790 and 791, respectively (Fig. 6b). The rapid sedimentation provides high-resolution records of bio-evolution and magnetic reversals. Applying the average sedimentation rates for the period 0.46-0.83 Ma indicates that the decrease of dipole intensity at the Brunhes/Matuyama polarity transition is limited to about 600 yr and that the reversal in inclination occurred in perhaps as little as 100 yr. However, it is possible that we recovered only one of several reversals in the polarity transition zone.

Bimodal mafic-felsic volcanism is recorded throughout the sedimentary history of the basin, though the relative proportions of each component change. Explosive arc volcanism, possibly from Sumisu and/or South Sumisu calderas, provided large thicknesses of felsic pumiceous sand and gravel five times during the deposition of Unit I at approximately 60-k.y. intervals. One geochemical analysis suggests that the mafic scoria and ash probably were derived from intra-rift basaltic eruptions. Thin ash beds and scattered clasts of basaltic scoria and felsic pumice, with the mafic components dominant, occur throughout Unit II and increase in proportion downhole.

Carbonate contents are less than 3% in the coarse clastics of Unit I, up to 20% in the finer interbeds and 20-40% in Unit II. Burial of organic carbon owing to the high sedimentation rates in Unit II at Site 791 led to reducing conditions in the sediment and precipitation of iron sulfides. The concentration of sedimentary organic carbon varies from below detection levels in the coarse clastics to as much as 1.2%. Fluid geochemistry studies indicate that fluids other than seawater are not circulating through the sediments.

The differential subsidence between the two sites is matched by both the clastic and the biogenic sedimentation, the rates for Unit II at Site 791 being nearly four times those at Site 790. This, and the lack of coeval material on at least the eastern rift flank, requires that a large proportion of the pyroclastic and pelagic materials were (re)deposited by submarine mass flows. Benthic foraminifers indicate deposition in 2-km water depths during the Brunhes chron and at somewhat deeper levels previously. Bedding at Site 790 is near horizontal, but at Site 791 the dip gradually increases to 15-20° by 600 mbsf and then rapidly increases to 35-45° by 760 mbsf down to basement. Multichannel seismics suggest that the dips are easterly above 650 mbsf and magnetic declinations after tilt corrections indicate that the dips remain easterly above basement. Near basement, Hole 791B may have crossed into the footwall of an intra-rift fault, thereby missing a few hundred meters (~0.1 m.y.) of early syn-rift sediments. Dips of basement rocks vary from 40° at the top to 5-40° in some of the basal fault slices.

The sparsely phyric basaltic volcanics at both sites are highly vesicular despite their eruption in deep water, probably owing to their high pre-eruption water contents. One more differentiated lava contains clinopyroxene in addition to the olivine and plagioclase typical of the more mafic lavas it overlies. The diabase intrusions range from relatively olivine rich and as mafic as any of the basalts, to Fe-Ti rich and more differentiated than any of the basalts. The 135-m-thick basaltic "mousse" consists primarily of highly expanded basaltic glass with vesicular "clasts" in an even more vesicular glassy matrix of the same composition. It is interpreted as the product of a large-volume, deep submarine eruption of gas-rich basalt. The rift basement basalts may be distinguished from Izu-Bonin arc basalts by their lower Ba (<30 ppm) and higher TiO_2 (>0.95%) with respect to MgO, Zr, and V. They are inferred to be of syn-rift origin but are more similar to rift wall rocks dated at 1.0-1.4 Ma and to seamounts in the outer rift than to the 250-Ka pillow ridges of the inner rift, which suggests a temporal evolution of rift volcanism toward compositions more depleted in high field strength elements. The basalts at Hole 791B have lower concentrations of Ba and Rb than do those at Hole 790C and the younger rocks of the inner rift. These concentrations are as low as those in mid-ocean ridge basalts (MORB) and in the most mature backarc basins.

The tuff and lapilli tuffs at the base of Hole 791B show strong flattening of pumice shards and development of a eutaxitic texture. They are interpreted as a sequence of hot pyroclastic flows from a proximal eruption site. They are dominantly andesitic, with one basal basaltic unit. Their most immobile elements have strong island arc characteristics (Ti/Zr = 195, Zr/Y = 1.5), suggesting that the tuffs cap an arc basement of unknown age. However, alteration effects make this conclusion preliminary. Alteration increases down the basement section, from fresh to zeolite or lower greenschist facies in the basal 41 m, which penetrated a fault zone as evidenced by slickensides, fault gouge, massive gypsum, and minor pyrite.

Physical-property measurements of the sediments indicate that (1) average bulk densities increase downhole from 1.55 to 1.8 and 1.9 gm/cm^3 at Sites 790 and 791, respectively, (2) average porosities decrease from 70% to 60% and 55% at Site 790 and Site 791, respectively, (3) sonic velocities range from 1.53-1.61 km/s in Unit I to, in Unit II, 1.52-1.55 km/s at Site 790 (a small velocity inversion) and 1.61-1.84 km/s at Site 791, (4) average thermal conductivities increase downhole from 0.9 to 1.1 and 1.2 W/m-°K at Sites 790 and 791, respectively. Basement physical properties at Site 791 include (1) bulk density of 2.2-3.0 gm/cm^3, (2) porosity of 8-44%, (3) sonic velocity of 2.6-5.2 km/s, and (4) thermal conductivity of 1.0-1.2 W/m-°K. The lower velocities and densities and the higher porosities are from the basaltic "mousse". The lowest porosities are from basal lapilli tuffs and the highest velocity is from a gypsum vein.

Geochemical logging at Site 791 identified isolated natural gamma-ray peaks with some of the silty clay beds. These high values are mostly due to thorium. Long sections in Unit I with uniformly low gamma-ray values are associated with unrecovered pumiceous sand and gravel. This and the increased frequency of the gamma-ray highs in Unit II helped locate the lithologic Unit I/II boundary.

The principal results of this site are (1) rifting began, and rift basement depths exceeded 2 km, prior to 1.1 Ma; (2) basement is formed by early rift basaltic lavas and intrusives, as well as by arc pyroclastics metamorphosed to zeolite or lower greenschist facies; (3) a large volume, deep submarine eruption of water-rich basalt produced basaltic mousse, a highly expanded basaltic glass with vesicular "clasts" in an even more vesicular glassy matrix of the same composition; (4) extremely rapid, differential and accelerating subsidence and sedimentation occurred in the inner rift half-graben in the last 1.1 m.y.; (5) intra-rift basaltic eruptions and rhyolitic arc eruptions were common, but explosive arc volcanic activity dramatically increased 250 Ka.; (6) a large proportion of the pyroclastic and pelagic materials were (re)deposited by submarine mass flows; (7) fluids other than seawater are not circulating locally through the sediments; and (8) the decrease of dipole intensity and the reversal in inclination associated with the Brunhes/Matuyama polarity transition is limited to about 600 yr and occurred in perhaps as little as 100 yr, respectively.

Site 792

Site 792 (proposed site BON-4; 32°23.96'N, 140°22.80'E; 1787 m water depth) is located on the western half of the Izu-Bonin forearc sedimentary basin, about 60 km east of the arc volcano Aoga Shima and 170 km west of the axis of the Izu-Bonin Trench (Fig. 2). It is located upslope from a fork in the Aoga Shima Canyon, where the forearc sediments lap onto the edge of a basement high. The principal objectives of this site were to determine (1) the stratigraphy of the forearc basin and hence both the temporal variations in sedimentation, depositional environment and paleoceanography, and the history of the intensity and chemistry of the arc volcanism; (2) the uplift and subsidence history across the forearc; (3) the nature of the igneous basement and the formation of the 200-km-wide arc-type forearc crust; and (4) the microstructural deformation and the large-scale rotation and translation of the forearc terrane since the Eocene. Site selection was based on multichannel seismic records and a short shipboard seismic survey; the site chosen lies on *Fred Moore* 3505, line 10, at 0134 UTC (Fig. 3b).

Hole 792A was spudded with an APC, coring 95 m with 76% recovery until an overpull and resulting severed piston rod terminated the hole. Hole 792B recored the mud line, washed to 50 mbsf, and continued with an APC to 69.2 mbsf before switching to XCB and coring to 146.4 mbsf, with recovery of 43% overall. Hole 792B was terminated at that point by a fractured cutting shoe. Hole 792C was washed to 136.8 mbsf, where another XCB attempt was made. The cutting shoe failed again, in the same manner as in Hole 792B. Hole 792D was washed to 136 mbsf and another attempt was made to cut an XCB core. The cutting shoe fractured again, in the same manner as the two previous holes. Hole 792E was spudded with an RCB, washed to 135.6 mbsf, and then cored to 885.9 mbsf, with 52% recovery in the sediments above 803 mbsf and 16% recovery in the basement below. While pulling out of the hole in preparation for logging, the pipe stuck with the bit at 286 mbsf. After attempts to save the BHA proved fruitless, a full suite of standard geophysical and geochemical logs was run above 878 mbsf. The first formation microscanner (FMS) logging in ODP history was completed successfully, and a vertical seismic profile (VSP) was collected as well. Finally, the pipe was severed with explosives at 134 mbsf.

Six lithostratigraphic units were defined at Site 792 (Fig. 5):

Unit I (0-183.7 mbsf) is upper Pliocene to Holocene nannofossil-rich, vitric silty clay and clayey silt, interbedded with vitric silts and sands and minor pumiceous and scoriaceous gravels.

Unit II (183.7-357.4 mbsf) is middle and upper Miocene sandy mudstone, muddy sandstone, and silty claystone (all with nannofossil-rich intervals), vitric sandstone, and vitric siltstone.

Unit III (357.4-429.3 mbsf) is upper Oligocene to middle Miocene intensely bioturbated, nannofossil-rich claystone and nannofossil chalk, and rare crystal-vitric siltstone and sandstone.

Unit IV (429.3-783.4 mbsf) is upper Oligocene vitric sandstone and volcanic sandy conglomerate containing claystone intraclasts, with minor silty claystone and claystone that have some nannofossil-rich intervals.

Unit V (783.4-804 mbsf) is altered volcanic sandstone with claystone intraclasts.

Unit VI (804-885.9 mbsf) is porphyritic andesite with minor basaltic andesite and dacite.

Units I-IV are dated using nannofossils, foraminifers, and paleomagnetics, with the addition of radiolarians in Units I and II. Four lacunae occur, representing 1-2.2, 3.5-6, 8-9, and 13-19 Ma. The second and fourth lacunae correspond to the basal boundaries of the first two units. Average sedimentation rates for the intervals between these lacunae were, from the present backward, 90 and 62 (Unit I), and 43 and 23 (Unit II) m/m.y. respectively. Sedimentation rates for Unit III were 11 and 9 m/m.y., above and below a normal fault which cuts out strata representing 23-24 Ma. Sedimentation rates for Unit IV (27-29 Ma) were 290 m/m.y. and greater prior to 28 Ma, but they slowed to 32 m/m.y. thereafter (Fig. 6a). Benthic foraminifers record that depositional water depths shallowed from 3.5-4.5 km in the late Oligocene to shallower than 2.3 km since the middle Pleistocene, requiring 1-2 km of basement uplift since 29 Ma.

The more than 200 ash layers in Unit I are evidence of ongoing explosive volcanism since the late Pliocene. Unit II records both hemipelagic and turbidite deposition of biogenic and volcanic components, with mixing of the two by burrowers. Unit III marks a period of very slow bathyal deposition without significant volcanic input. Unit IV consists of thick to thin-bedded turbidites and debris-flow deposits, and fine-grained hemipelagic sediments. The volcanogenic detritus includes the products of both concurrent volcanism and erosion of older volcanic terranes. Bedding is subhorizontal, with maximum dips of less than 5-10°. Extensional microfaults, conjugate high-angle fractures, slickensided horizontal shears, clastic injections, and dewatering veinlets in Units III and IV all evidence post-depositional extensional deformation. Zeolites and gypsum fill many of the veins and fractures. Correlation with multichannel seismics suggests that this site was drilled through a major unconformity somewhere between 690 and 730 mbsf. Although there is no lithologic change in this interval, physical-property and logging data suggest a significant boundary at 715 mbsf. Biostratigraphic evidence constrains the age of Unit IV strata below 715 mbsf and down to 770 mbsf as younger than 34 Ma. This implies that the more than 1-km-thick forearc basin section that laps onto the unconformity below the level reached at Site 792 was deposited in the mid-Oligocene (29-34 Ma). The age of the (hydrothermally) altered Unit V and of the igneous basement is mid Oligocene or older. Radiometric dating of the igneous rocks will be attempted in the next several months.

The basement lavas are massive flows with intercalated hyaloclastite and breccia layers. They are dominantly porphyritic, plagioclase-orthopyroxene-clinopyroxene andesites, with high aluminum, early oxide mineral precipitation, and concomitant iron depletion. They are less enriched in low field strength elements such as K, Rb, Sr, and Ba than are most arc lavas. Ratios between the high field strength elements (e.g., Zr/Y ~1.9) are consistent with a depleted mantle source. The presence of xenocrysts of quartz and other geochemical evidence may indicate that magmas from two distinct sources were mixed during a high-level fractionation process to produce the andesites.

The most extensively altered pore water of seawater origin ever sampled by DSDP or ODP occurs from 500 to 700 mbsf, with characteristic concentrations of sulfate, 15; Mg, 0-4; Ca, 155; and Si, 0.1-0.4 (all in mM/L). The maximum calcium concentration (170 mM/L) at 600 mbsf is higher than ever recorded except in evaporite settings. These extreme geochemical values are not a basement alteration effect but the result of low-temperature alteration of the volcanogenic sediments. They are reflected in the marked downhole increase, below 350 mbsf, in smectite and zeolite at the expense of volcanic glass in Units III and IV. This alteration releases Ca and consumes Mg, Si, and Na. Below 500 mbsf the pore waters are saturated with respect to gypsum, which in precipitating lowers the sulfate concentration. The concentration of organic carbon decreases exponentially from a near-surface high of 0.76% to less than 0.15% in Unit II and below.

Magnetic inclinations on cores younger than 15 Ma show no latitudinal shift, but some northward motion is required for cores older than 25 Ma. The inclination and declination records of the Brunhes-Matuyama reversal show a double transition during a period of decreased field intensity lasting about 3000 yr. This polarity transition period is about five times longer than at Site 791, but this may be an averaging effect from the three-fold decrease in sedimentation rate (120 m/m.y.).

Physical-property measurements indicate that (1) average bulk densities increase downhole from 1.7 to 1.9 g/cm^3 in Unit I, then decrease from 2.1 to 1.9 g/cm^3 in Unit II to 1.85 g/cm^3 in Unit III, (2) average porosities decrease from 65% at the top of Unit I to 55% at its base, then increase through Unit II to 65% at the base of Unit III, (3) sonic velocities average 1.59, 1.85 and 1.87 km/s in Units I through III respectively, and (4) carbonate values range from 1-36% at the top to 3-21% at the base of Unit I, from 0-4% at the top to 3-22% at the base of Unit II, and are commonly 20-67% in Unit III. Physical properties of Unit IV vary downhole in concert with lithologic changes. Four subunits of Unit IV may be defined, which correspond broadly to alternating finer (first and third) and coarser (second and fourth) material, divided at 514, 590, and 715 mbsf. In order downhole, the average values in the four subunits, Unit V, and Unit VI, are (1) bulk density: 1.87, 2.16, 2.09, 2.28, 2.02, and 2.64 g/cm^3, (2) porosity: 58, 44, 50, 42, 50, and 17%, and (3) sonic velocity: 2.3, 2.7, 2.2, 2.6, 2.2, and 4.3 km/s. Carbonate contents are 1-10%, as high as 25% in the upper subunit and typically less than 1-2% below that, except for thin nannofossil-rich layers with values of 10-20%. Thermal conductivities increase downhole, averaging 1.01, 1.02, 1.05, and 1.61 W/m-°K in Units I through III and VI. Three excellent Uyeda-probe temperature measurements down to 110 mbsf, together with the bottom-water temperature, define a linear geothermal gradient of 55°C/km. The heat flow is 56 mW/m^2.

Although the logs are excellent, they mostly require shore-based analysis before final interpretation. The *in-situ* geophysical measurements show similar physical properties to the laboratory measurements. All of the lithostratigraphic and physical-property unit boundaries can be recognized in the logs. The FMS clearly imaged features such as ash layers less than 1 cm thick. The temperature and caliper records identify permeable zones at 400-430 mbsf and at the top and bottom of Unit V which are most likely fault zones. The borehole is slightly elongate in a direction 020° throughout the sedimentary section but is circular in basement.

The principal results of this site are (1) characterization of varying volcanogenic input to the forearc, from extremely rapid prior to 27 Ma to minimal between 27 and 13 Ma to moderate and increasing between 13 Ma and the present, (2) documentation of ongoing explosive volcanism since the late Pliocene, (3) correlation via VSP and logging of the core and seismic stratigraphy, indicating sedimentary filling of the basin between the frontal arc and outer arc highs in the mid-Oligocene, (4) first recovery of the igneous basement beneath such an intra-oceanic forearc basin and initial description of its unusual trace element chemistry, characterized by weakly enriched low field strength elements and depleted high field strength elements, the latter indicating derivation from a refractory mantle source, (5) benthic foraminiferal evidence of 1-2 km of basement uplift since 29 Ma, (6) microstructural evidence of extensional deformation, (7) pore-water indications of low-temperature alteration of the volcanogenic sediments, producing fluids extremely enriched in Ca and depleted in Mg, silica, and sulfate, (8) paleomagnetic evidence that the Brunhes-Matuyama reversal involved a double polarity transition during a period of decreased field intensity lasting 3000 yr or less, and (9) measurement of heat flow at 56 mW/m^2.

Site 793

Site 793 (31°06.33'N, 140°53.27'E; 2964 m water depth) is located in the center of the Izu-Bonin forearc sedimentary basin, about 70 km east of the volcanic front between the islands of Sumisu Jima and Tori Shima and 125 km west of the axis of the Izu-Bonin Trench. It lies in an interchannel area on the southern side of the broad Sumisu Jima Canyon (Fig. 2). The principal objectives of this site were to determine (1) the stratigraphy of the forearc basin and hence both the temporal variations in sedimentation, depositional environment, and paleoceanography, and the history of the intensity and chemistry of the arc volcanism; (2) the uplift and subsidence history across the forearc; (3) the nature of the igneous basement and the formation of the 200-km-wide arc-type forearc crust; and (4) the microstructural deformation and the large-scale rotation and translation of the forearc terrane since the Eocene. Site selection was based on multichannel seismic records; the site chosen lies on *Fred Moore* 3505, line 12, at 0109:30 UTC (Fig. 3c).

Hole 793A was spudded with an APC, coring 99.7 m with 79% recovery until an overpull and resulting severed piston rod terminated the hole. A reentry cone was spudded into the sediment and Hole 793B was begun by drilling a 14-3/4-in. hole to 586.5 mbsf, which was then lined with 46 joints (562.66 m) of 11-3/4-in. casing. Special permission was granted not to core this section in order that the deep stratigraphic and basement objectives could be met in the time available. Over the next 12 days, 114 RCB cores were taken, with a pipe trip and subsequent reentry after Core 126-793B-87R (1422.9 mbsf) to change the drill bit. Hole 793B reached a total depth of 1682 mbsf with 74% recovery in the sediments above 1403.9 mbsf and 33% recovery in the basement below. Following a pipe trip to release the bit and add a casing landing tool, a full suite of geophysical and geochemical logs, including FMS and VSP, was planned. Several bridges were encountered that required clearing with the pipe, so the hole was logged in stages. Physical-property and temperature tools logged the intervals 1565.6-1034, 947.8-775.9, and 708.2-586.5 mbsf; the density tool failed. The FMS was run from 1539 to 1034 mbsf and from 764.1 to 586.5 mbsf. The geochemistry combination was used in open hole from 1531 to 1034 mbsf, and through the pipe from 917 to 586.5 mbsf. Poor clamping because of formation conditions limited an attempted VSP to only a few good recording levels.

Seven lithostratigraphic units were defined at Site 793 (Fig. 5):

Subunit IA (0-32.5 mbsf) is Pleistocene pumiceous gravel, sandy gravel, nannofossil clay, nannofossil clayey silt, nannofossil-rich clay; and nannofossil-rich clayey silt, with rare vitric sand, vitric silt, and vitric silty sand.

Subunit IB (32.5-99.7 mbsf) is Pleistocene pumiceous and vitric sand, nannofossil-rich clay and nannofossil-rich clayey silt, nannofossil clay and nannofossil silty clay, vitric silt, and pumiceous gravel.

Unit II (586.5-591 mbsf) is an olivine-clinopyroxene-orthopyroxene diabase.

Unit III (591-735.7 mbsf) is lower to middle Miocene nannofossil-rich silty claystone, silty claystone, nannofossil-rich and nannofossil claystone, vitric siltstone and sandstone, clayey siltstone, and nannofossil-rich clayey siltstone.

Unit IV (735.7-759 mbsf) is lower Miocene claystone, nannofossil and nannofossil-rich claystone, and vitric siltstone.

Unit V (759-1373.1 mbsf) is upper lower and upper Oligocene vitric sandstone, pumiceous sandstone, granule- to fine-pebble conglomerate, siltstone, clayey siltstone and silty claystone.

Unit VI (1373.1-1403.9 mbsf) is upper lower Oligocene very poorly sorted volcanic breccia with sandy matrix, and mixed fresh to altered clasts of mainly plagioclase-rich andesite.

Unit VII (1403.9-1682 mbsf) is upper-lower Oligocene breccias and massive to pillowed flows of porphyritic clinopyroxene-orthopyroxene, and aphyric, basaltic andesites and andesites.

Units I and III through V are dated using nannofossils, radiolarians (Units I and III), foraminifers, and paleomagnetics. Units VI-VII are dated using paleomagnetics. Sedimentation rates for Units V and VI were 250 m/m.y. (31-29 Ma) and for the upper part of Unit V were 80 m/m.y. (29-27 Ma). Unit IV was deposited very slowly (~5 m/m.y.) with probable lacunae at 18-21 and 23-25 Ma. Sedimentation rates for Unit III were 70 m/m.y., averaged 40 m/m.y. for the uncored interval, and for Unit I (<0.83 Ma) were 105 m/m.y (Fig. 6a). Benthic foraminifers indicate that depositional water depths shallowed from 4-5 km in the late early Oligocene to 2-4 km at present.

Unit VI represents a debris or talus apron, eroded from local basement topography. Several of the clasts are geochemically similar to the basement calcalkaline andesites at Site 792. The more than 600-m-thick Unit V records rapid filling of the forearc basin by turbidite sandstones, conglomeratic debris flows, and finer interbeds. These sediments were produced by concurrent volcanism as well as by erosion of surrounding highs. Hemipelagic Unit IV was deposited in oxygenated bottom waters during a time of regional volcanic quiescence. Unit III represents an alternation of fine-grained turbidites fed by renewed arc volcanism, and hemipelagic sediments. Unit II is a high-Mg series tholeiitic diabase, intruded in the middle Miocene or younger. Unit I records the continuation in the late Pleistocene of the infilling, begun in the early Pliocene, of a broad canyon that was probably incised during the latest Miocene. The increased pumiceous input to the upper part of Unit I records a late Pleistocene increase in explosive arc volcanism.

Units III through VI contain numerous normal microfaults and locally abundant, subvertical dewatering veinlets, which indicate an extensional regime throughout the basin history. The minimum horizontal compressive stress direction determined from hole ellipticity is N70°E. Paleomagnetic inclination data from the sediments and lavas show that the forearc has been translated about 15° north since 30 Ma.

Volcanism without epiclastic sedimentation accompanied the initial mid-Oligocene forearc basin subsidence, as the formerly contiguous Eocene outer-arc and frontal-arc highs were separated. This separation probably resulted from rifting rather than spreading at a well-defined axis, given the scale of the basin (40-70 km wide) and because multichannel seismic data suggest the presence of half-graben and low-angle detachments in the basement.

Most of the Site 793 basement lavas and breccias belong to a high-Mg measurements) because of the gradual transition through the breccias. However, the volcanic breccia and lava flows within the basement are clearly different in their physical properties. Deeper layers, containing a greater abundance of flow units, are characterized by generally lower porosities (average of 23.3%) and higher bulk densities (2.62 g/cm^3) and velocities (3.84 km/s), compared with values in breccia units (means of 28%, 2.5 g/cm^3, 3.4 km/s, respectively).

The principal results of this site, which made the deepest penetration reaching basement in the history of DSDP/ODP, are (1) documentation of the absence of pre-middle Oligocene sediments in the forearc basin depocenter; (2) benthic foraminiferal evidence that depositional water depths shallowed from 4-5 km in the middle Oligocene to 2-4 km at present; (3) interpretation that the forearc basin formed by mid-Oligocene rifting separating the formerly contiguous Eocene forearc and outer arc highs; (4) recovery of the igneous basement beneath the center of the forearc basin, which includes high-Mg series basaltic andesites and andesites with boninitic affinities as well as a low-Mg series with tholeiitic affinities; (5) confirmation of varying volcanogenic input to the forearc, including volcanic quiescence during the early Miocene and a dramatic increase in volcanic activity in the late Quaternary; (6) documentation of a Neogene intrusion 70 km in front of the "volcanic front;" (7) microstructural evidence of an extensional regime throughout the forearc basin history; (8) paleomagnetic evidence that the forearc has been translated about 15° north since 30 Ma; (9) pore water indications of low-temperature alteration of the volcanogenic sediments, producing Ca-Cl-type waters; and (10) establishment of a deep, open reentry site for future investigators.

SUMMARY AND CONCLUSIONS

Leg 126 investigated three aspects of the Izu-Bonin intra-oceanic volcanic arc system: the evolution of the forearc basement, the recent rifting of the arc, and the spatial and temporal variations in volcanism. Initial results of Leg 126 show that:

1. The forearc basin formed between 31 and 34 Ma by separation of formerly contiguous frontal and outer-arc highs. Igneous basement beneath the center of the forearc basin includes high-Mg series basaltic andesites, andesites with boninitic affinities, and low-Mg series lavas with tholeiitic affinities. The forearc has been translated about 15°N and uplifted 1-2 km since 30 Ma.

2. The present rifting of the arc at 31°N began 1.1-3.56 Ma. The basement of the rift is composed of early rift basaltic lavas and intrusives as well as arc pyroclastics metamorphosed to zeolite or lower greenschist facies. The pyroclastic eruption of highly vesicular basalt ("mousse") in the rift occurred in relatively deep water (>1.5-2.0 km). The footwall of the Sumisu Rift has been uplifted 200-1700 m.

3. Following a minimum in volcanic output between 24 and 13 Ma, there has been a steady increase in explosive volcanic activity, with a dramatic increase at 250 Ka in the Sumisu Jima region.

4. High-resolution paleomagnetic records of the Brunhes/Matuyama reversal event document a sequence of two rapid reverse to normal changes in inclination and declination, with transitions occurring on a scale of hundreds of years.

5. The most extensively altered pore-water fluids ever documented by DSDP/ODP occur in Oligocene volcanogenic sediments in the forearc basin. Low-temperature alteration of the volcanogenic sediments has produced fluids enriched in calcium and depleted in magnesium, silica, and sulfate, relative to seawater.

REFERENCES

Fryer, P., Langmuir, C. H., Taylor, B., Zhang, Y., and Hussong, D. M., 1985. Rifting of the Izu arc, III, Relationships of chemistry to tectonics. *Eos, Trans. Am. Geophys. Union,* 66:421.

Hanzawa, S., 1947. Eocene foraminifera from Hahajima. *J. Paleontol.,* 21:254-259.

Hochstaedter, A. G., Gill, J. B., Langmuir, C. H., Norris, J. D., and Pringle M., in press. Petrology and geochemistry of lavas from the Sumisu Rift: an incipient back-arc basin. *Earth Planet. Sci. Lett.*

Honza, E., and Tamaki, K., 1985. Bonin Arc. *In* Nairn, A.E.M., and Uyeda, S. (Eds.), *The Ocean Basins and Margins, v. 7, The Pacific Ocean.* New York (Plenum Press), 459-499.

Huchon, P., and Kitazato, H., 1985. Collision of the Izu block with central Japan during the Quaternary and geological evolution of the Ashigara area. *Tectonophysics,* 110:201-210.

Hussong, D. M., and Fryer, P., 1983.

Hussong, D. M., and Uyeda, S., 1981. Tectonic processes and the history of the Mariana Arc: A synthesis of the results of Deep Sea Drilling Project Leg 60. *In* Hussong, D. M., Uyeda, S., et al., *Init. Repts. DSDP,* 60: Washington (U.S. Govt. Printing Office), 909-929.

Karig, D. E., 1975. Basin genesis in the Philippine Sea. *In* Ingle, J. C., Karig, D. E., et al., *Init. Repts. DSDP,* 31: Washington (U.S. Govt. Printing Office), 857-879.

Karig, D. E., Anderson, R. N., and Bibee, L. D., 1978. Characteristics of backarc spreading in the Mariana Trough. *J. Geophys. Res.,* 83:1213-1226.

Karig, D. E., Ingle, J. C., Jr., et al., 1975. Site 296. *In* Karig, D. E., Ingle, J. C., Jr., et al.,*Init. Repts. DSDP,* 31: Washington (U.S. Govt. Printing Office), 191-274.

Kobayashi, K., and Nakada, M., 1979. Magnetic anomalies and tectonic evolution of the Shikoku inter-arc basin. *In* Uyeda, S. et al. (Eds.), *Geodynamics of the Western Pacific.* Advances in Earth and Planet. Sci., Tokyo (Japan Sci. Soc. Pr.), 6:391-402.

Le Pichon, X., Iiyama, T., Chamley, H., Charvet, J., Faure, M., Fujimoto, H., Furata, T., Ida, Y., Kagami, H., Lallement, S., Murata, A., Okada, H., Rangin, C., Renard, V., Taira, A., and Tokuyama, H., 1987. The eastern and western ends of Nankai Trough: results of Box 5 and Box 7 Kaiko survey. *Earth Planet. Sci. Lett.,* 83:199-213.

Matsuda, T., 1978. Collision of the Izu-Bonin arc with central Honshu--Cenozoic tectonics of the Fossa Magna, Japan. *J. Phys. Earth,* 26:409-421.

Mrozowski, C. L., and Hayes, D. E., 1979. The evolution of the Parece Vela Basin, Eastern Philippine Sea. *Earth Planet. Sci. Lett.,* 46:49-67.

Natland, J. H., and Tarney, J., 1981. Petrologic evolution of the Mariana arc and backarc basin system--a synthesis of drilling results in the South Philippine Sea. *In* Hussong, D. M., Uyeda, S., et al., *Init. Repts. DSDP,* 60: Washington (U.S. Govt. Printing Office), 877-908.

Seno, T., Moriyama, T., Stein, S., Woods, D., Demets, C., Angus, D., and Gordon, R., 1987. Redetermination of the Philippine Sea Plate motion. *Eos, Trans. Am. Geophys. Union,* 68:1474.

Stern, R. J., Smoot, N. C., and Rubin, M., 1984. Unzipping of the volcano arc, Japan. *Tectonophysics,* 102:153-174.

Taira, A., Tokuyama, H., and Soh, W., in press. Accretion tectonics and evolution of Japan. *In* Ben-Avraham, Z. (Ed.), *Evolution of Pacific Ocean Margins:* New York (Oxford Univ. Press).

Taylor, B., Brown, G., Fryer, P., and Hussong, D., in press. Rifting of the Bonin Island Arc. *J. Geophys. Res.*

Taylor, B., Fryer, P., Hussong, D., and Langmuir, C. H., 1985. Active volcanism in the Izu Arc and rift: Tectonic setting. *Eos, Trans. Am. Geophys. Union,* 66:421.

Taylor, B., and Smoot, N. C., 1984. Morphology of Bonin fore-arc submarine canyons. *Geology,* 12:724-727.

TABLE CAPTION

Table 1. ODP Leg 126 operational site summary.

FIGURE CAPTIONS

Figure 1. Active plate boundaries and relict spreading centers in the Philippine Sea region. Barbed lines locate subduction zones, medium double lines locate active spreading centers, and thin double lines locate relict spreading centers. Basins and ridges are outlined by the 4 km bathymetric contour, except for the Izu-Bonin, West Mariana and Mariana arcs which are outline by the 3 km contour. Magnetic anomalies 6 and 6B are shown by thin lines in the Shikoku Basin. A = Amami Plateau; B = Daito Basin; D = Daito Ridge; H = Halmahera; L = Luzon; M = Mindanao; O = Oki Daito Ridge. The box shows the location of Figure 2.

Figure 2. Location map showing multichannel seismic (MCS) survey lines and precise setting of Leg 126 sites (filled circles) and Leg 125 sites (open circles).

Figure 3. Multichannel seismic profiles showing location of forearc sites (a) 787: *Fred Moore* 3505, line 2, 0710 UTC; (b) 792: *Fred Moore* 3505, line 10, 0134 UTC; and (c) 793: *Fred Moore* 3505, line 12, 0109:30 UTC. Dark vertical lines represent approximate depth of cored interval relative to the profile.

Figure 4. Multichannel seismic profiles showing location of arc/backarc sites (a) 788 and 789: *Fred Moore* 3507, line 4, 2138 UTC (788) and 2133 UTC (789); and (b) 790 and 791: *Fred Moore* 3507, line 4, 1933 UTC (790) and 1953 UTC (791).

Figure 5. Summary lithostratigraphic columns for Leg 126 sites.

Figure 6. Age-depth curves for (a) forearc Sites 787, 792, and 793, and DSDP Site 296 (Karing, Ingle, et al., 1975); and (b) arc/backarc Sites 788, 790, and 791. Dashed lines indicate stratigraphic unconformities.

Table 1. Leg 126 Site Summary

Hole	Latitude (°N)	Longitude (°E)	Water Depth (m)*	Number of Cores	Meters Cored	Meters Recov'd	Percent Recov'd	Meters Total Penetr.
787A	32°22.51'	140°44.64'	3259.0	1	34.5	6.0	17.4	34.5
787B	32°22.51'	140°44.64'	3259.4	34	320.1	159.9	50.0	320.1
788A	30°55.35'	140°00.23'	1111.0	5	45.3	1.2	2.7	45.3
788B	30°55.38'	140°00.17'	1113.0	4	35.6	0	0	35.6
788C	30°55.36'	140°00.21'	1113.0	28	258.5	146.2	56.5	262.5
788D	30°55.37'	140°00.22'	1113.0	16	154.4	12.3	8.0	374.0
789A	30°55.24'	139°59.84'	1128.5	6	54.1	0.1	.2	54.1
790A	30°54.95'	139°50.66'	2221.7	4	37.4	35.71	95.5	37.4
790B	30°54.96'	139°50.66'	2223.0	15	138.9	88.7	63.9	138.9
790C	30°54.95'	139°50.69'	2223.0	33	302.1	127.3	42.1	387.1
791A	30°54.96'	139°52.20'	2268.0	49	457.0	179.9	39.4	457.0
791B	30°54.98'	139°52.19'	2268.0	79	738.0	114.3	15.5	1145.0
792A	32°23.97'	140°22.81'	1786.8	10	95.0	72.1	75.9	95.0
792B	32°23.96'	140°22.81'	1787.2	11	100.7	43.6	43.3	146.4
792C	32°23.94'	140°22.78'	1787.2	1	9.6	0.6	6.2	146.4
792D	32°23.93'	140°22.80'	1787.2	1	9.6	0.8	8.8	146.4
792E	32°23.96'	140°22.79'	1787.2	78	750.3	361.9	48.2	885.9
793A	31°06.35'	140°52.26'	2964.3	11	99.7	79.0	79.2	99.7
793B	31°06.33'	140°53.27'	2964.3	114	1095.5	697.9	63.7	1682.0

*Water depth is given in meters below mean sea level, corrected from drill-pipe measurements from the rig floor.

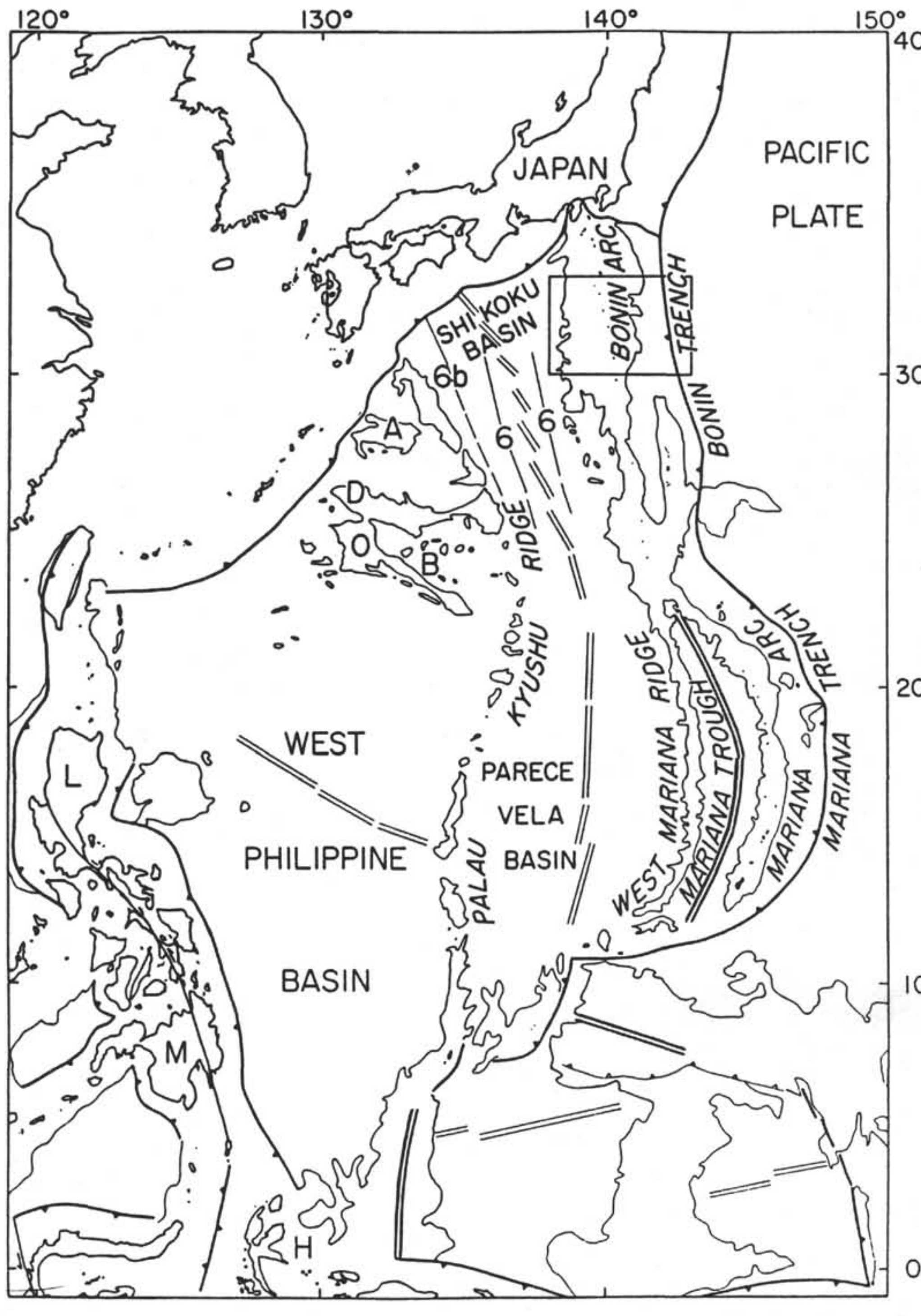


Figure 1. Active plate boundaries and relict spreading centers in the Philippine Sea region. Barbed lines locate subduction zones, medium double lines locate active spreading centers, and thin double lines locate relict spreading centers. Basins and ridges are outlined by the 4 km bathymetric contour, except for the Izu-Bonin, West Mariana and Mariana arcs which are outline by the 3 km contour. Magnetic anomalies 6 and 6B are shown by thin lines in the Shikoku Basin. A = Amami Plateau; B = Daito Basin; D = Daito Ridge; H = Halmahera; L = Luzon; M = Mindanao; O = Oki Daito Ridge. The box shows the location of Figure 2.

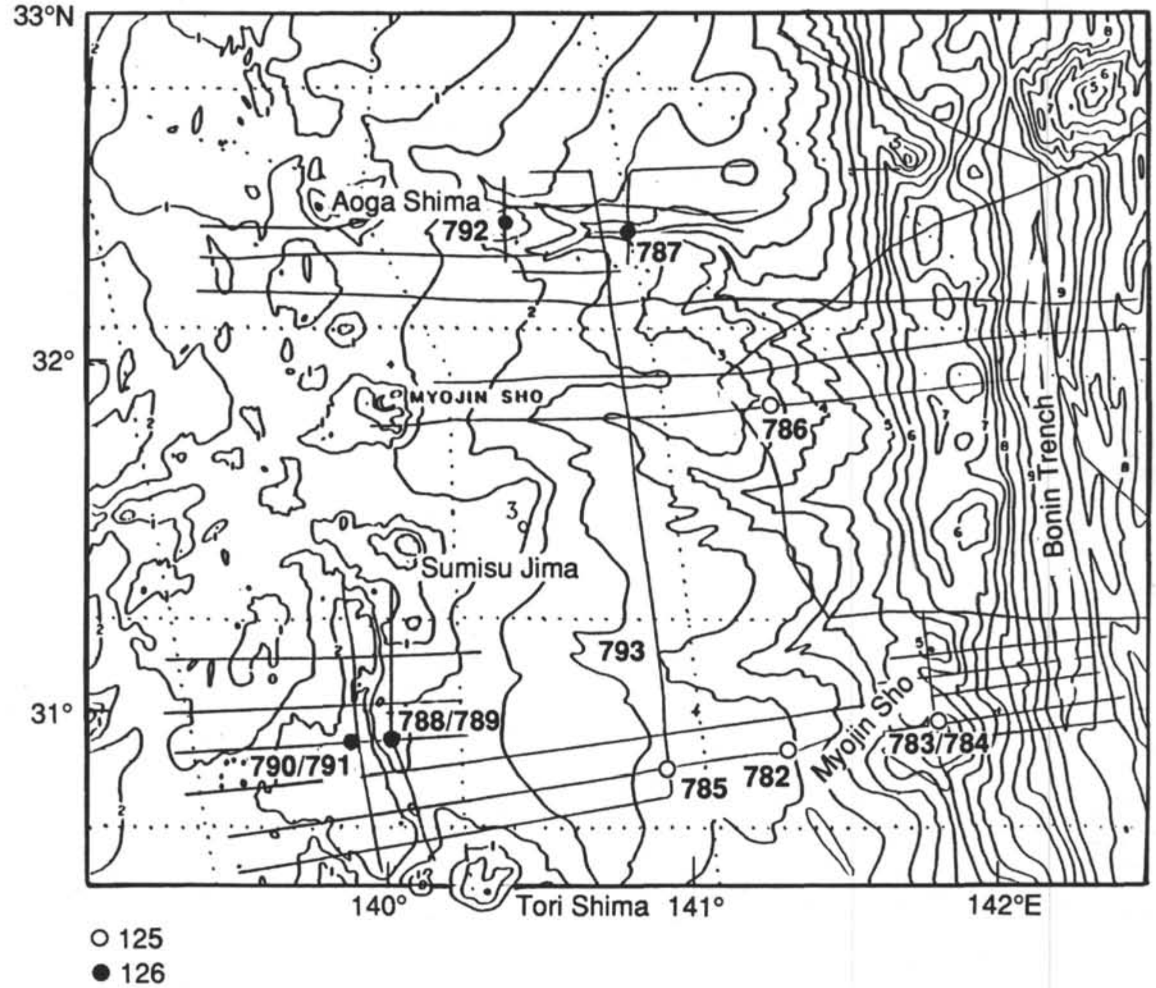


Figure 2. Location map showing multichannel seismic (MCS) survey lines and precise setting of Leg 126 sites (filled circles) and Leg 125 sites (open circles). Bathymetry in meters.

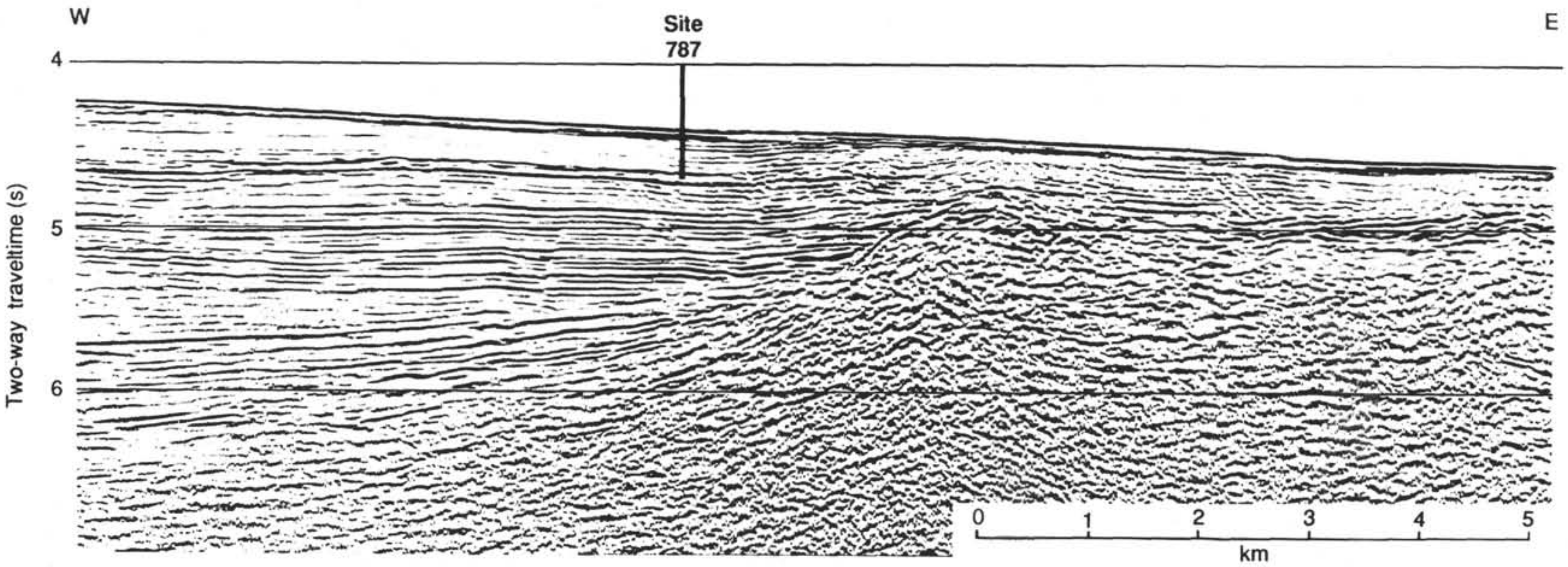


Figure 3a. Multichannel seismic profiles showing location of forearc Site 787: *Fred Moore* 3505, line 2, 0710 UTC. Dark vertical lines represent approximate depth of cored interval relative to the profile.

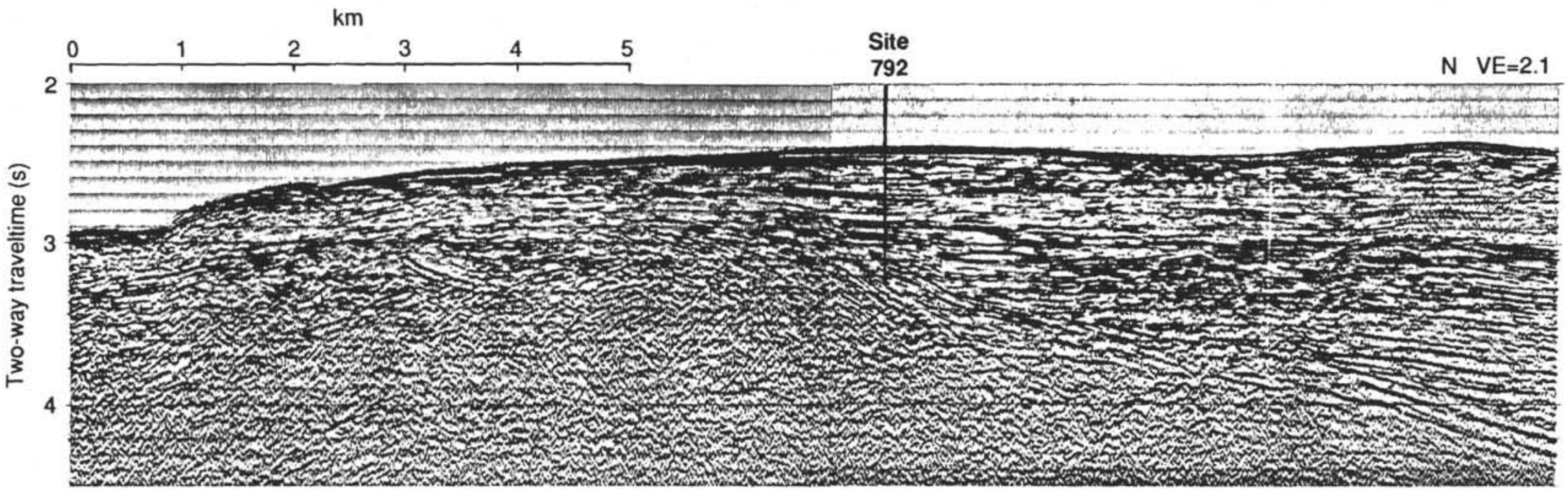


Figure 3b. Multichannel seismic profiles showing location of forearc Site 792: *Fred Moore* 3505, line 10, 0134 UTC. Dark vertical lines represent approximate depth of cored interval relative to the profile.

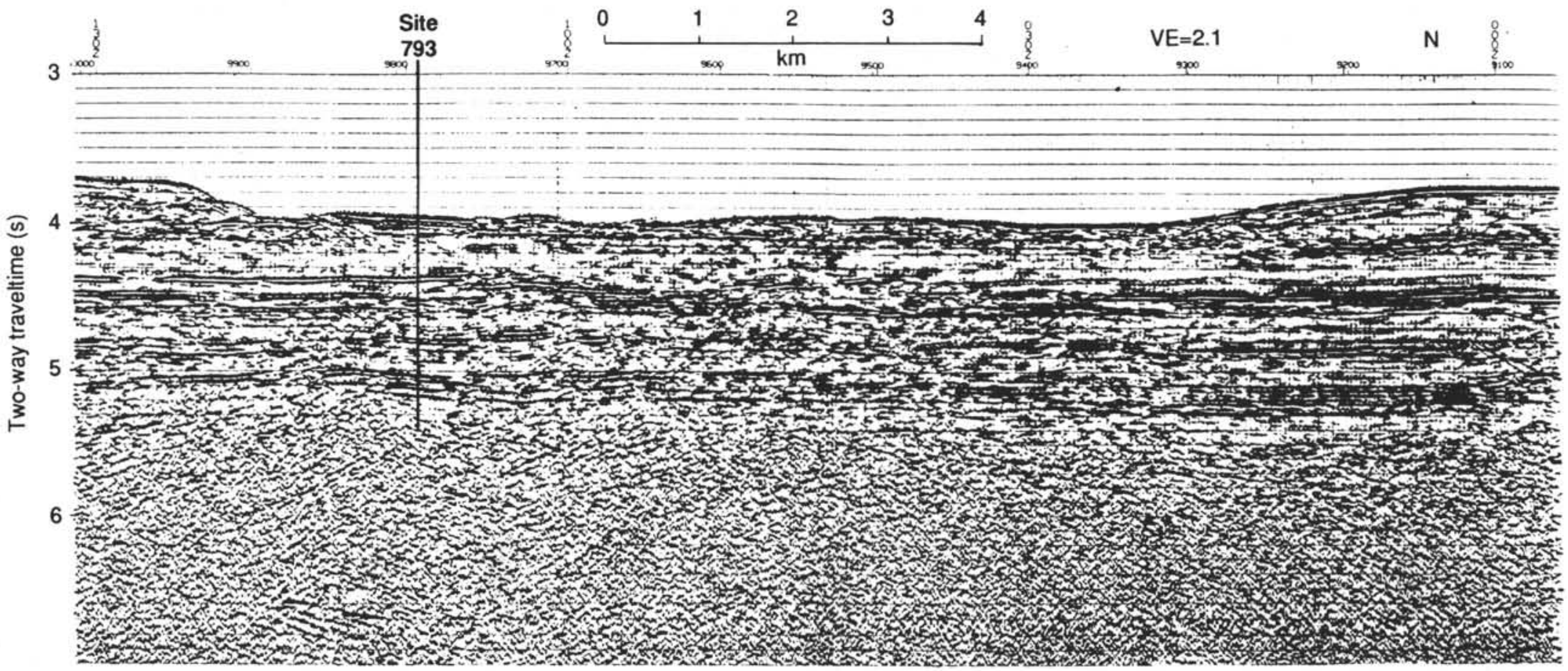


Figure 3c. Multichannel seismic profiles showing location of forearc Site 793: *Fred Moore* 3505, line 12, 0109:30 UTC. Dark vertical lines represent approximate depth of cored interval relative to the profile.

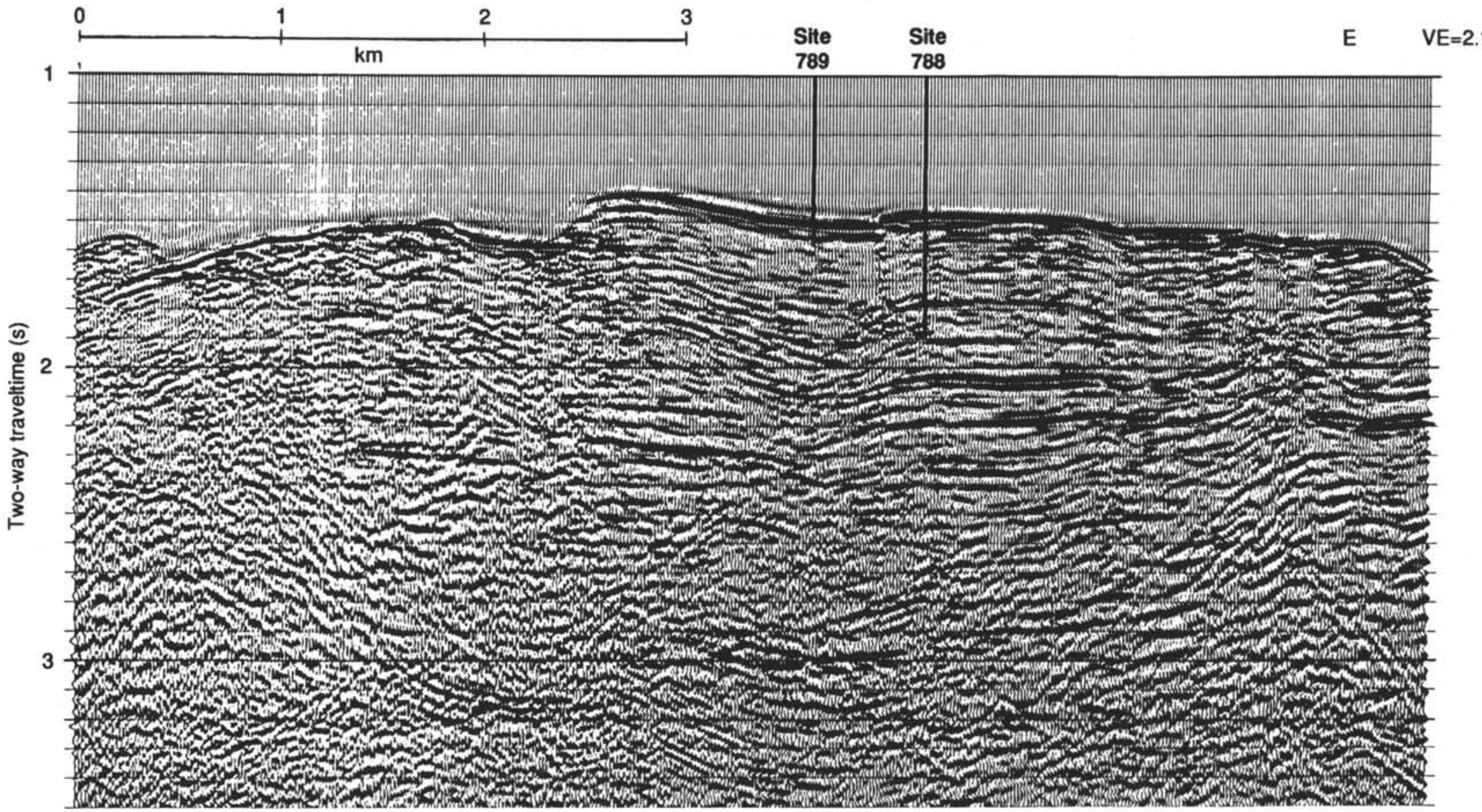


Figure 4a. Multichannel seismic profiles showing location of arc/backarc Sites 788 and 789: *Fred Moore* 3507, line 4, 2138 UTC (788) and 2133 UTC (789).

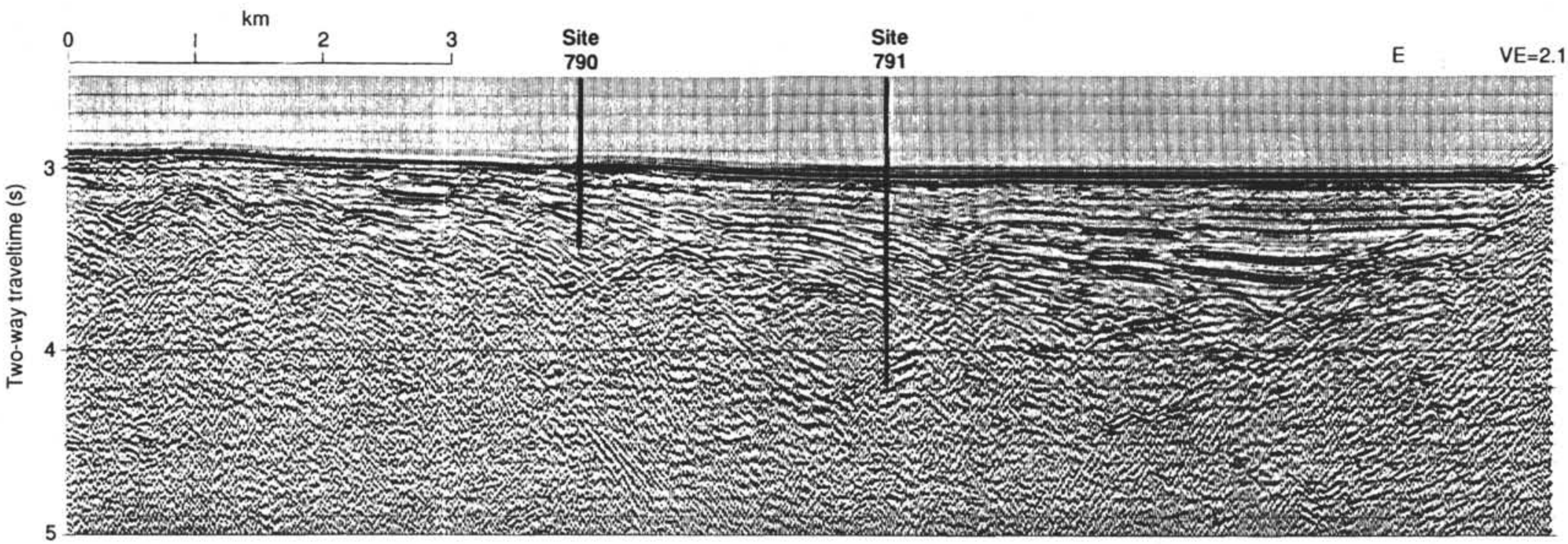


Figure 4b. Multichannel seismic profiles showing location of arc/backarc Sites 790 and 791: *Fred Moore* 3507, line 4, 1933 UTC (790) and 1953 UTC (791).

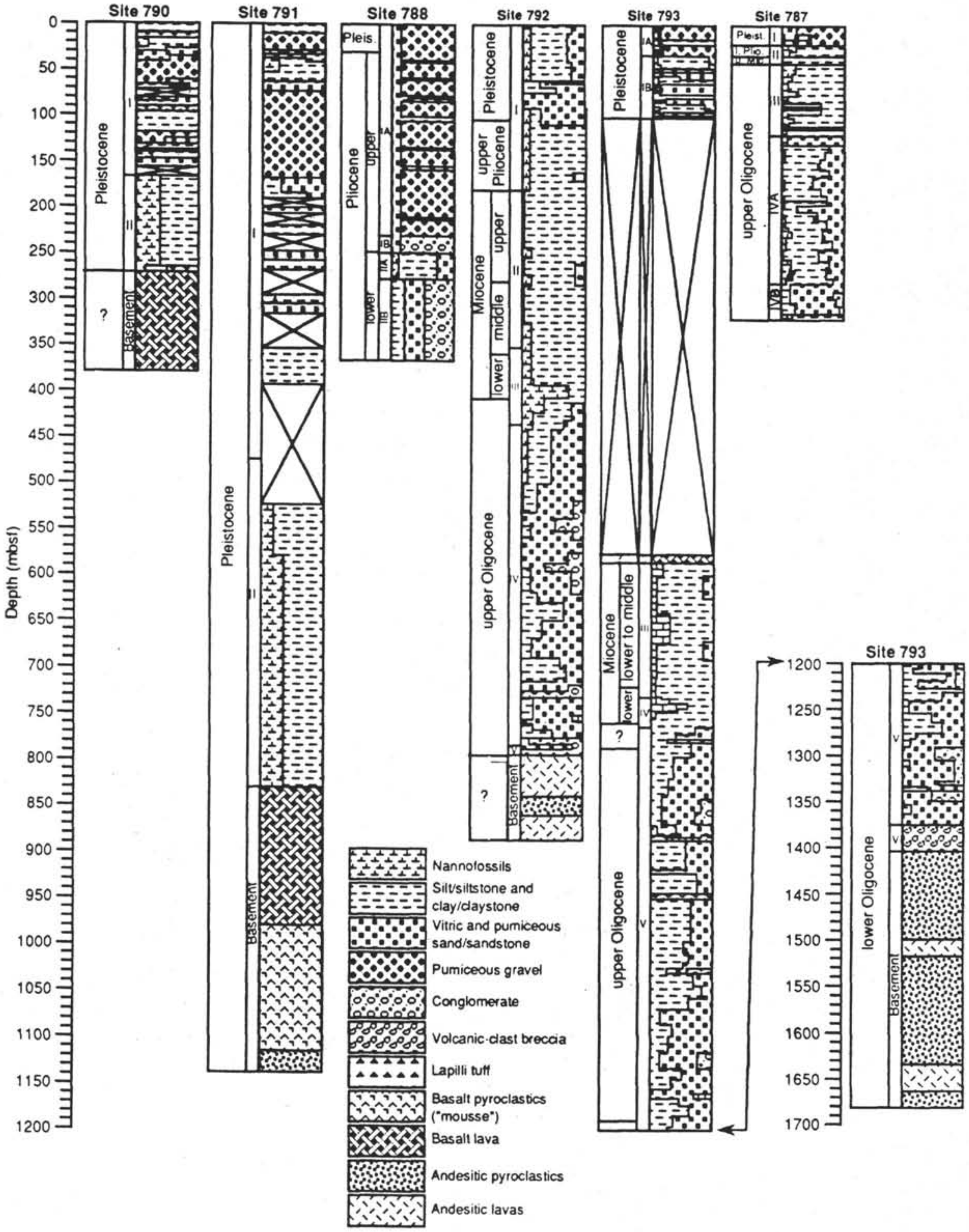


Figure 5. Summary lithostratigraphic columns for Leg 126 sites.

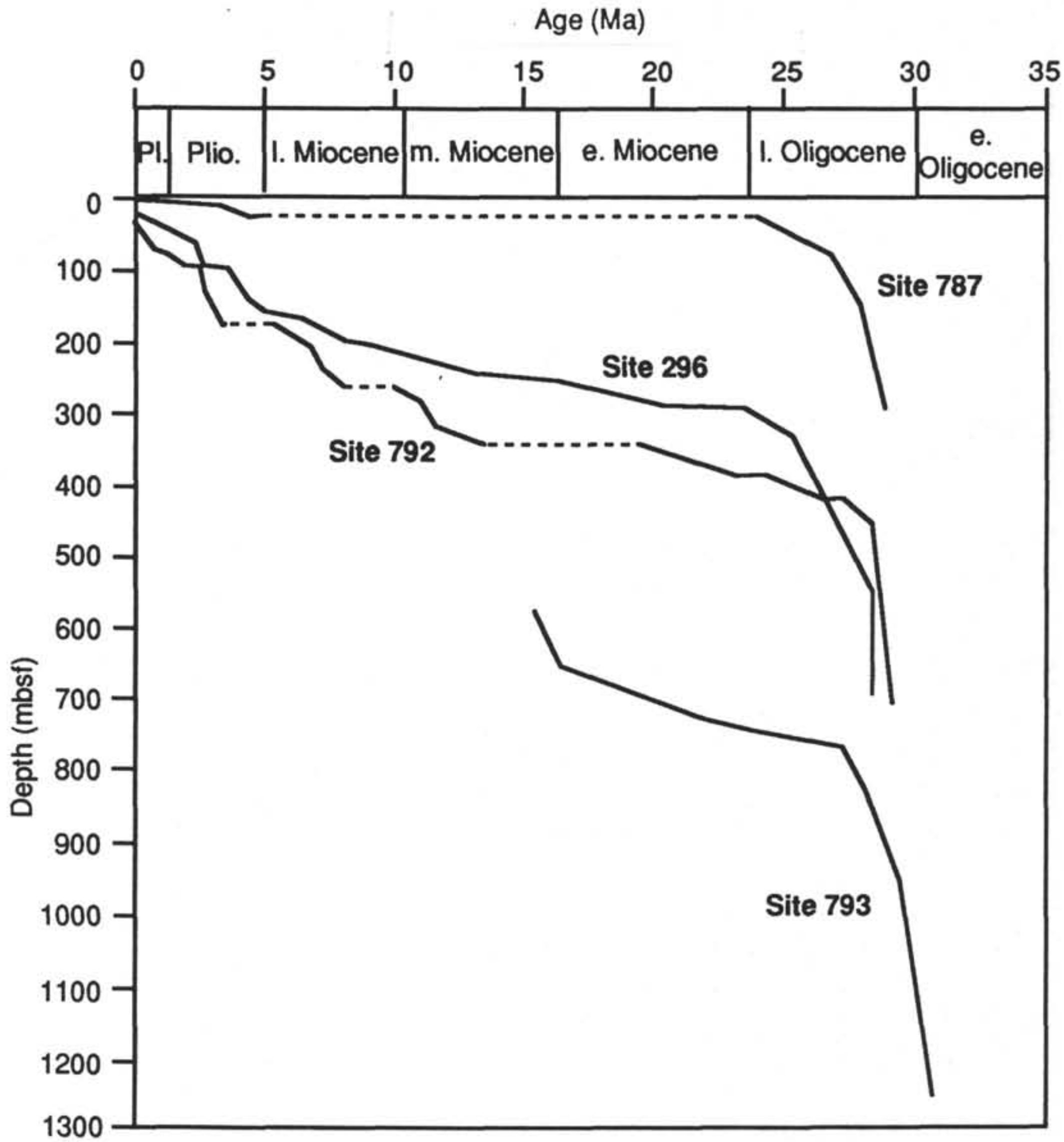


Figure 6a. Age-depth curves for forearc Sites 787, 792, and 793, and DSDP Site 296 (Karig, Ingle, et al., 1975). Dashed lines indicate stratigraphic unconformities.

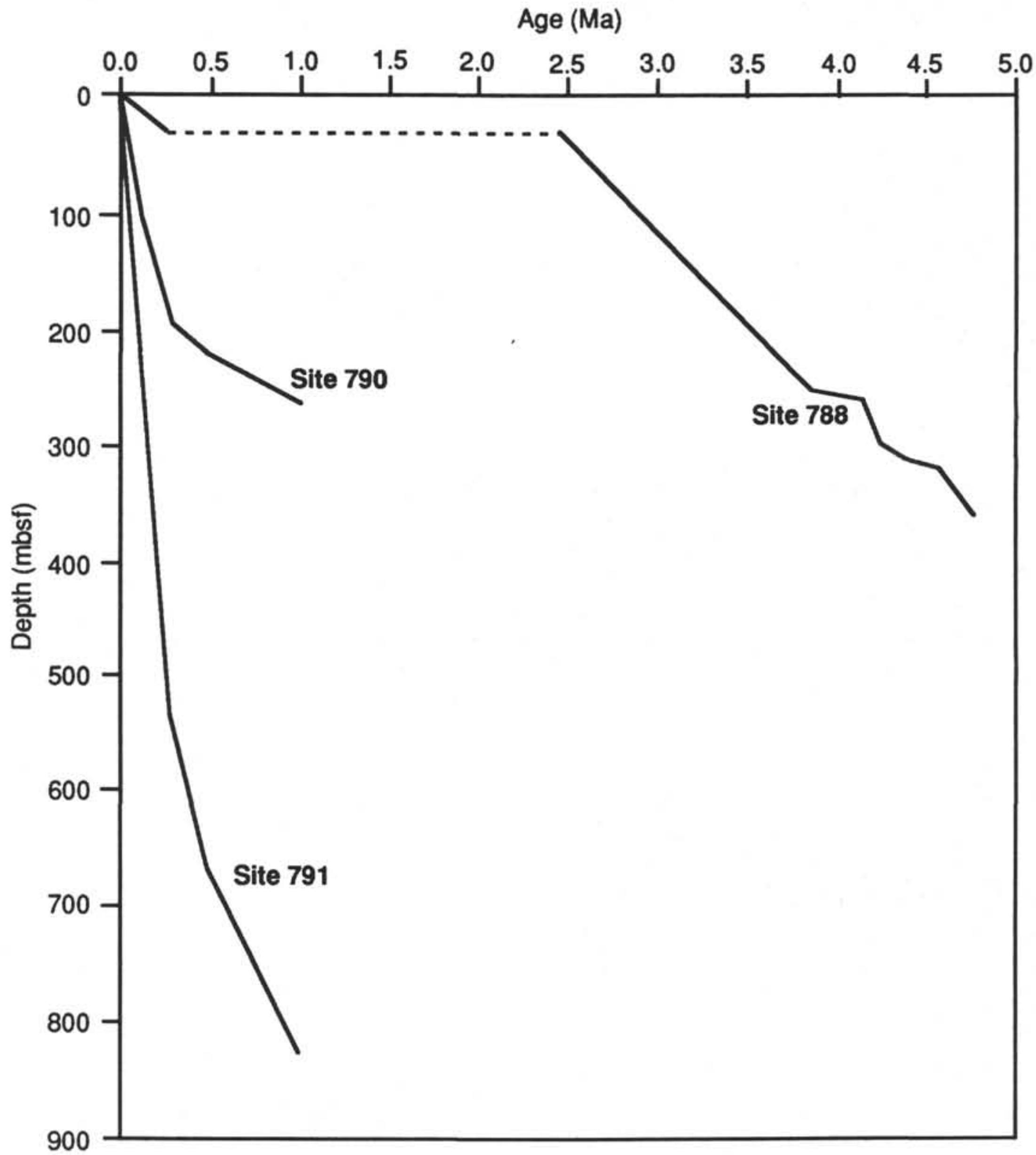


Figure 6b. Age-depth curves for arc/backarc Sites 788, 790, and 791. Dashed lines indicate stratigraphic unconformities.

OPERATIONS REPORT

The ODP Operations and Engineering personnel aboard JOIDES Resolution for Leg 126 were:

Operations Superintendent	Ron Grout
Operations Superintendent	Dave Huey
Schlumberger Engineer	Steve Diana

TOKYO TO SITE 787

JOIDES Resolution departed Tokyo at 1700 hr on 22 April 1989 and steamed toward Site 787. Selection of the first site was based on the need to first occupy the site in the deepest water so that the new TV coaxial cable could be paid out to maximum depth, allowing it to de-torque prior to its first use in conjunction with the drill pipe. Thus, proposed site BON-5C was selected and the ship proceeded directly to that site. Whether or not to perform the pre-site survey and drop the beacon at the site prior to the cable de-torquing exercise depended on the availability of a Global Positioning System (GPS) window, or adequate Loran navigation coverage. GPS was not up but the Loran fixes appeared to be accurate so the pre-site survey was conducted in a normal fashion. One north-south pass was made over the site, followed by an east-west pass where the beacon was dropped. One beacon, poised over the side ready for release on command, broke free without weights and was lost. A backup beacon was readied in just 6 min and released just before the ship left the acceptable drop zone.

SITE 787

The second beacon was deployed at 2010 hr on 23 April, initiating Site 787. The seismic survey line was continued for 5 nmi, then the gear was pulled. As the ship returned over the beacon and the thrusters were lowered, heavy seas dislodged several large parts of a reentry cone assembly lying loose on the main deck. These plate steel brackets moved across the deck and landed partially on an exposed section of the TV coaxial cable that had been strung out in preparation for the de-torquing run. The damage to the cable made its water-tight integrity suspect so the de-torquing exercise was postponed.

Hole 787A

The potential target depth for the site was as great as 1400 mbsf, which was expected to require more than one bit to reach. One of the possible scenarios for attacking the site was the emplacement of a full reentry cone and casing installation. Accordingly, Hole 787A was a jet-in test to determine the depth for jetting in 16-in. casing with a full-size reentry cone.

The anticipated seafloor conditions suggested lithified sediments at or near the surface with interlayered volcaniclastic materials and claystones below. The rotary coring system (RCB) was deemed best for the type of formation expected, and a standard nine drill collar bottom-hole assembly (BHA) with a hydraulic bit release was put together and run to the seafloor. The precision depth recorder (PDR) indicated a very firm reflector at the seafloor in 3272.0 m of water.

The seafloor proved to be more suitable for jetting than anticipated. The hole was spudded at 1300 hr on 24 April and the bit was successfully jetted in to a sub-bottom depth of 34.5 mbsf, based on apparent mud-line contact at 3265.0 mbsl. At that point firmer material was encountered. The bit was pulled clear of the seafloor at 1455 hr and the core barrel used for the jet-in test was retrieved. Unexpectedly, 6.00 m of volcanic gravel had been trapped in the core barrel. Scientific interest in the material was high so the core was designated a wash barrel and the jet-in hole became Hole 787A.

Hole 787B

The ship was offset 20 m northeast and Hole 787B was spudded at 1647 hr. RCB coring in unconsolidated gravel at the seafloor was unexpectedly successful and the first three cores averaged 3.74 m recovery using minimum circulation, pipe rotation, and weight on bit. Five RCB cores followed in a zone of apparently firm but loose sand or gravel where recovery was almost impossible. Despite this ominous start the conditions for rotary coring improved dramatically at that point and the next 22 cores (126-787B-9R to -30R) were very good in terms of percentage and quality of core recovered. The formation contained just enough claystone and clay-bearing sediment to stabilize the hole and, most likely, "made its own mud" so that the loose material near the surface did not cause fill or pipe-sticking problems. Several well-preserved rock-over-claystone contacts were recovered, indicating unusually favorable conditions not usually encountered in interbedded RCB coring.

The good drilling conditions ended abruptly after the hole encountered a zone of unconsolidated black sandstone at about 282 mbsf. The hole was deepened to 320.1 mbsf, with recovery averaging 2.2 m per core in the last four cores. The low recovery suggested a highly unstable zone, but hole conditions were quasi-stable until the sinker bars were being stabbed into the top drive swivel to retrieve Core 126-787B-34R. At that point severe backflow indicated the probability of hole collapse. Once the sinker bars were in and the wireline blowout preventer could be closed, the bit was found to be plugged. The core barrel was stuck at the bit, suggesting flow-in of loose material around the core barrel at the bit. By the time the core barrel was retrieved to the deck the pipe was stuck firmly. Although circulation was regained, the pipe could not be worked free and after 3-1/2 hr of continuous overpull the decision was made to sever the pipe and abandon the hole.

The first 31-pellet high-energy engineering (HEE) severing charge was fired in 5-1/2-in. transition joints at the top of the BHA, but the charge was a partial dud and the pipe did not come free. The second charge was fired 10 m below the mud line in case the first charge had been unsuccessful because it had been applied below the free point of the drill string. The second shot was successful and the pipe came free with minimum pull. The pipe was then pulled and the severed joint reached the deck at noon on 27 April.

SITE 787 TO SITE 788

Before departing Site 787 the TV umbilical cable de-torquing procedure was conducted. A dead weight consisting of 1.5 joints of downgraded 5-in. pipe, simulating the vibrationisolated television (VIT) frame, was attached to the TV cable and lowered to 3000 mbsl. Although the new cable looked bad and spooled poorly, it was serviceable for the remainder of the leg.

The ship departed the site at 2100 hr on 27 April and arrived at Site 788 with a routine beacon drop at 0930 hr on 28 April.

SITE 788

The beacon drop was not as well located as desired so the ship was offset 100 m from the beacon location along bearing 060° to place the hole as far as possible from a suspected fault. The PDR water depth was 1112 mbsl. A new RCB BHA was put together and run to the seafloor.

Hole 788A

The pipe was lowered slowly and contact with a very firm mud line was felt at 1655 hr in 1111 m of water. No penetration was possible without slight drill-pipe rotation, so a jet-in test was impossible. The material near the surface of the formation behaved like loose sand and this suspicion was increased by the fact that four of the first five core barrels were empty. After recovery of only 1.23 m of loose granular material in the upper 45 m of penetration, the site was declared undrillable. The hole was abandoned and pipe cleared the seafloor at 2215 hr on 28 April.

Hole 788B

The ship moved to a new location 100 m due north of the beacon to try another spud, in the hope of finding at least some sediment or cohesive material. The results again were disappointing. Virtually identical circumstances prevailed and four cores were taken without any recovery in a formation assumed to be loose sand. After penetrating 35.6 mbsf the hole began to exhibit signs of caving in and some overpull was necessary to free the pipe, clear the seafloor, and terminate the site. The hole was abandoned at 0320 hr on 29 April.

SITE 789

Hole 789A

The ship was offset to the location of an apparent shallow sediment pond where conditions at the seafloor might allow for some sediment recovery and better hole stability. The move was beyond beacon range, so a separate beacon was dropped and a new site designated. The hole was spudded at 0505 hr on 29 April in 1128.5 m of water. Six RCB cores were taken with only traces of recovery. After experiencing a 50,000-lb overpull to lift the pipe at a sub-bottom depth of only 54 mbsf, the hole was declared undrillable and abandoned. The string was pulled and the bit was on deck at 1300 hr on 29 April.

SITE 790

The vessel made the quick transit from Site 789 to Site 790 in 3 hr and dropped a beacon at 1556 hr on 29 April.

Hole 790A

Since the seafloor sediments were assumed to be soft enough for piston coring, an APC/XCB BHA was made up and run to the seafloor. It included a lockable float valve (to allow logging through the bit if desired) and a nonmagnetic drill collar (to allow magnetic orientation of the piston cores). The mud-line APC core was taken in 2223 m water depth at 2300 hr on 29 April. Four APC cores were recovered. While Core 126-790A-4H was being retrieved a lighted buoy and several smaller floats from nearby fishing vessels were observed floating in the water on both sides of the ship. If the floats were attached to nets or long fishing lines they were close enough to represent a hazard to the dynamic positioning thrusters. As a precautionary measure the thrusters were shut down and retracted. Since station-keeping ability could not be guaranteed, the drill string was pulled clear of the seafloor until the fishing-float problem could be solved. The bit cleared the seafloor at 0155 hr, 30 April, ending Hole 790A.

Hole 790B

The fishing vessels responsible for the floats and long lines eventually came by to collect their wayward equipment and were seen pulling the lines aboard close to *JOIDES Resolution*. The boats appeared to be Taiwanese but the crewmen would not communicate with personnel on the drillship. While pulling in their lines they apparently had one snagged under the drillship in the vicinity of the drill pipe. They seemed to have cut that line and then departed, leaving the potential problem of lines fouled around the drill string. Since lines in the water could not be seen in the darkness hours, the thrusters could not be lowered safely. Without positive station keeping, drilling could not proceed so the time was spent pulling the drill bit to the deck to check for fishing lines or nets. Nothing was found so the BHA was again run to the seafloor to continue coring. During the pipe trip the ship was offset 20 m north.

The short coring sequence completed in Hole 790A was repeated with a 3.3-m vertical overlap between the two holes. Eleven APC cores were recovered successfully despite the sandy nature of the formation, which often frustrates piston coring attempts. An unsuccessful pore-water/heat-flow sample run was attempted after Core 126-790B-5H was cut.

Following Core 126-790B-11H, a 55,000-lb overpull in a sticky clay interval dictated a change to the XCB coring system. The switch was apparently too soon, however, because the next four XCB cores netted a total of only 0.8 m of loose, sandy material. Before more coring could be accomplished a serious ground fault in the power cables to the top drive was discovered. Since the problem appeared to be one that would require many hours to fix, the hole was terminated and the bit was pulled above the seafloor at 1115 hr on 1 May.

Hole 790C

After the 20.5 hr necessary to repair shorted umbilical lines to the top drive, coring operations were continued. Hole 790C was spudded at 0110 hr on 2 May and the bit was washed without coring to 85 mbsf, where piston coring resumed. This time the overpull through the sticky zone at 90-100 mbsf was tolerable (<30 Kpsi) and APC coring was extended to Core 126-790C-8H at 155.2 mbsf. During most of this sequence the APC did not achieve full stroke in the sand/silt-dominated sediment and the high recovery rate observed was probably due to flow-in. The change was made to XCB coring at Core 126-790C-9X and proceeded with fine results through Core 126-790C-20X at 271 mbsf. At that point a new lithologic unit was encountered that resisted all attempts to recover by XCB coring methods. Traces of material trapped in the recesses of core catchers indicated that the missing sediment was very loose sand or gravel. Lack of recovery continued to frustrate efforts until Core 126-790C-31X was cut at 367 mbsf.

While running in with the sand line to retrieve Core 126-790C-31X, the bit plugged. The core barrel was found to be stuck also, undoubtedly by sand packed around the cutting shoe and bit throat. To remedy the stuck core barrel situation the drill string was pulled until the bit was out of the gravel/sand zone at 261 mbsf. At that point circulation was again achieved, and an extensive mud treatment was pumped through the system to stabilize the hole and wash away the material jamming the core barrel. Mud did the trick and the core barrel was retrieved on the next sand-line run.

The pipe was washed back to total depth through 44 m of fill that had collected when the hole partially caved in, and XCB coring resumed. Three more cores were cut but with negligible recovery in a formation consisting of pebbly gravels. At each connection and when attempting to insert the sinker bar assembly severe backflow was observed. The implication was that the hole annulus was heavily laden with sand and/or cuttings. When backflow did not decrease when the core barrels were out of the string it was assumed that the float valve at the bit was jammed open and, therefore, unable to prevent ingress of sand. Repeated temporary bit plugs were experienced after each backflow. The hole was terminated at 387.1 mbsf when the backflow was deemed to be too great a hazard to personnel and downhole equipment.

Before the pipe was pulled completely out the hole, the possibility of logging the lower unrecovered interval was evaluated by doing a short trip up 100 m and back down. The short trip took less than an hour but the hole was already filled with more than 30 m of sand. The possibility of getting a logging tool into the unstable zone was considered remote and logging plans were abandoned. The pipe was pulled out of the hole and the bit reached the deck at 0715 hr on 4 May.

SITE 790 TO SITE 791

Although the plan had been to run the drill string back to the bottom at Site 790 for coring Hole 790D with the RCB system, a change of heart occurred when geophysical interpretation determined that the site had been located too far from the sediment structure originally targeted. The site was abandoned and the vessel made a short transit to a more likely location 1.2 min of longitude east of Site 790. The move was beyond beacon offset range so a new beacon was dropped at 1038 hr and Site 791 was begun.

Hole 791A

An APC/XCB BHA was run to the seafloor. It included the nonmagnetic drill collar to enable oriented piston coring. A prototype set of Hydrolex mechanical jars was included and an extra stand of drill collars was added above the jars for hammer weight if needed. The mud-line APC coring attempt encountered unexpectedly firm material at the surface (2279 mbsl) and did not bleed off the shoot-off pressure, indicating that the core barrel was not able to extend to its full length. Since the roller cone bit and drill string were hanging some 5 m above the seafloor, the column-loaded piston corer barrel was unsupported and consequently it buckled. The bent barrel would not at first pull back into the drill string when the attempt was made to retrieve it with the sand line. The stuck barrel was dislodged after a few minutes of hammering with the sand-line link jars. On deck it was found that the lower 15-ft core-barrel section had broken off from the upper section. The upper barrel was bent beyond reuse. The cutting shoe, core catchers, and the core itself were lost.

Rather than risk another buckled core barrel with a mud-line shot, the next core was taken at the normal location for the second core in the sequence with the BHA buried 4.5 m. The results were good and piston coring continued for a total of 23 cores to a depth of 207.9 mbsf. Ninety minutes of working a tight hole at a depth of 168 mbsf was required when the hole sloughed in around the BHA. The formation penetrated in the APC sequence was dominated by sand and pebbly gravel. The coring results were unusual for APC performance in sands, with recovery averaging 82% and over half the shots registering full stroke of the core barrel. Recovery figures in the cases of partial stroke were clearly augmented by flow-in. Poor penetration finally dictated APC refusal and the change was made to the XCB.

Recovery in the XCB sequence (Cores 126-791A-24X through -49X) was poor, as the material continued to be dominated by vitric silt and sand that were virtually impossible to coax into the core barrel. No combination of drilling parameters or core barrel mechanical adjustments could be found to improve the results. Seventeen of the 26 XCB cores contained less than 1 cm of recovered material. Penetration rates were quick and a cautious pace in advancing the drill string did not improve core recovery but probably helped to keep unstable material from collapsing around the drill string. Liberal gel mud sweeps were used after each second core in an attempt to hold off erosion of the hole walls.

The hole was ended abruptly when the rope socket on top of the sinker barrel assembly backed off, leaving the sinker bars and core barrel in the pipe. An attempt was made to wireline fish for the sinker bars using a taper tap but the tap broke off after engaging the fish. The drill string was pulled and the core barrel wash removed on deck. Hole 791A ended when the bit reached the deck at 1645 hr on 6 May.

Hole 791B

With the basement objective and firmer lithology expected to appear only a little deeper than the total depth of Hole 791A, the RCB was chosen for Hole 791B. A 12-drill-collar BHA was assembled, including the Hydrolex jars, which passed inspection on deck between holes. The hole was spudded at 0140 hr on 7 May and drilled using a center bit to 173 mbsf. Some tight hole conditions were experienced at that point, requiring 45 min of remedial hole conditioning. Center bit drilling continued to 230 mbsf, where the first spot core was attempted but with no recovery. The pipe was washed down to 250 mbsf where the pipe became stuck while making a connection. The new jars were used to hammer the BHA free. A single 40,000 lb up-jar was enough to loosen the pipe. The wash interval ended at 416 mbsf where routine RCB coring commenced.

Cores 126-791B-4R to -8R were overlaps of the bottom of the XCB coring interval at Hole 791A. The recovery was virtually zero over this zone but picked up slightly as the hole deepened and some clay layers were encountered. In an attempt to retrieve Core 126-79B-19R the sinker bar assembly came apart at the 3-lug quick release. The Q/R was fished successfully with another wireline run and coring continued without further difficulties.

Relatively normal RCB coring conditions and results prevailed through Core 126-791B-46R as a series of interbedded units of claystone, silt, and chalk was recovered. At 834 mbsf a hard streak was detected by the driller and basalt breccia was recovered in the core barrel (126-791B-47R). Core recovery dropped off dramatically as a basal zone of gravel and pumice material was penetrated. Hole stability in the basal zone was also significantly poorer than in the clays above but not enough to prohibit advancing the drill string. As at Hole 791A, liberal amounts of gel mud were applied throughout coring.

At about 1100 mbsf the formation turned to hard rock, and penetration rates fell off to the range of 2-5 m/hr. Coring operations were continued to 1145.0 mbsf where the scientific objectives were deemed satisfied. The final core was cut short by 2 m when a sudden increase in torque with the bit on the bottom indicated possible bit failure. Further attempts to determine bit health were curtailed so that the bit could be saved for an extensive wiper trip to condition the hole for logging.

The hole was displaced several times with both sweep mud and seawater before a wiper trip was begun to the logging depth (121 mbsf) and back to total depth. Greater than normal care was taken during the wiper trip in an attempt to prepare a potentially unstable formation for open-hole logging runs. The top drive was engaged to ream a tight section from 165 to 336 mbsf. The bit was then lowered without rotation through a 548-m interval of open hole without encountering any bridges or detectable obstructions. At 261 m above the former total depth (884 mbsf) a solid bridge was found and the top drive was again picked up. This spot was just above a probable gauge-sized pinch spot immediately overlying the basal zone. After the top drive was picked up, the pipe was found to be stuck and the annulus packed off, apparently around the lower drill collars. The Hydrolex jars again were used to free the pipe by applying 60,000-lb up-jars. With the pipe free to move the bit was pulled up to 826 mbsf to regain circulation. The hole was swept with high-viscosity mud, and the process of drilling out the fill/bridge began.

Before the redrilling process could proceed the annulus apparently packed off again, as standpipe pressure increased dramatically. Neither rotation nor circulation was lost but the pipe was free to move vertically only about 4 m before becoming stuck in both up and down directions. With free bit rotation it was not possible to apply left hand torque to cock the Hydrolex jars. It could not even be determined if the upper stuck point was above or below the jars. Within the hour rotation and the limited amount of vertical movement were both lost as the hole apparently began to slough faster. After 3 hr of pulling and attempting to rotate the pipe without any success it became evident that the pipe would not come free.

Before severing the drill pipe a geochemical log was run through the pipe. In order to get the logging tools (and later the severing charges) into the drill string at the rig floor the pipe had to be broken out. The only available connection was at the bottom of the 20-ft knobby drilling joint below the top drive. Even to reach this connection required placing 160,000 lb of (apparent) weight on bit as the drill string was lowered to the elevators. Neither the iron roughneck nor tongs could reach the top of the 20-ft drilling joint to break the upper connection. The ship's welder used a cutting torch to sever the saver sub between the drilling joint and the stem of the top drive. The drilling joint was removed and the top drive set back.

The geochemical tools (NGT/ACT/GST/TEMP) were rigged and run into the pipe until encountering an "obstruction" in the pipe apparently 203 m above the bit. (Later log analysis and inventory of the pipe in the rackers revealed that a 203-m pipe tally error had occurred during the down-going portion of the wiper trip. The "obstruction" in the pipe was actually the bit itself.) As the logging tools would not go any deeper, the logging run commenced. Data were acquired solely on the uphole run of the combination tool, at a speed of 450 ft/hr (137 m/hr), starting at a depth of 811.67 mbsf.

After logging, one more optimistic attempt was made to free the stuck pipe by picking up the top drive and circulating while attempting to rotate, pull free, and activate the drilling jars. All the efforts were fruitless and the severing charges were rigged. In the hope of saving the experimental and much-needed Hydrolex jars, the first severing shot was intended to be fired in the drill collars just below the jars. The severing charges, of course, were stopped by the mysterious "obstruction" since the pipe tally error still had not been discovered. The 84-pellet HEE severing charge was triggered at the "obstruction" point but did not fire owing to a flooded firing assembly.

A second severing charge was rigged, run to the "obstruction" point, and fired. The pipe was still stuck after the severing charge was removed. It was assumed that the shot had been fired near the top of the BHA (rather than near the bit as it actually was), so the depth for the next severing attempt had to be chosen near the assumed seafloor in order to guarantee that the pipe would be freed on the next attempt. A charge was run in the pipe and detonated at a point 46 mbsf and the pipe was freed. The remains of the drill string were recovered with the stub arriving on deck at 2245 hr on 13 May.

RETURN TO SITE 788

The original attempts to core at Site 788 had been with the RCB coring system. Recovery after four to five cores in very loose sand and gravel had been essentially nil and the site was declared uncoreable since it was thought that the APC would do poorly in the incompressible vitric material. Surprising success with piston coring in similar material at Sites 790 and 791 demonstrated that the APC was a viable coring approach after all. Armed with this new knowledge, the vessel returned in dynamic-positioning mode to the still-active beacon at Site 788 to APC core Hole 788C.

Hole 788C

A six-collar APC/XCB BHA was assembled with a 10-1/2-in., 5-cone bit. The pipe was run to the seafloor. The hole was spudded with the first shot taken from a point 4 m below the mud line to avoid any chance of repeating the buckled core barrel problem experienced at 791A. The piston coring results were successful and continued until Core 126-788C-26H was cut at a depth of 248.2 mbsf. APC refusal was defined by lack of penetration in apparently firm granular material. The XCB coring system was then applied for two core attempts but problems ensued. During the piston coring sequence sand or cuttings had infiltrated the BHA and plugged off the five 14/32-in. bit nozzles. Because of the obstruction the flow to the bit was then channeled entirely into the cutting-shoe flow path on the XCB. Core 126-788C-27X was a misrun when the cutting-shoe inner flow sleeve collapsed completely owing to the high nozzle pressures and blocked the throat of the core barrel. Core 126-788C-28X was attempted at very low flow rates in an attempt to reduce the nozzle back pressure. The low flow and unstable formation combined to allow the hole to collapse in the vicinity of the BHA and the pipe became stuck. Repeated overpulls of 260,000 lb freed the string after about 30 min. With the bit nozzles plugged and the hole deteriorating the only choice was to pull out of the hole. The bit was on deck at 0315 hr, 15 May, ending Hole 788C.

Hole 788D

In the final XCB core of Hole 788C (cut short by hole collapse and stuck pipe), a sample of material representing a significant change in lithology was recovered. This, plus the possibility of still more lithologic alternations nearby, meant that the scientific goals of the hole were not quite accomplished. An RCB BHA was made up and run back to the seafloor. Hole 788D was spudded at 0935 hr on 15 May and drilled with a center bit to 219.6 mbsf. Sixteen RCB cores were taken, and the hole was terminated at 374 mbsf. Recovery was poor but adequate to satisfy the first-order scientific objectives. The hole was abandoned and the bit was on deck after the pipe trip at 1230 hr on 16 May.

SITE 788 TO SITE 792

JOIDES Resolution departed Site 788 at full speed for Site 792 at 1230 hr on 16 May and arrived in the vicinity of the new site at 2115 hr the same day. After a 4-1/2-hr survey, the first beacon was deployed at 0136 hr on 17 May. Within 30 min, this beacon exhibited erratic pulse time behavior, and a second unit was launched.

SITE 792

Hole 792A

A standard 6-collar APC/XCB BHA with a nonmagnetic drill collar was lowered to just above the mud line and the first APC core was shot at 0630 hr on 17 May. Although the retrieved core was 9.7 m long, it was used to establish mud-line depth at 1797.8 mbsl. After the fifth piston core, a Uyeda heat-flow experiment was conducted and piston coring resumed. Another heat flow experiment was conducted after Core 126-792A-10H was cut. Recovery for the 10 cores averaged 76%.

The eleventh piston core was shot at 95.1 mbsf, and extraction of the core barrel from the formation resisted all efforts until an overpull of 170,000 lb was applied. The piston rod severed at the rod connection and the inner core barrel and 5 m of piston rod remained in the hole. The remnants of the APC prevented further coring efforts, so the BHA was short-tripped above the mud line. The BHA cleared the mud line, officially terminating Hole 792A, at 1725 hr on 17 May.

Hole 792B

The ship was offset 20 m farther south of the beacon and Hole 792B was spudded at 1825 hr on 17 May. The mud-line core established the seafloor at 1789.2 mbsl. The drill string was then washed to 50 mbsf where a second piston core was shot, followed by a heat-flow experiment. The third and last piston core was shot at 59.6 mbsf. The APC core barrel was retracted and XCB coring was initiated at 78.8 mbsf. Cores 126-792B-4X through -10X were obtained, averaging less than 80% recovery. When Core 126-792B-11X was tripped to the surface, it was discovered that the cutting shoe had broken off.

Since the fractured shoe in the hole could destroy the rotary cones if coring were continued, the hole was terminated and the BHA tripped out. The BHA cleared the seafloor at 0810 hr, ending Hole 792B.

Hole 792C

Once again the vessel was offset 20 m farther south of the beacon. The bit "felt" the sea floor at 1798.2 mbsl and the hole was washed down to 1935 mbsl, where another XCB attempt was made. The cutting shoe failed again, in the same manner as at Hole 792B. At this point it was decided that the two cutting-shoe failures may have been caused by a defect in the fabrication of the lot of cutting shoes. A CMP diamond impregnated 3-blade cutting shoe was selected for the next attempt. The drill string was short-tripped above the sea floor. The BHA cleared the seafloor at 1745 hr on 18 May, signifying the end of Hole 792C.

Hole 792D

The center bit was run down to the bit and the drill string lowered to the mud line at 1798.2 mbsl. The drill string was washed down to 136 mbsf and another attempt was made to cut core. After coring for some 52 min, the driller noticed that penetration had stopped. The core barrel was retrieved and it was found that the cutting shoe had separated in the same manner as in the previous two incidents. The drill string was tripped out of the hole and the BHA cleared the mud line at 0035 hr on 19 May. The bit was on deck at 0455 hr on 19 May.

Hole 792E

Hole 792E was spudded with a standard 9-collar RCB BHA and drilled to 135.6 mbsf, where rotary coring was initiated. No problems were encountered at the level where the three XCB cutting shoes were fractured. Seventy-eight cores were cut to a depth of 885.9 mbsf over the next 83 hr. After cutting Core 126-792E-78R, a multishot survey was conducted from bottom (885.9 mbsf) up to 60 mbsf at 100-m increments. This survey took about 30 min, during which there was no circulation or drill-pipe rotation. The survey indicated that the hole never exceeded 2.5° from vertical.

After retrieving the survey and just before removing the sinker bars, the formation started to flow into the bit and the hole began to slough in, trapping the BHA. From 1325 hr to 1840 hr on 23 May, a successful (albeit temporary) effort was conducted to save the BHA and the hole. After mud treatment and some minor hole reaming, it was decided to withdraw strategically to logging depth.

The bit was released at 2010 hr. The hole was sticky all the way, and the drill string stuck at 286 mbsf, where overpulls of 230,000 lb were futile. It was decided to start the downhole measurements program.

With the uncertainty of downhole conditions a prime consideration, the first log was a reduced geophysical combination (DIT/LSS/NGT/TEMP) without the density tool. The tool was run at 0745 hr on 24 May to a depth of 877.1 mbsf and returned at 1245 hr. The results of this log were excellent and showed a good match with physical-properties data.

The formation microscanner (FMS/NGT/TEMP) was rigged for its maiden voyage with ODP. The tool was deployed at 1345 hr on 24 May and successfully logged the hole from 285 mbsf to 878.6 mbsf. All conductivity curves were visibly very active and promised to yield first-class images. Both calipers showed that the bore was cylindrical to slightly elliptical with a typical diameter of 10 in. except between 370 and 400 mbsf where the radius exceeded 15 in.

In spite of the rough going while trying to retrieve the drill string, the hole was found to be in excellent shape and the absence of fill suggested that the zone which sloughed in on the pipe was essentially sealed off by the BHA.

The FMS was rigged down at 1745 hr and the geochemical (GST/ACT/NGT/TEMP) logging suite was prepared. Between 1845 hr on 24 May and 0330 on 25 May, the GST logged the borehole through the pipe up to the mud line with excellent results.

Completing the standard suite of logs was a run of the geophysical combination with the density tool (HLDT/LSS/NGT/TEMP), which was run between 0500 and 1100 hr. This last run was marred because the short-spacing density sensor failed downhole. The final log at this site was a vertical seismic profile (VSP), which obtained a high-grade log between 1230 and 2300 hr on 25 May. Apparently as a result of the drill pipe being firmly anchored in the sediment, the ambient noise level of the log was extremely low.

After the logging program was completed, the top drive was put up and a final (unsuccessful) attempt was made to free the stuck pipe. The decision was made to sever the pipe. A 31-pellet severing charge was run in the hole to the first 5-in. pipe above the BHA and detonated successfully. The pipe parted with 150,000 lb of overpull.

The pipe was tripped to the surface and the string cleared the rotary table at 0640 hr, terminating Hole 792E. An unsuccessful attempt was made to recall the commandable beacon. The thrusters and hydrophones were pulled and *JOIDES Resolution* made way at full speed to Site 793 at 0730 hr on 26 May.

SITE 792 TO SITE 793

The transit from Site 792 to Site 793 took 8.6 hr to traverse 82 nmi at an average speed of 9.5 kt. At 1615 hr on 26 May, the first of two beacons was dropped. As the BHA was being made up, the first beacon died and a backup beacon was deployed at 1713 hr.

The drilling program for this site called for coring 1700 mbsf into middle Oligocene-middle Eocene forearc sediments. In order to complete operations within the remaining 22 days, some changes in scientific objectives were needed, and a plan of action was established that included blind drilling, spot coring, and setting a reentry cone with 11-3/4-in. casing.

SITE 793

Hole 793A

Prior to spudding Hole 793A, a jet-in test was conducted to examine the capabilities of the top sediments to support a reentry cone and to determine what length to make the 16-in. casing shoe. At 0235 hr on 27 May, the jet-in test concluded with a final penetration of 22 mbsf.

The bit was lifted off bottom, the ship offset 10 m south, and the first APC core of Hole 793A was shot at 2970 mbsl at 0245 hr on 27 May. The first core established the mud line at 2975.3 mbsl. Orientation of cores commenced with Core 126-793B-6H. The recovery rate for the first 11 cores was 79%.

After Core 125-793A-12H was shot, the core barrel became firmly embedded in the sediment and required 120,000 lb overpull to extract. The excessive overpull was too much for the piston rod connection and it sheared, leaving part of the piston rod and the core barrel in the hole. Since the scientific objectives of this hole were completed, the drill pipe was tripped to the surface and was on deck at 1335 hr on 27 May, terminating Hole 793A.

Hole 793B

As soon as the APC/XCB BHA was laid down, work began on the reentry cone running assembly. The cone was skidded over the center of the moonpool, a commandable beacon permanently attached to the upper lip of the cone, and the 16-in. casing shoe spaced out. The BHA was latched to the reentry cone, and the unit was lowered through the moonpool doors at 1200 hr on 28 May.

There were two short stops on the way to the seafloor to reduce the buoyancy of the drill pipe and at 1833 hr the casing shoe was spudded in. The jet-in procedure was finished and the reentry cone released by 2030 hr.

The drilling phase of this hole began at 2030 hr on 28 May and continued until 1645 hr on 29 May, when a total depth of 586.5 mbsf was attained. The hole was stopped short of the original target depth of 600 mbsf when a formation change at 535 mbsf indicated harder material that was suitable for anchoring the bottom of the casing string. The hole was swept twice and displaced with KCL-treated mud. The top drive was racked and at 2315 hr the drill string began to be pulled out of the hole.

The bit cleared the seafloor at 0110 hr and was on deck at 0700 hr. The casing running tools were made up, and 46 joints (562.66 m) of 11-3/4-in. casing were run to the bottom. When the end of the casing reached a depth corresponding to 9 m above the reentry cone, a 2-hr TV search for the cone was conducted starting at 0300 hr. At 0515 hr, the casing string was stabbed into the reentry cone.

The casing string encountered resistance almost immediately upon entering the 16-in. casing hanger. After mud and was pumped the vessel was repositioned, the casing was fed into the hole. The casing was worked while maintaining circulation to slowly advance down the bore. At 1325 hr, the casing hanger was landed successfully in the reentry cone. The casing was secured with a cement slurry, after which the pipe began its trip to the surface at 2045 hr.

First Reentry

A 6-collar RCB BHA was made up without a bit release. The BHA was run in the hole with the VIT to 2961.5 mbsl. At 1530 hr on 1 June, a TV search for the reentry cone commenced and found its target within 10 min. Reentry occurred at 1550 hr.

At 2015 hr, the tedious process of drilling out the cement plug began and, after cleaning up the rat hole, RCB coring commenced at 0830 hr on 2 June at a depth of 586.5 mbsf. The first core taken in Hole 793B took 115 min to cut 8.2 m of sediment, which corresponded to a rate of penetration (ROP) of 4 m/hr. It turned out that the casing had been anchored in a basement-hard sill of a type that would not be seen again until 1300 mbsf. This zone ended with Core 126-793B-1R. The remaining cores for the day took ~40 m/hr to penetrate the sediment. By the end of the first day, 114.3 m had been cored with 40% recovery.

By the end of 2 June, the ROP slowed to a more stable level, and recovery improved to 79%. Hole surveys conducted at 1000, 1105, and 1201.5 mbsf found the hole angle at 1° or less from the vertical.

The penetration rate slowly continued to decrease with depth so that by the end of 8 June, the ROP had dropped to 10 m/hr. As the afternoon of 9 June approached, the ROP had slowed to 3.5 m/hr. While there were no visible signs of bit distress, the long rotating time (74 hr), hardness of bottom, the light BHA (only 6 drill collars), and nearly 5 days of site time remaining dictated that a bit change was in order. The progress up to that time had been 836.4 m cored with 73.4% recovery (613.9 m).

Starting at 1830 hr on 9 June, the drill bit was pulled to the surface, arriving on deck at 0330 hr on 10 June. Examination of the bit showed it to be in fair condition, with about 25 inserts missing.

Second Reentry

A 9-collar BHA was made up and the new bit was run in to 2170 mbsl at 0800 hr. The cone was reentered at 1110 hr on 10 June and the drill string was run to bottom. After some hole cleaning, coring operations resumed at 1745 hr on 10 June.

Cores 126-793B-88R through -90R (1442.3-1450.4 mbsf) recovered lower Oligocene volcanic breccia. An increase in pump pressure was observed while pumping down the core barrel for Core 126-793B-90R. This was ascribed initially to a plugged jet, and Core 126-793B-90R was cut and retrieved. Recovery for this core was 5 cm of breccia.

The core barrel for Core 126-793B-91R was pumped down with the slightly higher pressure still in evidence. When this core was retrieved with no recovery, it was assumed that the abnormally higher pressure problem was more likely an obstruction in the core throat or a partially jammed flapper. A core barrel with a "deplugger" was pumped down and the pump pressure monitored for a drop to normal operating pressure. A couple of taps with the wireline jars were needed to unseat the deplugger, which was then tripped to the surface. There was no drop in pressure.

A center bit was dropped in the hope that this would clear the obstruction. Still the pressure remained high. The center bit was tripped out and the deplugger run in for a second time, this time with success. The pressure dropped, the deplugger was withdrawn, and a standard core barrel was run.

Normal coring operations resumed at 1045 hr on 11 June with Core 126-793B-92R, which yielded 4 m of volcanic breccia. The average ROP for the day was 4 m/hr. Surveys were run at Cores 126-793B-96R and -106R and found the hole at 1.75° and 2.0° from vertical, respectively.

Shortly after noon on 14 June, Hole 793B reached total depth at 1682 mbsf and became the deepest hole ever cored into basement under DSDP or ODP operations. The drill string was pulled out of the hole and the bit reached the rotary table at 2200 hr on 14 June.

Third Reentry

The logging BHA was assembled and run in the hole in the early hours of 15 June. The bit reentered the cone at 0714 hr. The first log was a geophysical combination (DIL/LSS/NGT/TEMP), which immediately ran into a bridge at 703.7 mbsf. After attempts to pass this blockage failed, the logging tool was retrieved and the pipe run in to wipe the hole clean.The hole was displaced with seawater and the geophysical combination was run in the hole again at 2030 hr on 15 June. The instrument tagged a bridge at 951.7 mbsf and logged from that point to the end of the pipe, so that ~70% of the open hole was logged. The tool was retrieved, the top drive racked, and the hole washed and reamed to remove the bridges. Subsequent logging indicated that this was not effective in clearing the borehole.

Additional downhole measurement programs at this site were conducted with the formation microscanner (FMS/GR/TEMP), the geochemical combination, and the VSP. Logging was completed in Hole 793B at 1315 hr.

SITE 793 TO TOKYO

JOIDES Resolution was under way for Tokyo by 2130 hr on 17 June. Leg 126 ended officially when the first anchor was dropped in Tokyo harbor at 0700 hr on 19 June, 1989.

OCEAN DRILLING PROGRAM
OPERATIONS RESUME
LEG 126

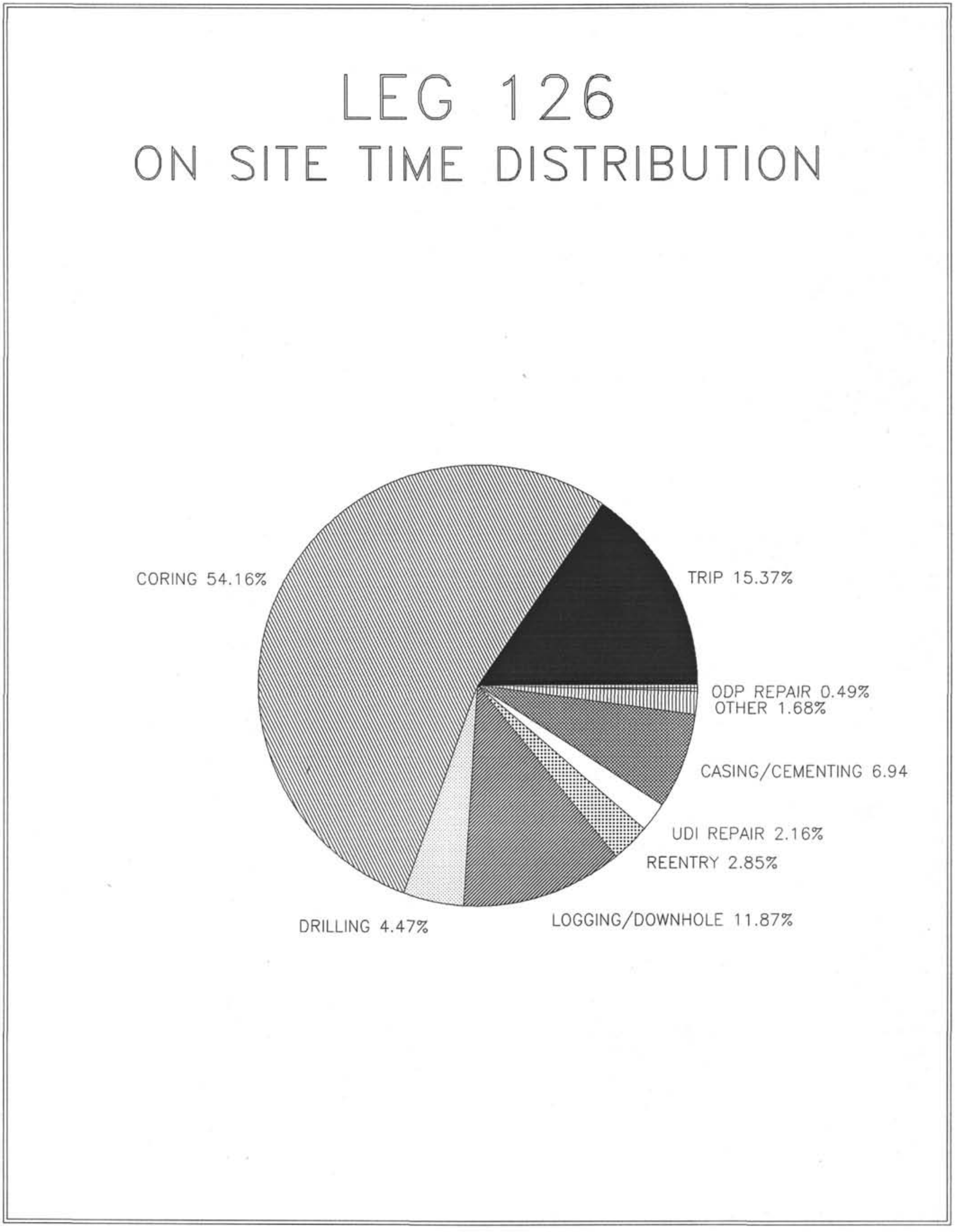
Total Days (18 April - 19 June 1989)	61.97
Total Days in Port	4.38
Total Days Under Way	4.28
Total Days on Site	53.31

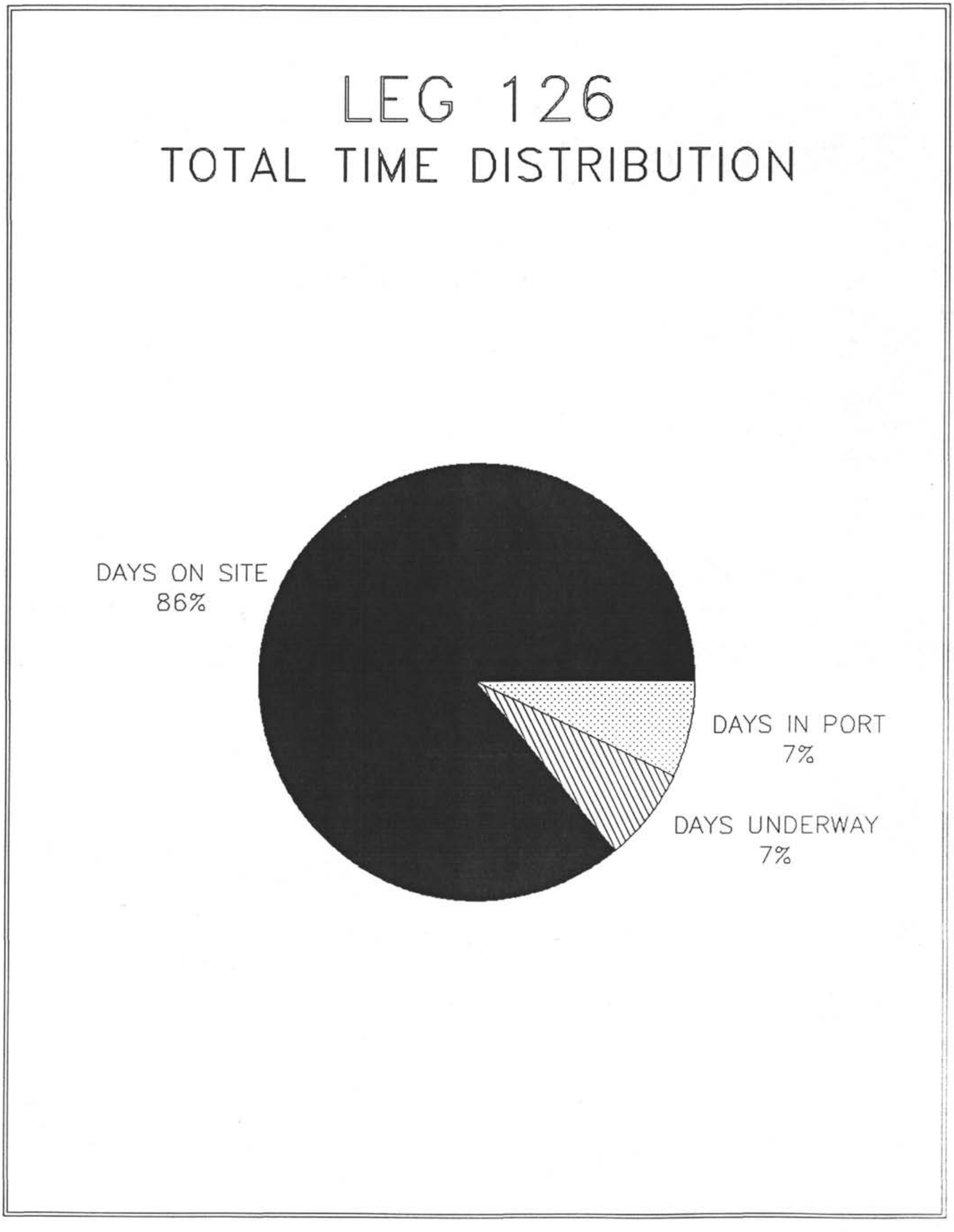
Trip Time	7.77
Coring Time	27.37
Drilling Time	2.26
Logging/Downhole Science Time	6.00
Reentry Time	1.44
Mechanical Repair Time (Contractor)	1.09
Casing and Cementing Time	3.51
Other	0.85
Repair Time (ODP)	0.25

Total Distance Traveled (nautical miles)	779.00
Average Speed (knots)	8.53
Number of Sites	7
Number of Holes	19
Total Interval Cored (m)	4736.50
Total Core Recovery (m)	2127.41
Percent Core Recovered	44.92
Total Interval Drilled (m)	1756.80
Total Penetration (m)	6493.30
Maximum Penetration (m)	1682.00
Maximum Water Depth (m from drilling datum)	3269.40
Minimum Water Depth (m from drilling datum)	1111.00

OCEAN DRILLING PROGRAM
SITE SUMMARY REPORT
LEG 126

HOLE	LATITUDE	LONGITUDE	DEPTH METERS	NUMBER OF CORES	METERS CORED	METERS RECOVERED	PERCENT RECOVERED	METERS DRILLED	TOTAL PENETRATION	TIME ON HOLE	TIME ON SITE
787A	32-22.50N	140-44.64E	3265.0	1	34.5	6.0	17.4	0.0	34.5	18.75	
787B	32-22.50N	140-44.64E	3269.4	34	320.1	159.9	50.0	0.0	320.1	69.00	87.75
788A	30-55.35N	140-00.27E	1111.0	5	45.3	1.2	2.6	0.0	45.3	12.75	
788B	30-55.38N	140-00.17E	1113.0	4	35.6	0.0	0.0	0.0	35.6	5.00	
788C	30-55.36N	140-00.21E	1113.0	28	258.5	146.2	56.6	4.0	262.5	26.00	
788D	30-55.37N	140-00.22E	1113.0	16	154.4	12.3	8.0	219.6	374.0	33.25	77.00
789A	30-55.24N	139-59.84E	1128.5	6	54.1	0.1	0.2	0.0	54.1	8.75	8.75
790A	30-54.95N	139-50.66E	2232.7	4	37.4	35.7	95.5	0.0	37.4	14.50	
790B	30-54.96N	139-50.66E	2234.0	15	138.9	88.7	63.9	0.0	138.9	28.75	
790C	30-54.95N	139-50.69E	2234.0	33	302.1	127.3	42.1	85.0	387.1	68.00	111.25
791A	30-54.96N	139-52.20E	2279.0	49	457.0	179.9	39.4	0.0	457.0	54.00	
791B	30-54.98N	139-52.19E	2279.0	79	738.2	114.3	15.5	406.8	1145.0	174.00	228.00
792A	32-23.97N	140-22.81E	1797.8	10	95.0	72.1	75.9	0.0	95.0	15.82	
792B	32-23.96N	140-22.81E	1798.2	11	100.7	43.6	43.3	45.7	146.4	14.75	
792C	32-23.94N	140-22.78E	1798.2	1	9.6	0.6	6.3	136.8	146.4	9.58	
792D	32-23.93N	140-22.80E	1798.2	1	9.6	0.8	8.3	136.8	146.4	12.83	
792E	32-23.96N	140-22.79E	1798.2	78	750.3	361.9	48.2	135.6	885.9	163.55	216.53
793A	31-06.35N	140-52.26E	2975.3	11	99.7	79.0	79.2	0.0	99.7	21.33	
793B	31-06.33N	140-53.27E	2975.3	114	1095.5	697.9	63.7	586.5	1682.0	509.34	530.67
	Totals :			500	4736.5	2127.5	44.9%	1756.8	6493.3		1259.95


LEG 126
ON SITE TIME DISTRIBUTION
CORING 54.16%
TRIP 15.37%
ODP REPAIR 0.49%
OTHER 1.68%
CASING/CEMENTING 6.94
UDI REPAIR 2.16%
REENTRY 2.85%
LOGGING/DOWNHOLE 11.87%
DRILLING 4.47%


LEG 126
TOTAL TIME DISTRIBUTION
DAYS ON SITE
86%
DAYS IN PORT
7%
DAYS UNDERWAY
7%

TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard *JOIDES Resolution* for Leg 126 were:

Laboratory Officer:	Brad Julson
Assistant Laboratory Officer:	Wendy Autio
Computer System Manager:	John Eastlund
Curatorial Representative:	Scott Chaffey
Yeoperson:	Dawn Wright
Electronics Technician:	Jim Briggs
Electronics Technician:	Dwight Mossman
Photographer:	Chris Galida
Chemistry Technician:	Valerie Clark
Chemistry Technician:	Joan Perry
Marine Technician:	Joe DeMorett
Marine Technician:	Dave Divins
Marine Technician:	Bettina Domeyer
Marine Technician:	Susan Erb
Marine Technician:	Gus Gustafson
Marine Technician:	Kazushi Kuroki
Marine Technician:	Chris Mato

INTRODUCTION

Leg 126 officially began when *JOIDES Resolution* tied up at Horumi Pier in Tokyo harbor at 0800 on 18 April 1989. During Leg 126 nineteen holes were drilled at nine sites in the Bonin-Mariana region of the western Pacific. A record was set for drilling the deepest hole in ODP history, and another for having the highest amount of drilling time during a leg, 82%. There was a rendezvous at the end of April, bringing to the ship an additional shipboard scientist and a defibulator for the ship's hospital. Leg 126 officially ended in Tokyo at 0600 on 19 June 1989, after 63 days.

PORT CALL

This was *JOIDES Resolution's* first visit to Japan. The ship was well received and helicopters with film crews circled around her as she was guided by tugs toward the dock. More film crews were waiting on the docks, as well as a reception committee from the Port of Tokyo Authority.

All Japanese longshoremen were on strike when we arrived in Tokyo and we were told there was a backlog of over 10,000 containers awaiting clearance. Negotiations were proceeding but we had no idea when or if our shipments would arrive at the dock. Fortunately the strike ended while we were there and almost magically our surface and air shipments arrived not long after the offgoing air and surface shipments were taken off the ship. We offloaded all the Leg 125 cores. Liquid helium arrived the first day to refill the cryogenic magnetometer but complications caused the transfer to take a few days and an additional 100 L of liquid helium. All thermal conductivity needles were calibrated by Dr. Makoto Yamano at the Earthquake Research Institute.

A full public-relations schedule was planned with press conferences and tours of the ship by everyone from VIPs to students and the general public. During part of the first and second days and almost all of the third day, tours of the ship were conducted. Students from the Ocean Research Institute at the University of Tokyo helped lead tours on the third day and many of the Japanese scientists who have sailed with ODP came to help. Most of the ODP technical staff also helped with the tours and those who did not were in the hold unloading, and distributing supplies and stocking labs after the tours finished.

We moved to another pier on the 4th day, where we took on bulk stores (drilling mud). The ship left for sea about 1700 on 22 April.

UNDER WAY

The outer harbor pilot was dropped off after a 3-hr passage through Tokyo harbor. Heavy seas and large swells were encountered as soon as the ship cleared Yokohama Bay.

There were a number of new technicians on this leg. We were surveying the first site less than 24 hr out of port. The first half of the cruise proceeded in a similar manner, with quick holes followed by short transits and quick site surveys. It was not until the second half of the leg that we drilled and logged a deep target.

LAB OPERATIONS

Laboratory Statistics: Leg 126

General Statistics:	
Sites	7
Holes	19
Interval Cored (m)	4736.5
Core Recovered (m)	2127.41
Number of Samples Taken	8880
Samples Analyzed:	
Inorganic Carbon ($CaCO_3$)	958
Total Carbon-CNS	416
Water Chemistry	99
Thin Sections	177
XRF (Minor & Major Elements)	80
XRD	400
Discrete Paleomag Samples	927
Whole-Core Pass-Through Cryomagnetometer	1500
Physical Properties Velocity	950
Index Properties	1046
Thermal Conductivity	332
Vane Shear	168
Underway Geophysics:	
Total Transit (nmi)	778
Bathymetry, Magnetics (nmi)	698
Seismics (nmi)	86
Downhole Tools:	
Heat Flow Runs	6
Heat Flow and Water Sampler Runs	1

Core Lab

The new multi-sensor track (MST) that was installed during Leg124E was used extensively. Several technicians were trained in its use during the port call. The *P*-wave and the GRAPE work best with APC cores and the first few XCB cores because normally these cores completely fill their liners. Programs to modify and concatenate the *P*-wave logger, GRAPE, and susceptibility meter were altered to accept a new header format.

New settings were developed for the Hamilton frame; this produced a good transducer signal and excellent velocity measurements all leg.

With the large amount of hard rock recovered, there was considerable interest in hard rock resistivity and a method was developed to compare laboratory resistivity measurements to downhole logs.

The multishot core orientation tool was used successfully 44 times at 4 different sites.

A new QMS laser printer was set up in the magnetics lab and is operational. A Japanese scientists brought an FAS magnetometer. It combines a spinner magnetometer with a demagnetizer and a susceptibility anisotropy meter, and worked well. He also helped us debug a number of programs. After initial problems filling the cryogenic magnetometer with liquid helium, we had a low boiloff rate and there were still 75 liters in the cryomag at the end of the leg.

Fo'c'sle Deck

Large amounts of igneous, sedimentary, and metamorphic rockswere recovered, and the XRF, thin section, and chemistry labs were exceptionally busy. The thin section lab processed a wide variety of samples from sandstones to pyrovolcanics, using impregnations and etching. The XRF instrument was calibrated and used to run 80 analyses for major and trace elements. The XRD equipment produced analyses of 400 samples.

Pore-water samples contained the highest calcium concentrations encountered in water from non-evaporite areas. Squeezes were continued on core material down to >1000 mbsf. Nearly 1000 carbonate analyses were run for the sedimentologists and the physical properties scientists. Analyses of total carbon, sulfur, and nitrogen contents were performed on over 400 samples. A new procedure was developed to store methods on the integrators, thereby allowing them to be easily reloaded if the memory fails.

Main Deck

The computer users' area ran smoothly all leg. The Macintosh (Mac) computers that were installed on Leg 124E saw heavy use and the scientists were very pleased with Mac plots of their data. The Apple Laserwriter is networked to the three Macs and one of the IBM PCs. It was very popular owing to the quality of its copies and the fact DOS files can be printed from the IBM PC. The VAX LAVc was problem-free; problems we had seen in the past with delays caused by overload on the old system have disappeared with this upgrade. New versions of some existing software were installed. The new chemistry database (CHEMDB) was particularly useful, as it downloads data in lotus files to the VAX to be loaded into the database.

The curatorial representative distributed over 8800 samples of sediment and rock.

Miscellaneous

Development of a multidimensional geophysical plotting program was completed during the cruise. The program plots profiles of various types of data such as total field magnetics, magnetic anomalies, and bathymetry along a track. It can also stack profiles of these along a track. It is compatible with our navigational formats and a program will be sent out next leg that will allow us to input bathymetry data while surveying.

New Loran C navigation equipment that was installed last leg was used during site surveys when global positioning system coverage was unavailable.

A small number of heat flow runs were attempted. They helped define the linear geothermal gradient at Site 792.

Three new pressure cases for the pore-water sampler were received and tested successfully.

A temporary problem with receiving weather maps from the geostationary GMS satellite was fixed and excellent maps were received throughout the leg.

Safety

The technical staff participated in the weekly fire and boat drills. They also viewed safety films. All technicians are now aware of the large volume of safety reference material available in the Laboratory Officer's office.