Fryer, P., Pearce, J. A., Stokking, L. B., et al., 1990
Proceedings of the Ocean Drilling Program, Initial Reports, Vol. 125

15. SUMMARY OF RESULTS FROM LEG 125[1]

Shipboard Scientific Party[2]

ABSTRACT

During Leg 125, nine sites were drilled in the Mariana and Izu-Bonin forearcs to determine the origin and evolution of the forearc terranes and to investigate the dewatering of the subducted lithosphere. Six sites were located on or adjacent to serpentinite seamounts between the outer-arc high and the trench, four (Sites 778–781) at Conical Seamount in the Mariana forearc and two (Sites 783 and 784) on the Torishima Forearc Seamount in the Izu-Bonin forearc. The remaining sites (Sites 782, 785, and 786) were located along the eastern edge of the Izu-Bonin forearc basin. The principal scientific achievements of the leg are (1) the recovery of the first evidence for Pliocene or younger magmatic activity in an extant, intraoceanic forearc terrane; (2) the first deep penetration of the Eocene basement of the outer-arc high to recover over 650 m of boninite flows and hyaloclastite, andesite-dacite flows, breccias, sills, and dikes; (3) the confirmation that some forearc serpentinite seamounts can form at least in part by flows of clast-bearing serpentinite sediments and flows from a central conduit as do mud volcanoes; (4) the discovery of mafic clasts within the serpentinite, which have both island-arc tholeiite and normal mid-ocean ridge basalt affinities and are metamorphosed in the greenschist and prehnite-pumpellyite facies; (5) the confirmation of high-pH, low-chlorinity fluids of probable deep subduction-related origin at shallow levels within the summit of the seamounts; (6) the recovery of hydrocarbon-rich gases of probable subduction-related origin within the Mariana serpentinite seamount; and (7) the identification of numerous ash layers within the forearc basin sediments that indicate peaks of volcanic activity in the Eocene-Oligocene and from the late Miocene to the Holocene.

REGIONAL SETTING

The Izu-Bonin-Mariana region (Fig. 1) is made up of a complex series of arcs and basins formed since the start of westward subduction of Pacific lithosphere during the Eocene. Subduction of Pacific oceanic lithosphere is currently taking place at absolute velocities between 8 and 10 cm per year to the northwest; the subduction angle is about 12° at shallow depths, steepening in some places to nearly vertical below about 100 km.

The evolution of these arc and basin systems is thought to have begun in the early to middle Eocene, when westward subduction of Pacific lithosphere began beneath the western part of the Philippine Sea Plate (Ben-Avraham and Uyeda, 1983; Karig, 1975; Ogawa and Naka, 1984). Development of the system continued through the early Oligocene with the formation of an intraoceanic volcanic arc. Rifting in the middle Oligocene split the entire arc system, and the southern part of the arc split again in the late Miocene.

The Mariana and Izu-Bonin forearcs differ in terms of both their tectonic evolution and plate-convergence characteristics. The northern half of the Izu-Bonin forearc has experienced relatively little deformation since subduction began (Honza and Tamaki, 1985) and is made up of a broad forearc basin filled with volcaniclastic and hemipelagic sediments that developed behind an outer-arc high (Fig. 2). The structure of the Mariana forearc is similar (Fig. 3), but the forearc has undergone extensive vertical uplift and subsidence resulting from seamount collision and from tensional and rotational fracturing associated with adjustments to plate subduction and to changes in the configuration of the arc (Fryer et al., 1985b). The serpentinite seamounts occurring in a broad zone along the trench-slope break (outer-arc high) of the Mariana system are suggested to have formed by some type of diapirism (Bloomer, 1983; Fryer et al., 1985a; Fryer and Fryer, 1987). In the Izu-Bonin forearc, chloritized mafic and serpentinized ultramafic rocks have also been dredged from a chain of local highs located less than 50 km from the trench axis along a lower-slope terrace (Ishii, 1985).

The modern 150– to 220-km-wide Izu-Bonin and Mariana forearcs may have formed by volcanism during arc development in the Eocene and early Oligocene. The origin and evolution of the forearc basement may have progressed in accordance with one of the following scenarios, each of which implies a different crustal structure:

1. The frontal arc and outer-arc high may have been continuous originally and subsequently separated by forearc spreading.
2. The frontal arc and outer-arc high may have been built separately but nearly synchronously on former Philippine Sea Plate crust.
3. The terrane may form part of a continuous Eocene arc volcanic province, possibly with overprints of later forearc volcanism.

The forearc stratigraphy records a history of the variations in intensity and chemistry of arc volcanism, which allows the correlation of these variations with such parameters as subduction rate and backarc spreading. Studies of the tephrachronology, and the frequency and geochemistry of ash and pyroclastic flow deposits in the forearc basin drill cores, will enable the various models of arc volcanism to be evaluated.

DRILLING OBJECTIVES

The principal objective of Leg 125 was to study two important and poorly understood aspects of the Izu-Bonin and Mariana forearc terranes:

[1] Fryer, P., Pearce, J. A., Stokking, L. B., et al., 1990. *Proc. ODP, Init. Repts.,* 125: College Station, TX (Ocean Drilling Program).
[2] Shipboard Scientific Party is as given in the list of participants preceding the contents.

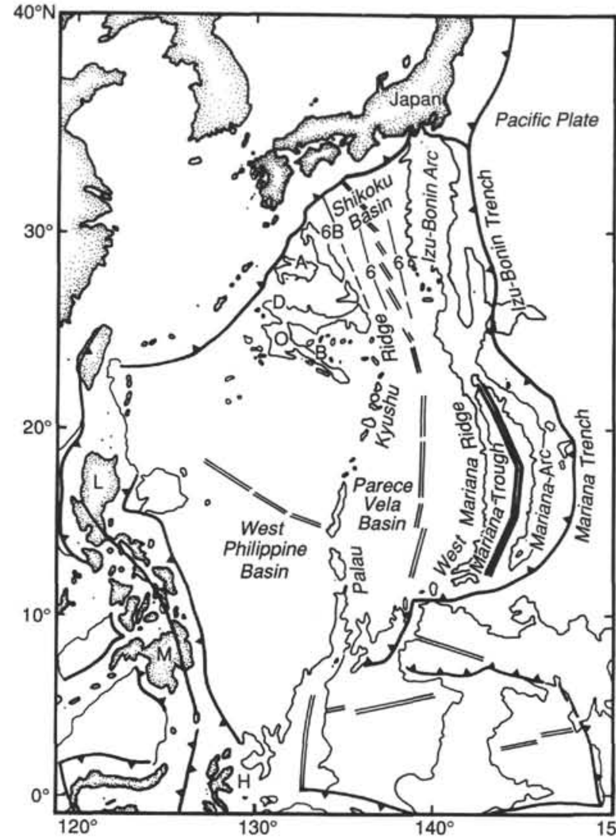


Figure 1. Active plate boundaries and relict spreading centers in the Philippine Sea region. Barbed lines locate subduction zones, medium double lines locate active spreading centers, and thin double lines locate relict spreading centers. Basins and ridges are outlined by the 4-km bathymetric contour,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

1. The origin and evolution of the forearc terranes, investigated by drilling a series of holes through the sediments and into the basement of the Mariana and Izu-Bonin forearc basins (Sites 782, 785, and 786) and into serpentinite seamounts from the Mariana mid-forearc region (Sites 778–781) and Izu-Bonin lower-slope terrace (Sites 783 and 784) (Table 1 and Fig. 4).

2. Dewatering of the subducted lithosphere, investigated indirectly from the composition of forearc basin crust and directly from analyses of fluids, chemical precipitates, and metamorphic rocks from the serpentinite seamounts. The results of these studies were to be compared with those of reference sites drilled on the Pacific Plate near the Mariana and Izu-Bonin trenches.

DRILLING RESULTS

Site 778

Site 778 (19°29.93′N, 146°39.93′E; water depth, 3913.7 m) is situated about halfway up the southern flank of Conical Seamount, a 1500-m-high cone-shaped serpentinite seamount on the outer-arc high of the Mariana forearc basin, about 100 km west of the trench axis. The site is located in the center of a major serpentine flow.

Two lithostratigraphic units are recognized at Site 778 (Fig. 5):

Subunit IA (0–7.2 m below seafloor, or mbsf) of Unit I contains lower to middle Pleistocene to Holocene(?) serpentine-rich sediment and serpentine flows overlying serpentine clay, silt-sized serpentine, and a serpentine-marl breccia.

Subunit IB (7.2–29.8 mbsf) consists of lower to lower to middle Pleistocene sandy marl containing cobbles and pebbles of serpentinite, vesicular volcanic rocks, and a foraminifer-bearing serpentine sandstone.

Unit II (29.8–107.6 mbsf) is made up of phacoidal sheared serpentine. The matrix is composed of serpentine, opaque minerals, epidote-group minerals, chlorite, talc, and olivine. A variety of clasts is present: variably serpentinized tectonized harzburgite (80%), metabasalts (15%), and other fragments including metagabbros, serpentinized dunites, and vein materials such as talc, carbonates, and quartz (5%).

The serpentine flow sequence in Unit II exhibits several structural features, including deformation of primary orthopyroxene, microbrecciation, ductile shearing of clasts, shear zones on all scales, a variably developed foliation parallel to shear-plane orientations, and open-to-isoclinal folding of bedding and foliation planes. These features may represent a combination of primary mantle tectonism, stresses related to intrusion and protrusion (flow emplacement) of the serpentinite diapir materials, and stresses resulting from post-protrusion remobilization.

The original mineralogy of the harzburgite clasts in Unit II was typically 70%–85% olivine, 15%–25% orthopyroxene with 1%–2% clinopyroxene (mainly as exsolution lamellae in orthopyroxene), and spinel.

Analyses of interstitial pore-water samples show a 10% decrease in chlorinity downhole. This decrease is interpreted

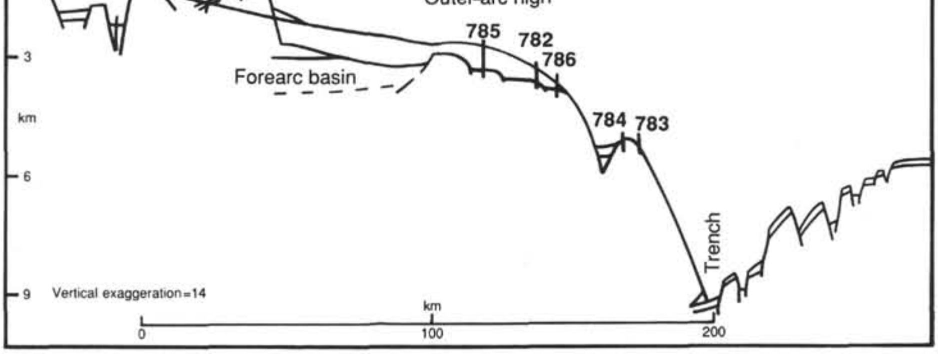


Figure 2. Transect across the Izu-Bonin region showing the location of Leg 125 drill sites.

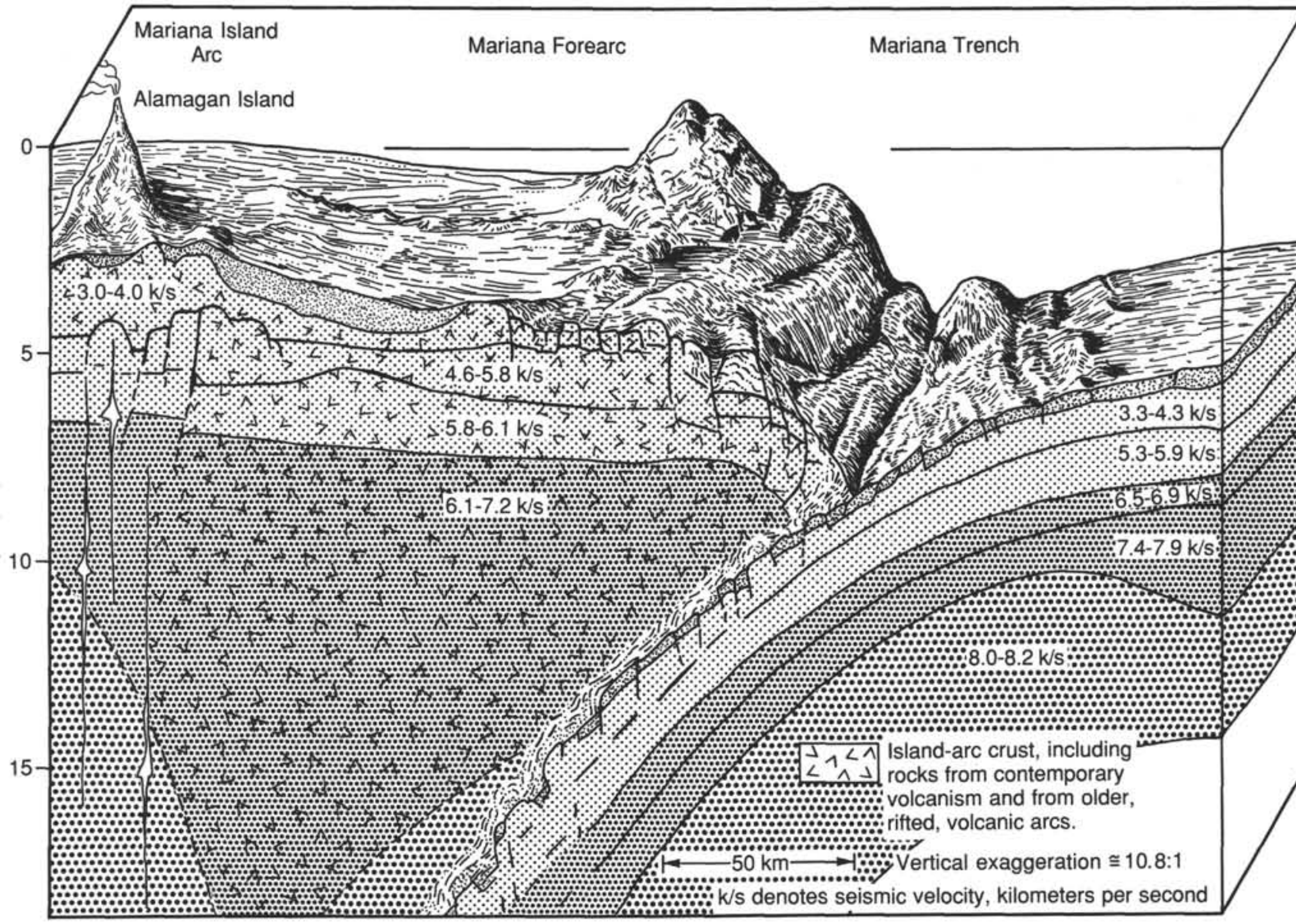


Figure 3. Block diagram representing the Mariana forearc region (after Hussong, Uyeda, et al., 1982).

as a relative decrease in the admixture of seawater with similarly chlorine-poor fluids entrained in the serpentine flow material.

The principal conclusions of Site 778 investigations are as follows:

1. Forearc seamounts can be constructed, at least in part, from serpentine flows emanating from a central conduit.
2. Low- to medium-grade metamorphism characterizes the source region of the serpentinite seamounts.
3. Dehydration of the subducted lithosphere may have played an important role in the serpentinization of the source region of the serpentinite seamounts.
4. The primary mantle material in the seamount is predominantly highly depleted, tectonized harzburgite with subordinate dunite.

Site 779

Site 779 (19°30.75′N, 146°41.75′E; water depth, 3947.2 m), the second site on the flanks of Conical Seamount, is situated

Table 1. Leg 125 site summary.

Hole	Latitude (N)	Longitude (E)	Water depth[a] (m)	Number of cores	Length cored (m)	Length recovered (m)	Recovery (%)	Total penetration (m)
778A	19°29.93′	146°39.93′	3913.7	13	107.6	22.8	21.2	107.6
779A	19°30.75′	146°41.75′	3947.2	37	319.2	73.2	23.1	317.2
779B	19°30.75′	146°41.75′	3947.2	1	9.0	8.7	96.7	9.0
780A	19°32.51′	146°39.27′	3086.8	1	3.5	3.5	100.0	3.5
780B	19°32.47′	146°39.22′	3094.0	2	18.2	10.3	56.6	27.7
780C	19°32.53′	146°39.21′	3083.4	18	163.5	14.4	8.8	163.5
780D	19°32.55′	146°39.20′	3088.9	7	32.4	9.1	28.1	41.8
781A	19°37.91′	146°32.56′	4420.6	27	250.0	39.6	15.8	250.0
782A	30°51.66′	141°18.85′	2958.6	50	476.8	278.3	58.4	476.8
782B	30°51.60′	141°18.84′	2965.9	1	9.6	0.1	1.0	468.9
783A	30°57.86′	141°47.27′	4648.8	18	168.2	47.0	27.9	168.2
784A	30°54.49′	141°44.27′	4900.8	45	425.3	218.3	51.3	425.3
785A	30°49.47′	140°55.17′	2660.8	11	104.7	18.4	17.6	104.7
786A	31°52.48′	141°13.58′	3058.1	19	166.5	85.0	51.1	166.5
786B	31°52.45′	141°13.59′	3071.0	72	666.0	190.1	28.5	828.5

[a] Below mean sea level, corrected from drill-pipe measurements from the rig floor.

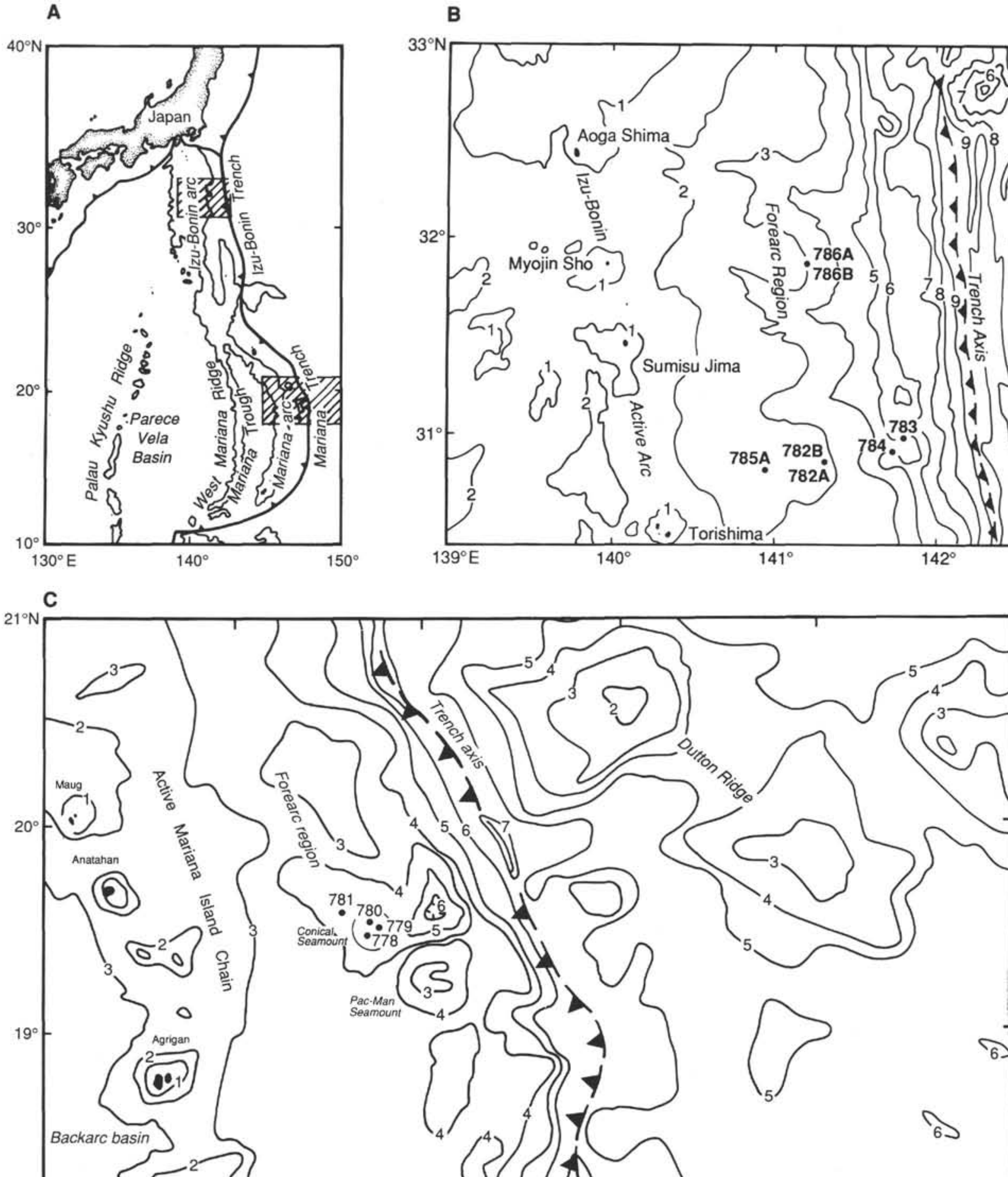


Figure 4. Location maps for Leg 125. Contour interval = 1 km. **A.** The regional setting of the Izu-Bonin and Mariana forearcs. **B.** Izu-Bonin drill Sites 782 through 786. **C.** Mariana drill Sites 778 through 781.

halfway up the southeast flank, about 3.5 km northeast of Site 778.

Three lithostratigraphic units were recovered at Site 779 (Fig. 5):

Unit I (0–10.6 mbsf in Hole 779A and 0–9 mbsf in Hole 779B) consists of lower Pleistocene to Holocene(?) unconsolidated sediments and flows consisting of clay, silt-sized serpentine, and lithic fragments in a matrix of sand- and silt-sized serpentine.

Subunit IIA (10.6–216.2 mbsf) of Unit II is lower Pleistocene sheared serpentine that contains clasts of variably serpentinized harzburgite and dunite.

Subunit IIB (216.2–303.0 mbsf) is upper Miocene to lower Pleistocene sheared serpentine containing clasts of serpenti-

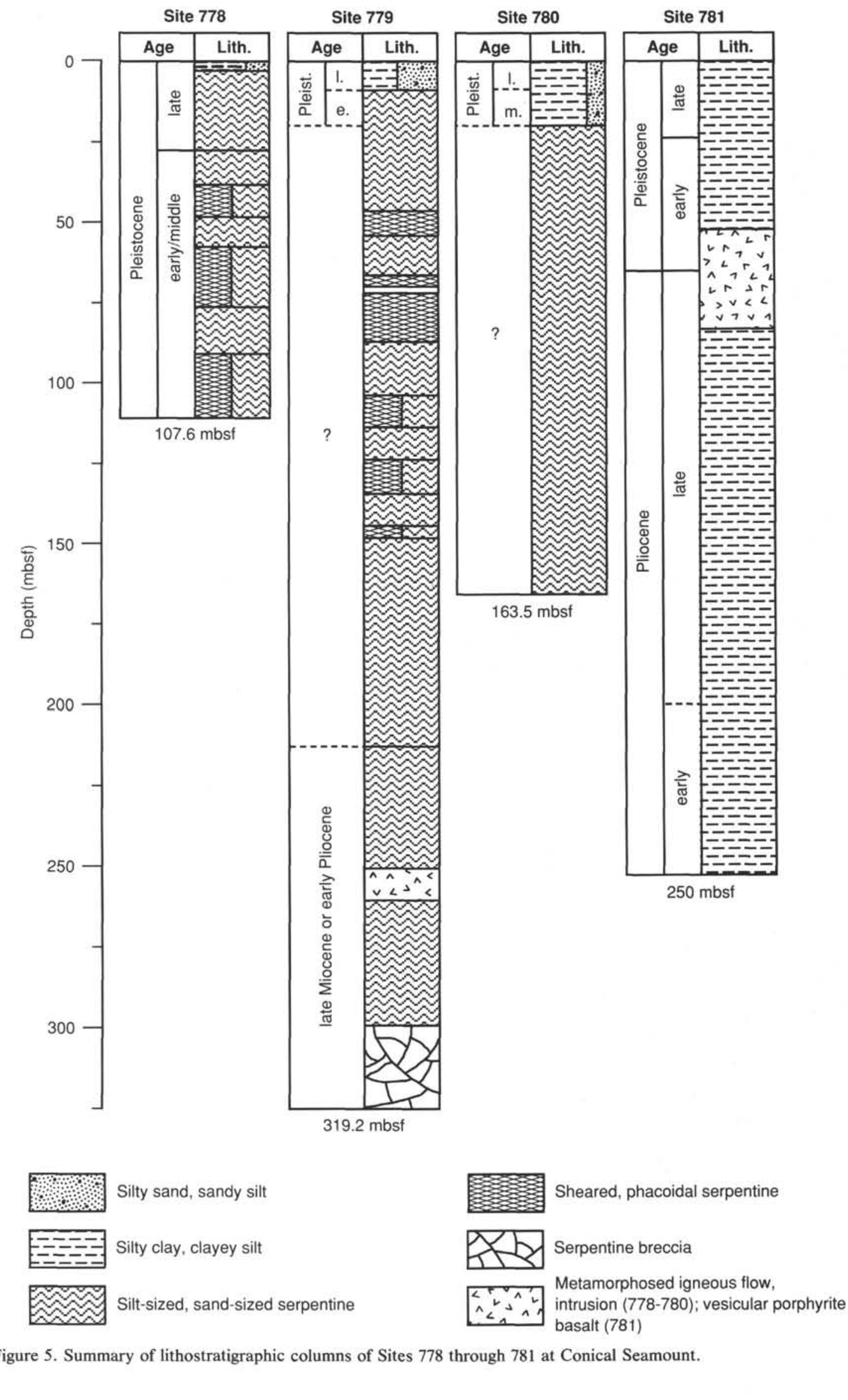


Figure 5. Summary of lithostratigraphic columns of Sites 778 through 781 at Conical Seamount.

nized harzburgite and dunite, as well as gabbro and metabasalt, with intercalations of detrital serpentine sediments.

Unit III (303.0–317.2 mbsf) is a serpentine breccia exhibiting convolute layering.

The serpentine-rich material in Subunit IIB contains recrystallized carbonate minerals, kerogen, and lithified filamentous chains of opaque minerals that may be bacterial remnants. The presence of kerogen indicates a primary sedimentary origin for this material, an interpretation supported by the presence of horizontal bedding and nannofossils within the same unit.

Ultramafic rocks are mostly harzburgite and subordinate dunite, which have primary mineral assemblages similar to those at Hole 778A. The degree of serpentinization varies, but decreases downhole; serpentine veins are common and show a polystage filling history. Mafic clasts are predominantly metabasalt and metagabbro. Common metamorphic minerals are clays, chlorite, pumpellyite, and rare albite and sphene.

Structures in the serpentinite are similar to those of Hole 778A and thus indicate a similar history. The deformation of the matrix is consistent with gentle flowage under an applied load. The average density of the serpentine matrix is 2.01 g/cm^3. The density of the ultramafic clasts decreases with increasing degree of serpentinization and averages 2.55 g/cm^3.

The composition of the interstitial pore-water samples at Site 779 varies from 0 to 100 mbsf: pH increases to a maximum of 11.9; alkalinity increases five-fold; ammonia and sodium show significant but smaller increases; calcium decreases by 80%; salinity and chlorinity both decrease by 10%; and potassium and sulfate show small decreases. Magnesium is totally depleted below 80 mbsf. These results confirm the presence of a fluid other than seawater, possibly from the subducting plate, as proposed for Site 778. Hydrocarbons increase dramatically with depth in Hole 779A, with methane (up to 30% in one gas pocket), ethane, and propane present in most samples.

The principal conclusions from the studies at Site 779 can be summarized as follows:

1. Site 779 provides further evidence for the depleted nature of the mantle wedge beneath Conical Seamount.
2. The construction of Conical Seamount resulted from the flow of unconsolidated serpentine coupled with sedimentary processes.
3. Hydrocarbons are a significant component of the fluids associated with the seamount.
4. The source region of the serpentinite seamount has experienced medium-grade metamorphism.
5. Water derived from the subducted slab may be an important source of fluids involved in the serpentinization of Mariana forearc materials.

Site 780

Site 780 (proposed Site MAR-3A; 19°32.5′N, 146°39.2′E; water depth 3090 m) is situated on the west-southwest side of the summit of Conical Seamount, in an area shown by *Alvin* submersible dives to be sediment-covered and marked by active venting of fluids and precipitation of material from solution.

Two lithostratigraphic units were recovered at Site 780 (Fig. 5):

Unit I (0–3.5 mbsf in Hole 780A, 0–18.2 mbsf in Hole 780B, 0–14.0 mbsf in Hole 780C, and 0–15.4 mbsf in Hole 780D) comprises middle Pleistocene(?) to Holocene(?) sand- and silt-sized serpentine with rare intervals of foraminifer-rich serpentine clay and serpentine-rich silty clay.

Unit II (14.0–163.5 mbsf in Hole 780C and 15.4–32.4 mbsf in Hole 780D) comprises intervals of serpentinized ultramafic rocks in a matrix of sandy silt-sized serpentine sediment.

The sediments in Unit I contain 65%–75% serpentine with minor amounts of opaque minerals, aragonite, and foraminifers. The presence of delicate aragonite needles implies authigenic growth after the serpentine was emplaced. The matrix in Unit II contains 70%–99% serpentine with minor to trace amounts of opaque minerals, clay, zoisite, chlorite, micrite, and garnet.

Serpentinized, tectonized ultramafic rocks and subordinate serpentinized dunites at Site 780 have primary mineral assemblages similar to those from Sites 778 and 779. Serpentine veins are common. The muddy matrix recovered from Site 780 lacks the foliation and shear fabric of the matrix from the flank sites; therefore, the matrix may be interpreted as the primary fabric of the upwelling serpentine, upon which foliation and shear fabric are imposed by compaction, extension, and pure shear during the downhill creep of serpentine flows.

Logging in Hole 780C showed temperatures increasing steadily from seawater values (1.5°C) near the surface to 13.5°C at 60 mbsf; the water sampler-temperature-pressure tool in Hole 780D measured a lower value, 3.15°C at 41 mbsf, and an estimated heat flow of 52 mW/m^2.

The density of the serpentine matrix in Unit II ranges from 1.75 to 2.0 g/cm^3. Rheological measurements indicate that this matrix is a weak, highly nonideal plastic material capable of supporting blocks up to 20 m across and compatible with models for diapiric injection of the serpentinite.

The composition of the interstitial pore-water samples changes significantly downhole: salinity decreases by 25%, chlorinity by 20%, calcium by 90%, magnesium is totally depleted, sulfate nearly doubles, alkalinity increases from 2.5 to 34, pH increases from about 8 to 12.4, potassium increases significantly, and ammonia increases from 0 to 210 mmol/kg. These changes take place within a few meters of the seafloor, showing that the fluid entrained within the serpentinite may mix with seawater only at very shallow levels. The magnitude and direction of these changes also differ from those at the flank sites.

The principal conclusions from the studies at Site 780 can be summarized as follows:

1. Fluids characterized by high pH, high alkalinity, and very low magnesium can exist within a few meters of the seafloor at the summit of Conical Seamount, indicating that mixing between entrained fluids and seawater need not take place at depth.
2. Rheological studies support a model for the origin of the seamount by the diapiric rise of variably serpentinized clasts supported by a low-density, plastic matrix.

Site 781

Site 781 (proposed Site MAR-3C; 19°37.91′N, 146°32.56′E; water depth 4420.6 m) lies on the lowermost flank of Conical Seamount about 7 nmi northwest of its summit.

One lithostratigraphic unit, divided into three subunits, was defined (Fig. 5):

Subunit IA (0–72.32 mbsf) consists of upper Pliocene(?) to Holocene(?) diatom-radiolarian silty clay that grades downward into vitric silty clay and vitric clayey silt.

Subunit IB (72.32–91.80 mbsf) is a massive basalt containing up to 30% phenocrysts and glomerocrysts of plagioclase, olivine, and clinopyroxene in a fine-grained groundmass. The basalt contains 2%–10% vesicles, which increase in abundance and size toward the center of the subunit.

Subunit IC (91.80–250 mbsf) is a lower to upper Pliocene vitric silty clay and vitric clayey silt.

Structures within the sediments of Subunit IA indicate deposition from gravity-driven mass flows. At least 19 turbidite sequences were identified, with thicknesses ranging between 1 and 180 cm and averaging 3–12 cm.

The principal point of interest at Site 781 is the presence of a thick, massive basalt of Pliocene or later age, the first evidence for such recent magmatic activity in any extant intraoceanic forearc terrane. The basalt of Subunit IB is an island-arc tholeiite characterized by enrichment in large-ion-lithophile elements relative to high-field-strength elements. This indicates that the magma originated from the mantle wedge above, and hence was modified by fluids from, the subducting lithosphere. The basalt produced a strong reflector at 60 mbsf in the site survey and in a brief shipboard seismic survey and may be a near-surface sill or a lava flow.

Site 782

Site 782 (proposed Site BON-6B; 30°51.6′N, 141°18.8′E, water depth, 2959 m) is located on the eastern margin of the Izu-Bonin forearc basin, about halfway between the active volcanic arc and the trench.

Two lithostratigraphic units were defined at Site 782 (Fig. 6):

Subunit IA (0–153.6 mbsf in Hole 782A) of Unit I is lower Pliocene to Holocene(?) gray to yellow-greenish, homogeneous nannofossil marl containing scattered volcanic debris and volcanic ash layers.

Subunit IB (153.6–337.0 mbsf in Hole 782A) is middle to upper Miocene light to dark gray, vitric nannofossil marl containing scattered volcanic debris and volcanic ash layers.

Subunit IC (337.0–409.2 mbsf in Hole 782A) is middle Eocene to upper Oligocene vitric nannofossil chalk intercalated with tuffaceous sediment and pebble-rich sands, gravelly conglomerates, and ash layers.

Unit II (409.2–476.8 mbsf in Hole 782A and 459.3–468.9 mbsf in Hole 782B) consists of angular to subrounded clasts of intermediate-acid lava.

Sedimentation rates increased from the late Oligocene (5 m/m.y.) and middle Miocene (47 m/m.y.), through the early Pliocene (16.5 m/m.y.), to the late Pliocene and even higher in the Pleistocene. Two unconformities were identified in the succession: one between upper Oligocene and middle Miocene sediments, the other between lower Oligocene and upper Oligocene sediments. More than 100 volcanic ash layers were identified.

The lavas of Unit II are slightly vesicular and contain phenocrysts of plagioclase, orthopyroxene, and clinopyroxene in a glassy groundmass. The rocks fall into two compositional groups, an andesite group and a dacite-rhyolite group, and are transitional between the tholeiitic and calc-alkaline volcanic-arc rock series.

Logging enabled us to divide the section penetrated by Hole 782B into three distinct units according to physical and chemical properties: an upper unit from 0 to ~300 mbsf, a middle unit from about ~300 to ~370 mbsf, and a lower unit from ~370 mbsf to the lower limit of logging at ~420 mbsf. The boundary between the upper and middle units is marked by a sudden downhole increase in density and resistivity and may correspond to an increase in sediment compaction. The boundary between the middle and lower units is marked by an increase and greater variability in compressional-wave velocity and density, together with an increase in silica and potassium. This boundary may correspond to the Eocene/Oligocene unconformity.

Preliminary measurements of magnetic inclinations from Hole 782A cluster around +50° and −50°, indicating little or no translation of the site since the late Eocene.

The principal conclusions drawn from studies of Site 782 are these:

1. Basement in this part of the forearc basin is Eocene.
2. The uppermost basement consists of intermediate-acid submarine volcanic rocks of island-arc tholeiite to calc-alkaline affinities.
3. Preliminary paleomagnetic data indicate little or no translation of the site since the late Eocene.

Site 783

Site 783 (proposed Site BON-7; 30°57.86′N, 141°47.27′E; 4648.8 m) is located on the northern, midflank part of a seamount that forms part of a 500-km-long ridge running along the lowermost, inner wall of the Izu-Bonin Trench.

Two lithostratigraphic units were defined at Site 783 (Fig. 6):

Unit I (0–120.0 mbsf) is lower Pliocene to middle or lower Pleistocene or older glass-rich silty clay to claystone.

Unit II (120.0–158.6 mbsf) is phacoidal, sheared serpentine that contains clasts of serpentinized harzburgite.

Deformation observed in the sediments at Site 783 includes shear fabrics and convolute plastic folding within the claystones of Unit I and the phacoidal serpentine of Unit II. High-temperature preserpentinization and lower temperature post-serpentinization fabrics similar to those described from Conical Seamount are found in the ultramafic clasts of Unit II. Densities increase from 1.47 to 1.59 g/cm^3 in the sediments of Unit I and cluster at about 2.10 g/cm^3 in the serpentine of Unit II. Thermal conductivities average ~1 W/mK in sediments and 1.9 W/mK in the serpentine. Heat flow in the sediments is 23 mW/m^2.

Interstitial-fluid compositions vary only slightly with depth in the sediments of Unit I, with a sharp discontinuity at the claystone/serpentine boundary and rapid chemical changes thereafter. The pH of the fluid increases from about 8 at the claystone/serpentine boundary to 9.5–10 at the bottom of the hole, and alkalinity, silica, magnesium, potassium, salinity, and sulfate decrease. Both calcium and chlorinity increase with depth.

The principal conclusions from investigations at Site 783 are these:

1. The seamount is made up, at least in part, of serpentinite.
2. The serpentinite is at least early Pliocene in age and, hence, older than Conical Seamount in the Mariana forearc.
3. There is structural evidence for deformation within the overlying sediments as well as within the serpentinite.
4. Serpentinization is still taking place, but without the low-chlorinity component identified at Conical Seamount.

Site 784

Site 784 (30°54.49′N, 141°44.27′E; water depth, 4900.8 m) is located approximately 7 km southwest of Site 783 on the lowermost, western flank of the same seamount on the inner wall of the Izu-Bonin Trench.

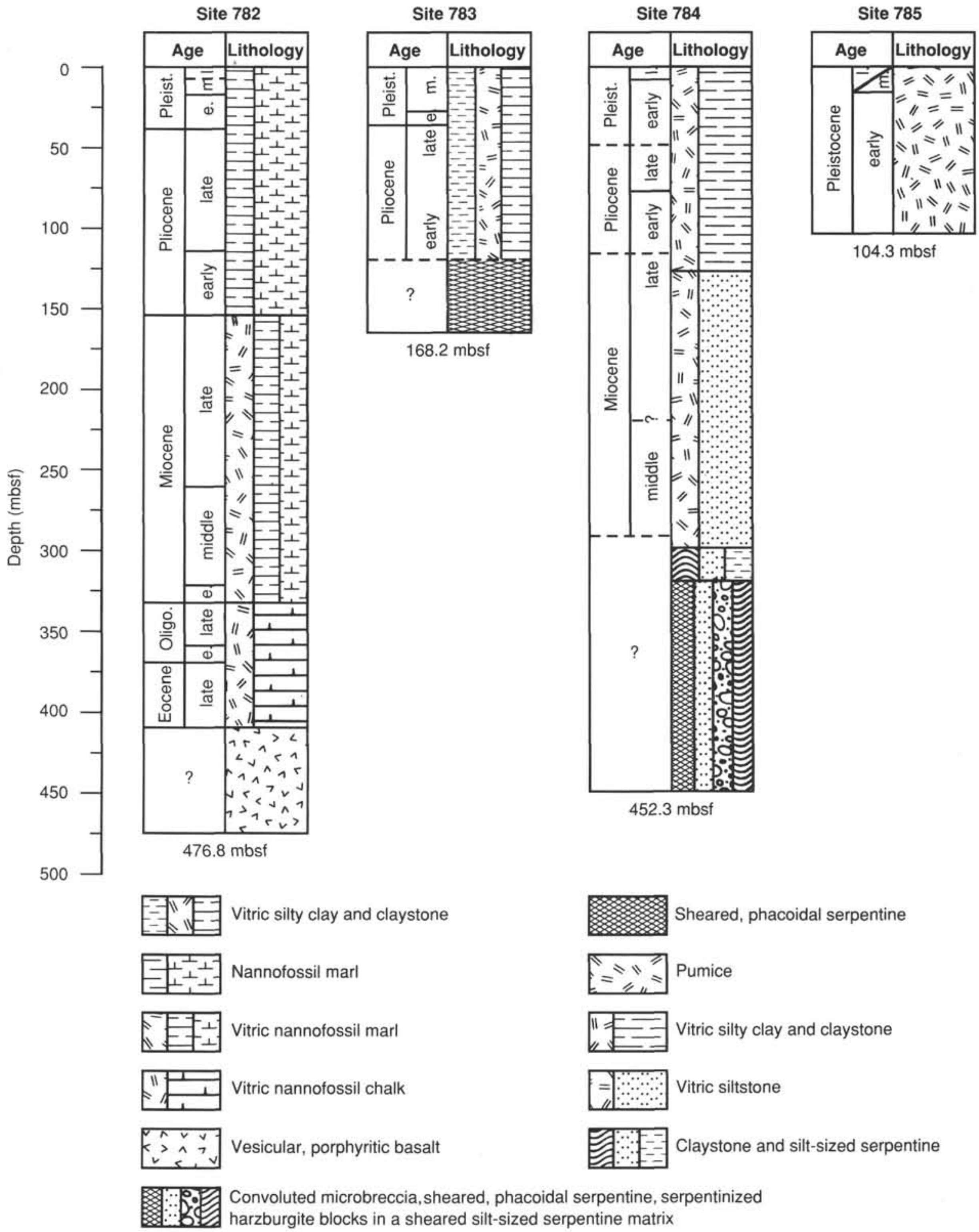


Figure 6. Summary of lithostratigraphic columns of Sites 782 through 785.

The stratigraphic section recovered at Site 784 is divided into two lithostratigraphic units (Fig. 6):

Subunit IA (0–126.4 mbsf) of Unit I is lower Pliocene(?) to upper Pleistocene vitric silty clay and claystone.

Subunit IB (126.4–302.7 mbsf) is middle Miocene to lower Pliocene (?) vitric claystone.

Subunit IC (302.7–321.1 mbsf) contains claystone and silt-sized serpentine of unknown age.

Unit II (321.1-425.3 mbsf) includes pebbly serpentines with convolute lamination, sheared and relatively unsheared pebbly silt-sized serpentines without convolute lamination, and serpentine microbreccias.

Lithostratigraphic Subunit IB may correlate with Subunit IB at Site 782 in the forearc basin on the basis of age and ash content. Sediments from Subunits IA and IB are laminated and contain abundant graded beds, structures that are indicative of current activity during sediment deposition. The sediment contains an abundant volcanogenic component and numerous ash layers. Subunit IC shows a clear interfingering of background pelagic sediments derived from the volcanic areas to the west and silt-sized serpentine from the topographic high to the east.

The ultramafic clasts from Unit II are of two types: variably serpentinized tectonized harzburgite and subordinate dunites. About 30 metabasalt clasts were also identified.

Deformation in the claystones of Unit I at Site 784 includes sets of en echelon tension veinlets and sets of microfaults, some of which are clearly associated with water-escape pipes. The zone of greatest microfaulting correlates directly with an interval of increased water content and porosity of the sediments. Most structures are extensional and can be shown to have formed in a nonhydrostatic stress regime.

The composition of the interstitial waters varies with depth in the serpentinite, as at Site 783. Silica decreases, and pH increases to 9.6. Alkalinity falls to a value about half that of seawater, sulfate and magnesium decrease, calcium increases, and chlorinity, bromide, and salinity show no major changes. The concentration of sodium decreases with depth, although it increases at Site 783. As at Site 783, therefore, there is evidence for ongoing serpentinization at the Izu-Bonin Seamount.

Average bulk densities are 1.6 g/cm^3 in the sediments of Unit I and 2.2 g/cm^3 in the serpentine of Unit II. Thermal conductivities average about 0.9 W/mK in the sediments and 1.74 W/mK in the serpentine.

Preliminary interpretation of the paleomagnetic data indicates little translation since the Pliocene, although translation may have been significant between the middle Miocene and Pliocene.

The principal conclusions from studies of Site 784 are these:

1. The western lower flank of the seamount is made up of serpentine sediments and serpentinite.
2. The serpentinite is at least middle Miocene in age and hence the seamount is considerably older than Conical Seamount.
3. Structural evidence indicates that deformation within the more compacted sediments overlying the serpentinite was extensional.
4. Preliminary paleomagnetic evidence suggests significant translation of the site between the middle Miocene and the Pliocene.
5. Serpentinization is still taking place despite the lack of evidence for active protrusion.

Site 785

Site 785 (30°49.47′N, 140°55.17′E; water depth, 2660.8 m) is located in the center of the Izu-Bonin forearc basin about 40 nmi east-northeast of the active volcano Torishima.

One lithostratigraphic unit was recovered at Site 785 (Fig. 6):

Unit I (0–104.7 mbsf) consists of lower to upper Pleistocene pumice-bearing nannofossil ooze overlying a bed of porphyritic dacite-rhyolite pumice fragments, 1 mm to 6 cm in diameter.

The principal conclusion from this site is evidence for a major Pleistocene pumice bed in this part of the Izu-Bonin forearc basin.

Site 786

Site 786 (31°52.5′N, 141°13.6′E; water depth, 3062 m) is located in the center of the Izu-Bonin forearc basin about 120 nmi east of the active volcano Myojin Sho.

The stratigraphic section recovered at Site 786 is assigned to four lithostratigraphic units (Fig. 7). Units I through III are defined only in Hole 786A (Fig. 7A), which recovered the sedimentary sequences at the site. Unit IV is defined in both Holes 786A and 786B (Fig. 7B).

Unit I (0–83.46 mbsf) consists of a succession of middle Miocene to lower Pleistocene nannofossil marls and clays.

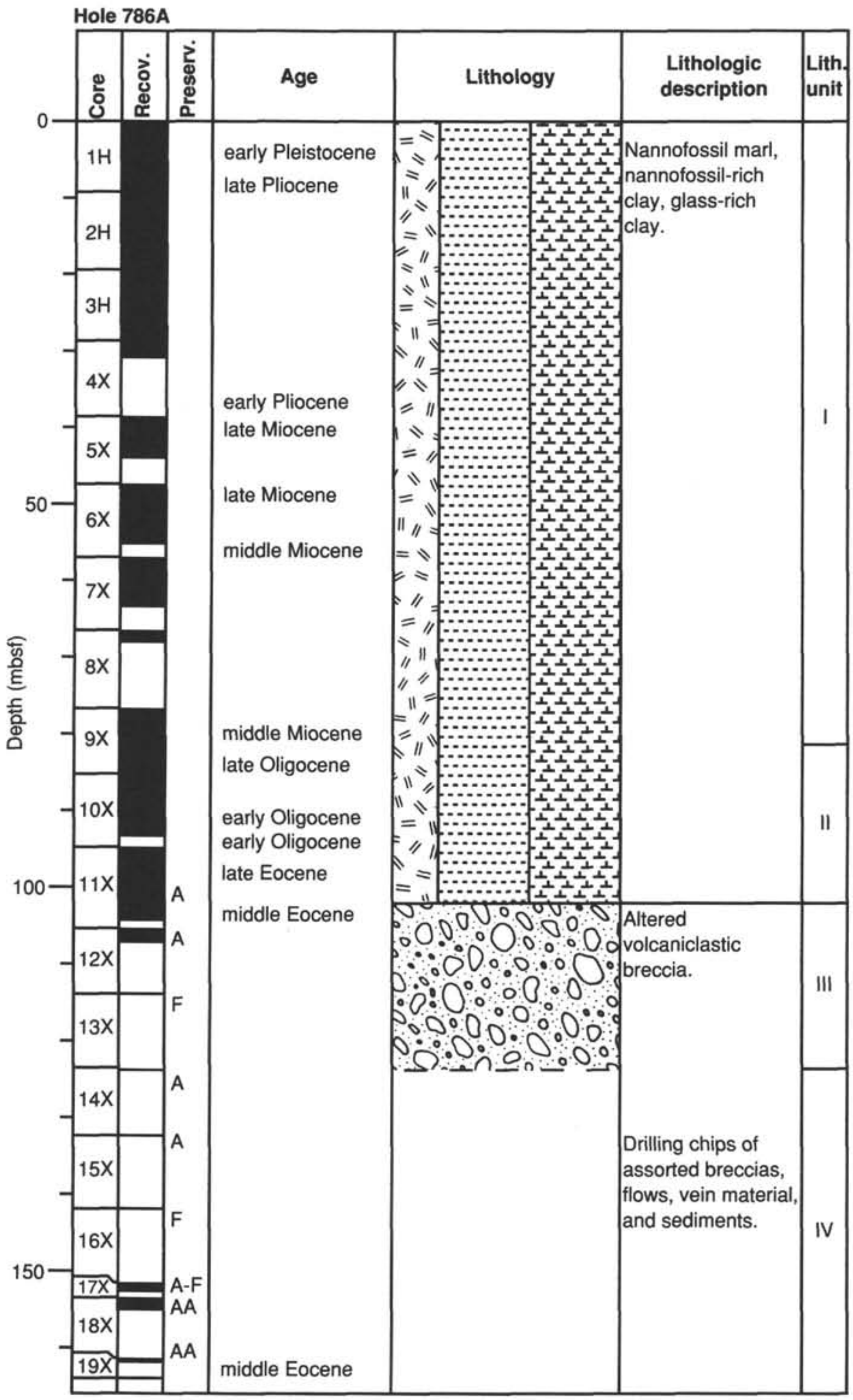
Unit II (83.46–103.25 mbsf) contains upper Oligocene to middle Eocene nannofossil marl and nannofossil-rich clay, as well as a volcaniclastic sequence containing vitric ash and mineral fragments.

Unit III (103.25–124.90 mbsf) is a sequence of middle Eocene volcaniclastic breccias.

Unit IV (124.9–166.5 mbsf in Hole 786A and 162.5–826.6 mbsf in Hole 786B) includes massive and brecciated flows, ash flows, and intercalated vitric siltstones and sandstones in the upper part of the unit and pillow lavas and dikes or sills in the lower part. Igneous rock types include high-magnesian basalts, boninites, basalts, andesites, dacites, and rhyolites. Secondary minerals include hydrothermal deposits of pyrite and native copper.

Sedimentation rates were highest in the Pliocene (8.6 m/m.y.) and lower (4.2 m/m.y.) between the latest and middle Miocene. A hiatus exists between the middle Miocene and the late Oligocene; below this point, evidence indicates that the rate was very low (0.8–1.4 m/m.y.).

Hole 786B penetrated more than 650 m into the massive, brecciated, and pillowed lavas and dikes of an Eocene volcano, providing information on the tectonic and volcanic activity that marked the initiation of subduction from the deepest hole yet into a submarine volcanic edifice. A simplified stratigraphic column is shown in Figure 7B. The upper part contains primarily welded ash flows and massive and brecciated lavas with interbedded clastic sediments. One of these sedimentary units is reddened and contains hydrated aluminum oxide, indicating a subaerial to shallow-water environment. At deeper levels, pillowed and massive lavas dominate, initially cut by a small number of intrusive dikes and sills. The hole ends at 828.6 mbsf in dikes and sills with minor lava screens. The rock types range from basalt to rhyolite in terms of silica content, but about half the rocks belong to the boninitic series that is thought to characterize the early stages of subduction. Shear zones are common throughout the sequence, and there is abundant evidence of hydrothermal activity, including pyrite-rich breccias and one zone containing native copper. Microfossil determinations from sediments intercalated within the lavas show that the



Key for preservation for 7A and 7B

AA= very altered: groundmass and phenocrysts are pervasively altered, only phenocryst traces remaining.

A = altered: groundmass and olivines altered, other phenocrysts largely fresh, some fresh glass.

F = fresh: some alteration of groundmass and phenocrysts, olivine altered.

FF= very fresh: no signs of alteration, vesicles may contain secondary mineralization.

Figure 7. Summary of lithostratigraphic columns of (A) Hole 786A and (B) Hole 786B.

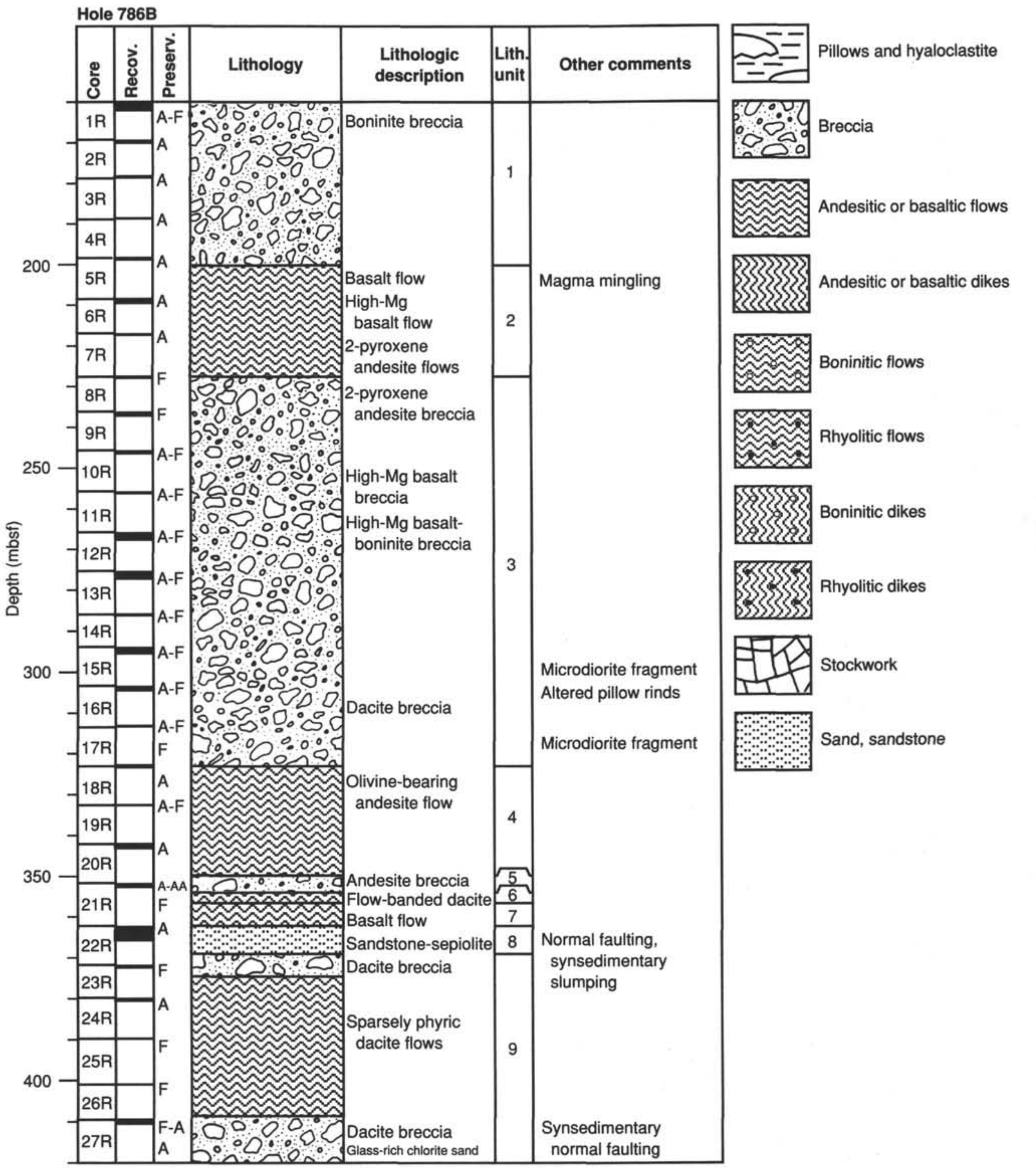


Figure 7 (continued).

sequence is middle Eocene (~42 Ma), similar in age to other parts of the outer-arc high.

Average bulk densities are 1.65 g/cm^3 in the sediments and 1.8 to 22.1 g/cm^3 in the volcanic sequences. Preliminary paleomagnetic data indicate little translation of the site since the late Miocene. The four suites of logging tools run in Hole 786B consisted of the dual induction tool, the digital sonic tool, the natural gamma-ray spectrometry tool, the lithodensity tool, the compensated neutron tool, the induced gamma-ray spectrometry tool, the aluminum clay tool, and the borehole televiewer.

The principal conclusions from investigations of Site 786 are these:

1. The penetration of over 650 m of Eocene volcanic crust shows that the basement in this region of the Izu-Bonin forearc consists of boninite flows and hyaloclastite and andesite flows, breccias, and dikes.

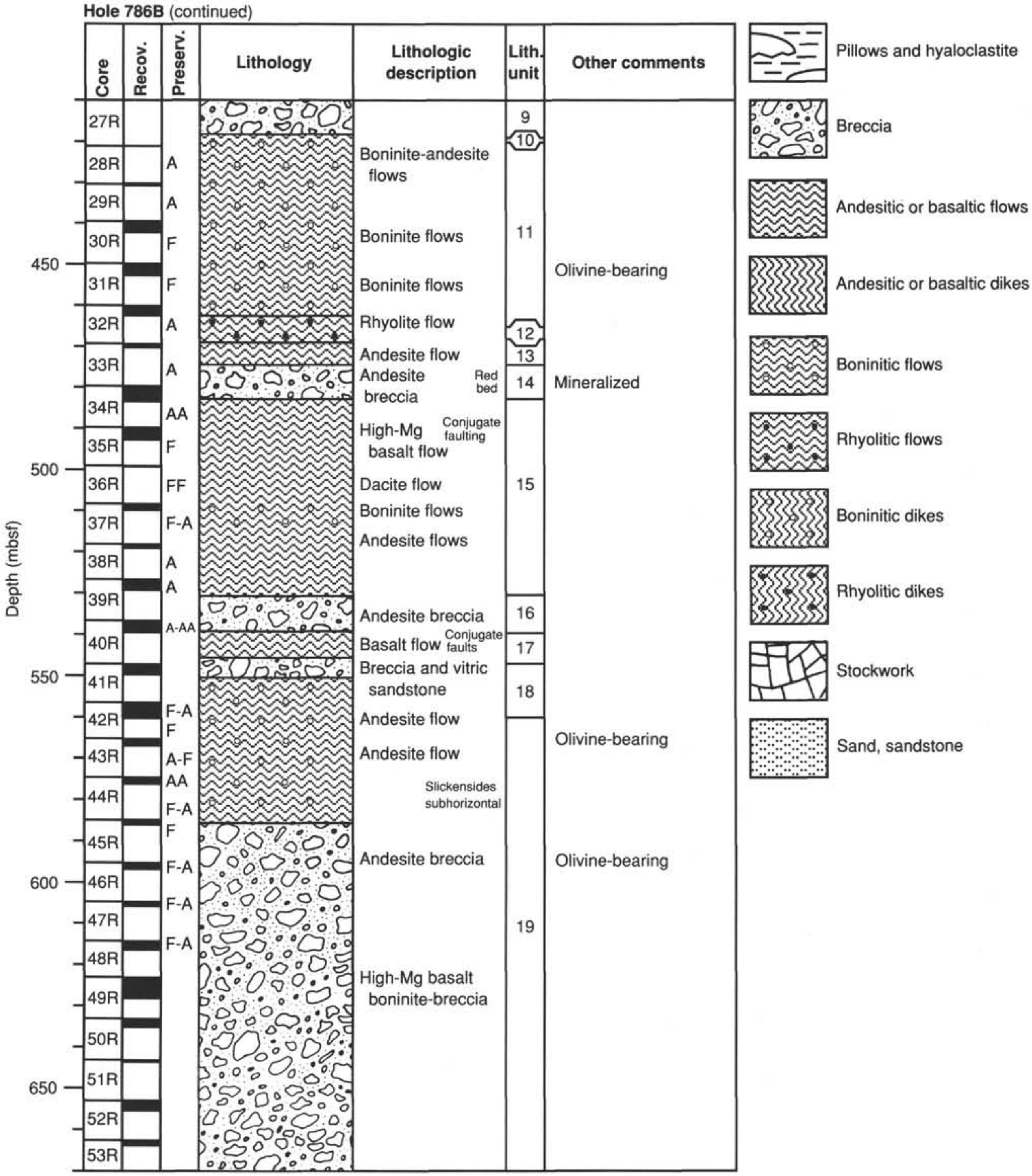


Figure 7 (continued).

2. Rocks recovered from the volcanic basement show extensive evidence of hydraulic fracturing and precipitation of sulfide and other minerals from hydrothermal fluids.

3. Preliminary paleomagnetic evidence indicates little translation of the site since the late Miocene.

4. Sedimentation rates were highest during the Pliocene, decreased between the latest Miocene and middle Miocene, and were quite low (from evidence below a hiatus) from the middle Miocene to the late Oligocene.

The most significant achievement at Site 786 was the deep penetration of an Eocene volcanic edifice that provided (1) a record of the construction and structure of the forearc volcanic basement and (2) a basis for the understanding of early arc magmatism in general and boninite petrogenesis in particular.

SUMMARY

Leg 125 drilled nine sites to answer fundamental questions about the magmatic, tectonic, and sedimentary evolution of

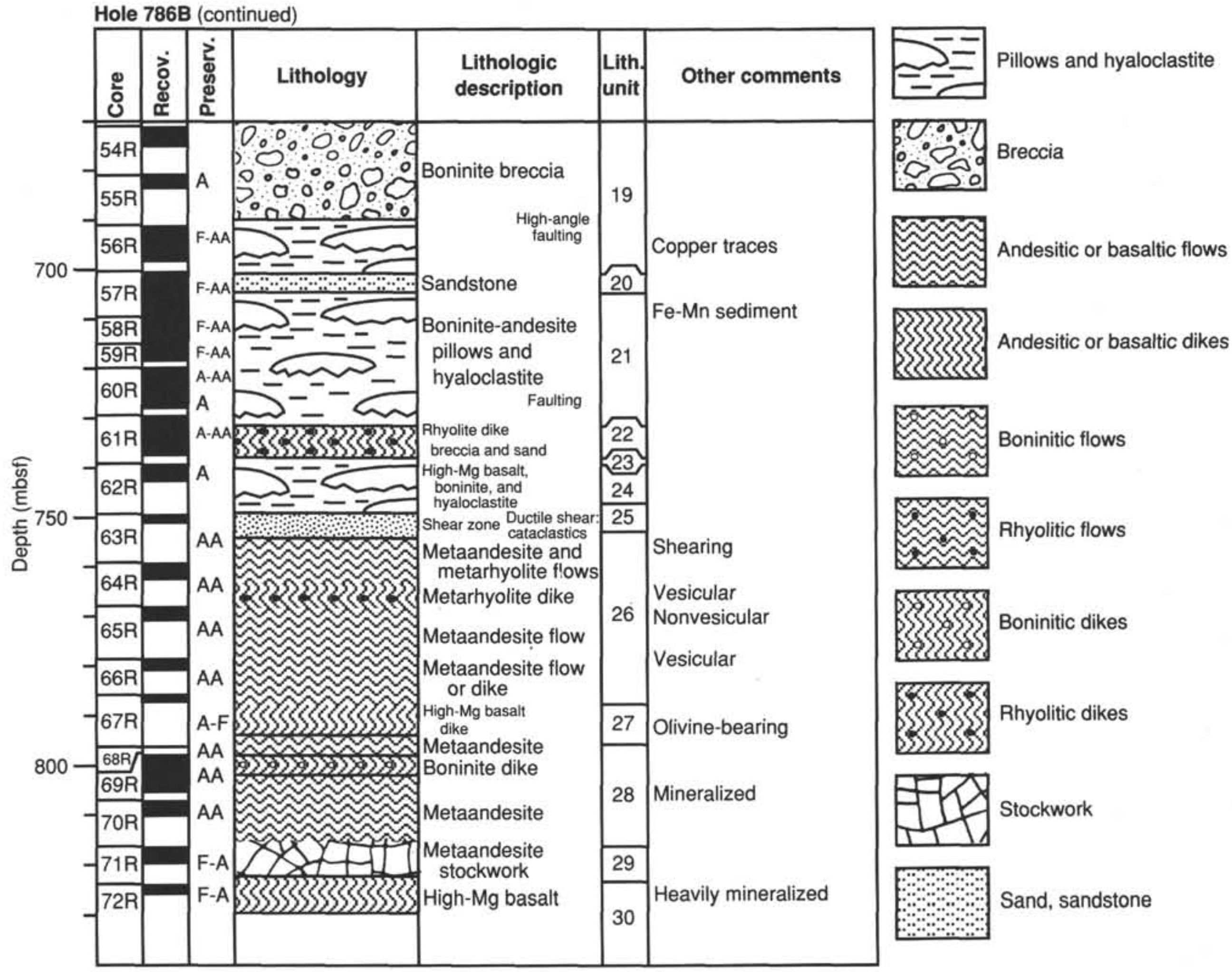


Figure 7 (continued).

the Mariana and Izu-Bonin forearcs and the flux of subduction-derived fluids through the forearc mantle wedge. The principal results and conclusions from drilling in the Mariana and Izu-Bonin forearcs include the following:

1. A Pliocene or younger basalt flow or sill penetrated at Site 781 is the first evidence for such recent magmatic activity in any extant intraoceanic forearc terrane.
2. The uppermost basement recovered in Site 782 consists of Eocene intermediate-acid submarine volcanic rocks of island-arc tholeiite to calc-alkaline affinities.
3. The deep penetration of Eocene volcanic crust at Site 786 provided (1) a record of the construction and structure of the forearc volcanic basement and (2) a basis for the understanding of early arc magmatism in general and boninite petrogenesis in particular. The basement in that part of the Izu-Bonin forearc consists of boninite flows and hyaloclastite and andesite flows, breccias, and dikes.
4. The identification of numerous ash layers within the forearc basin sediments indicates peaks of volcanic activity during the Eocene-Oligocene and from the late Miocene to the Holocene.
5. The volcanic basement at Site 786 shows extensive evidence of hydraulic fracturing and precipitation of sulfide and other minerals from hydrothermal fluids.

The principal results and conclusions from Sites 783, 784, and 778 through 780 drilled in the Mariana and Izu-Bonin serpentinite seamounts are as follows:

1. The Mariana serpentinite seamount may be constructed from protrusions of serpentinite mantle materials and/or flows of unconsolidated serpentine and entrained ultramafic and rare mafic clasts emanating from a central conduit.
2. Low- to medium-grade metamorphism characterizes the source region of the serpentinite that formed both seamounts.
3. Dehydration of the subducted lithosphere may have played an important role in the serpentinization of the source region of the serpentinite seamounts.
4. Hydrocarbons are a significant component of the fluids associated with the Mariana seamount.
5. The Izu-Bonin seamount is at least middle Miocene in age—hence older than Conical Seamount—and currently inactive in terms of flow generation.
6. Serpentinization is still taking place in the Izu-Bonin Seamount, but without the low-chlorinity component identified at Conical Seamount.

REFERENCES

Ben-Avraham, Z., and Uyeda, S., 1983. Entrapment origin of marginal seas. *In* Hilde, T.W.C., and Uyeda, S. (Eds.), *Geodynamics* *of the Western Pacific-Indonesian Region*. Am. Geophys. Union, Geodynamics Ser., 11:91–104.

Bloomer, S. H., 1983. Distribution and origin of igneous rocks from the landward slopes of the Mariana Trench. *J. Geophys. Res.*, 88:7411–7428.

Fryer, P., Ambos, E. L., and Hussong, D. M., 1985a. Origin and emplacement of Mariana forearc seamounts. *Geology*, 13:774–777.

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

Fryer, P., and Fryer, G. J., 1987. Origins of nonvolcanic seamounts in a forearc environment. *In* Keating, B., Fryer, P., and Batiza, R. (Eds.), *Seamounts, Islands, and Atolls*. Am. Geophys. Union, Geophys. Monogr. Ser., 43:61–69.

Honza, E., and Tamaki, K., 1985. Bonin arc. *In* Nairn, A.E.M., and Uyeda, S. (Eds.), *The Ocean Basins and Margins* (vol. 7): New York (Plenum Press), 459–499.

Hussong, D. M., Uyeda, S., et al., 1982. *Init. Repts. DSDP*, 60: Washington (U.S. Govt. Printing Office).

Ishii, T., 1985. Dredged samples from the Ogasawara fore-arc seamount or "Ogasawara Paleoland" fore-arc ophiolite. *In* Nasu, N. (Ed.), *Formation of Active Ocean Margins:* Tokyo (Terra Scientific), 307–342.

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

Ogawa, Y., and Naka, J., 1984. Emplacement of ophiolitic rocks in forearc areas: examples from central Japan and Izu-Mariana-Yap island arc system. *In* Gass, I. G., Lippard, S. J., and Shelton, A. W. (Eds.), *Ophiolites and Oceanic Lithosphere*. Spec. Publ. Geol. Soc. London, 13:291–302.

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