OCEAN DRILLING PROGRAM

LEG 134 PRELIMINARY REPORT

VANUATU (New Hebrides)

Dr. Gary Greene
Co-Chief Scientist, Leg 134
U.S. Geological Survey
MS-999, 345 Middlefield Road
Menlo Park, California 94025

Dr. Jean-Yves Collot
Co-Chief Scientist, Leg 134
ORSTOM
B. P. 48
06230 Villefranche-sur-Mer
France

Dr. Laura Stokking
Staff Scientist, Leg 134
Ocean Drilling Program
Texas A&M University
College Station, Texas 77845-9547

Philip D. Rabinowitz
Director
ODP/TAMU

Audrey W. Meyer
Manager
Science Operations
ODP/TAMU

Timothy J.G. Francis
Deputy Director
ODP/TAMU

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SCIENTIFIC REPORT

The scientific party aboard JOIDES Resolution for Leg 134 of the Ocean Drilling Program consisted of:

Gary Greene, Co-Chief Scientist (U.S. Geological Survey, MS-999, 345 Middlefield Road, Menlo Park, California 94025).
Jean-Yves Collot, Co-Chief Scientist (ORSTOM, B.P. 48, 06230 Villefranche-sur-Mer, France).
Laura Stokking, ODP Staff Scientist (Ocean Drilling Program, 1000 Discovery Drive, College Station, Texas 77845-9547).
Kazumi Akimoto (Nagoya Jiyu Gakuin Junior College, 281 Furui, Kumanosho, Shikatsu-cho, Nishikasugai-gun, 481 Aichi Prefecture, Japan).
Maria V.S. Ask (Division of Rock Mechanics, Lulea University of Technology, S-951 87 Lulea, Sweden).
Peter E. Baker (Department of Earth Sciences, University of Leeds, Leeds LS2 9JT, United Kingdom).
Louis Briqueu (C.N.R.S. France, Laboratoire de Geochimie Isotopique, U.S.T.L., C.P. 066, 34095 Montpellier Cedex 2, France).
Thierry Chabernaud (Borehole Research Group, Lamont-Doherty Geological Observatory, Palisades, New York 10964).
Massimo Coltorti (Mineralogy Institute, Ferrara University, C.soE. 1 d'Este 32, 44100 Ferrara, Italy).
Michael A. Fisher (U.S. Geological Survey, MS-999, 345 Middlefield Road, Menlo Park, California 94025).
Margaret Goud (Coastal Research Center, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543).
Toshiaki Hasenaka (Institute of Mineralogy, Petrology and Economic Geology, Faculty of Science, Tohoku University, Aoba, Sendai, Miyagi 980, Japan).
Mike Hobart (Lamont-Doherty Geological Observatory, Palisades, New York 10964).
Anton Krammer (Geophysical Institute, Hertzstrasse 16, D-7500 Karlsruhe 21, Federal Republic of Germany).
John Leonard (Department of Oceanography, Texas A&M University, College Station, Texas 77840-3146).
Jonathan B. Martin (Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California 92093).
Jose I. Martinez-Rodriguez (Department of Geology, Australian National University, GPO Box 4, Canberra, ACT 2601, Australia).
Stefan Menger (Deutsche Montan Technologie, Institut für Angewandte Geophysik, Herner Strasse 45, D-4630 Bochum, Federal Republic of Germany).
Martin Meschede (Institut für Geologie, Universität Tübingen, Sigwartstrasse 10, D-7400 Tübingen, Federal Republic of Germany).
Bernard Pelletier (ORSTOM, B.P. A5, Noumea, New Caledonia).
Russell C.B. Perembo (Department of Geology, University of Western Australia, Nedlands, Western Australia 6009, Australia).
Terrence M. Quinn (Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan 48109-1063).
Pamela Reid (Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami, Florida 33149).
William R. Riedel (Geological Research Division, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California 92093).
Pierrick Roperch (ORSTOM, B.P. 48, 06230 Villefranche-sur-Mer, France).

Thomas S. Staerker (Department of Geology, Florida State University, Tallahassee, Florida 32306).
Frederick W. Taylor (Institute for Geophysics, University of Texas, 871 Mopac Boulevard, Austin, Texas 78749-8345).
Xixi Zhao (Earth Sciences Board, University of California, Santa Cruz, California 95064).

ABSTRACT

Leg 134 of the Ocean Drilling Program investigated the influence of ridge collision and subduction on the structural evolution of island arcs by drilling at a series of sites in the collision zone between the d'Entrecasteaux Zone (DEZ) and the central New Hebrides Island Arc. The DEZ is an arcuate Eocene-Oligocene submarine chain extending from the northern New Caledonia ridge to the New Hebrides trench. Near the New Hebrides trench, the DEZ comprises two parallel, E-W trending morphologic features: the fairly continuous North d'Entrecasteaux Ridge (NDR) and the South d'Entrecasteaux Chain (SDC), composed of seamounts and guyots whose most eastern member is the Bougainville Guyot. The impingement of the DEZ upon the central New Hebrides Island Arc has greatly disrupted and tectonically modified the forearc and arc morphology and structure. Holes at Sites 827 and 829 were drilled to penetrate the lowermost accretionary wedge and the interplate thrust fault (décollement). The primary objective of drilling at Site 828 was to obtain a critical reference section of north-ridge rocks. Sites 830 and 831 are located where the Bougainville Guyot has collided with the arc. At Site 830 we sought to penetrate imbricated arc rocks, and at Site 831 we sought to determine the lithology, age, paleobathymetry, and mechanical properties of the guyot. Sites 832 and 833 are located in North Aoba Basin (NAB), an intra-arc basin that is considerably deeper than any other basin along the arc summit and that occurs directly east of the collision. This basin contains several unconformities that appear to document the structural evolution of the Central New Hebrides Island Arc.

Preliminary interpretations of the results of Leg 134 suggest that each ridge of the twin-ridge DEZ causes different forearc deformation. The sedimentary and surficial basement rocks of the NDR, whose basement rocks (MORB) are denser than those of the Bougainville Guyot, appear to have been scraped off and accreted to the forearc during subduction. This accretion has formed the Wousi Bank, which consists of uplifted forearc rocks and stacked thrust sheets. The SDC impacts the forearc in a different manner: little deformation has occurred compared to the NDR collision zone, although the SDC is converging at the same rate and at the same angle as the NDR. Major compositional changes of pore fluids in the collision zone result from diagenetic alteration of volcanic sediment and are manifested as chloride and calcium concentrations greater than seawater values and sodium, potassium, and magnesium concentrations lower than seawater values. Variations in these solute concentrations correspond to structural features, particularly across thrust faults at Site 829 and in a fractured zone at Site 830. More fluid is present below thrust faults penetrated at Site 829, which implies that the faults may channelize fluid flow similar to the Barbados accretionary wedge. Low chloride and high methane concentrations characterize fluids from deep levels at Site 829, a covariance that also characterizes the pore fluid chemistry within the décollement at the Barbados accretionary wedge. Thus, the fluid near the deep thrust fault at Site 829 may have been derived from the décollement and subduction-related processes.

Middle Miocene to Pleistocene sedimentary and volcaniclastic rocks were recovered from two holes deeper than 1 km in the NAB. Drilling at Site 832 penetrated over 1106 m of basin-fill deposits and at Site 833 cored 1001 m of basin material. A strong reflector observed in the seismic reflection data around 700 mbsf correlates with an apparent upper Pliocene or lower Pleistocene unconformity in the sediment record.This suggests a change in the basin's base and may indicate that uplift of Espiritu Santo Island in response to the collision of the DEZ occurred at that time. Over 600 m of Pleistocene sediments were

found at Site 832 with the upper 400 m apparently being the contribution of active Central Chain volcanism. At Site 833 a volcanic sill intrudes lower Pliocene sedimentary rocks at 840 mbsf, demonstrating that volcanism was active along the Eastern Belt from the early Pliocene to Pleistocene time. Volcanic sediment within the NAB has been diagenetically altered, producing some of the most altered and concentrated fluids yet drilled on an ODP or a DSDP leg. The concentrations of calcium, chloride, potassium, sodium, and magnesium are most affected by this alteration.

INTRODUCTION

The New Hebrides Arc system extends for a distance of 1700 km from the Santa Cruz Islands in the north to Matthew and Hunter islands in the south (Fig. 1). This arc lies in the middle of a complex system of active volcanic arcs that extends from Papua New Guinea southward through the Solomon Islands to Vanuatu, where the New Hebrides Island Arc is displaced eastward along the Hunter Fracture Zone to Tonga (Fig. 1). From Tonga the arc system continues southward through the Kermadec Islands to New Zealand. Along most of the arc system, the Pacific Plate is being subducted under the Australia-India plate. From Papua New Guinea to Vanuatu, however, the arc system defines a major plate boundary where the Australia-India Plate is being subducted beneath the Pacific Plate and the North Fiji Basin. The New Hebrides Island Arc is the product of intra-oceanic subduction, possible subduction polarity reversal, and ridge-arc collision that has taken place during the Cenozoic. Leg 134 focused on three important and poorly understood aspects of this arc system, namely:

1. The style of deformation occurring in the region of the collision between the d'Entrecasteaux Zone (DEZ) and the New Hebrides Island Arc and comparison to the deformation in two different types of ridges (the North d'Entrecasteaux Ridge, NDR, and the South d'Entrecasteaux Chain, SDC, of seamounts) that are impinging upon the arc (Fig. 1). Impingement of the DEZ against the arc has greatly altered the arc's morphology and structure. To determine the recycling of lithosphere, or the transfer of material from one plate to another, a series of holes (Fig. 2) was drilled through the sediments and carbonate rocks of the forearc (Sites 827, 829, and 830), of the NDR on the Australia-India Plate (Site 828), and of the Bougainville Guyot of the SDC (Site 831).

2. The evolution of the magmatic arc in relation to a possible reversal of subduction during the Neogene. To investigate the evolution of intra-arc basins and to determine whether or not subduction polarity reversed, two sites (Sites 832 and 833; Fig. 2) were drilled in the summit basin of the arc, the intra-arc North Aoba Basin (NAB). The age of a major discordance in the basin fill may be contemporaneous with the beginning of collision of the DEZ with the arc, providing one of the best estimates of the age of subduction polarity reversal and initiation of collision. The holes drilled in the North Aoba Basin show the provenance, age, paleobathymetry, and lithology of basin fill, from which the rate and timing of basin subsidence can be derived.

3. Dewatering of the forearc and subducted lithosphere, to be investigated indirectly from the composition of the forearc crust and directly from the analyses of fluids and chemical precipitates from the forearc.

Drilling Objectives

Arc-Ridge Collision Sites

Sites within the collision zone were designed to determine the influence that ridge composition and structure exert on the style of accretion and type of arc structures produced during collision. Sites 827 and 829 are located where the north ridge of the DEZ and the arc collide (Fig. 2). At Site 828 we sought to obtain a critical reference section of north-ridge rocks to enable recognition of these rocks in other drill holes (Fig. 2). At Sites 827 and 829 we sought to penetrate the lowermost accretionary wedge, the interplate thrust fault (décollement), and the north ridge itself. We hoped that this site would show whether north-ridge rocks have been accreted onto the arc as well as the age and mechanical properties of rocks where, despite the great relief of the subducted ridge, the collision has caused little forearc deformation.

Sites 830 and 831 are located where the Bougainville Guyot has collided with the arc, causing considerable forearc deformation (Fig. 1). At Site 830 we sought to penetrate imbricated arc rocks to test whether these rocks are part of an uplifted old accretionary wedge, recently accreted guyot rocks, or island-arc basement. At Site 831 we sought to determine the lithology, age, paleobathymetry, and mechanical properties of the guyot. Results obtained from drilling near the guyot were contrasted with those obtained near the north ridge to determine why arc structures induced by the collision are so different. The rate of uplift of the accretionary wedge was determined and compared to the rate at which onshore areas have emerged; this emergence occurred synchronously with collision, and onshore areas rose at Holocene rates exceeding 5 mm/yr.

Intra-Arc Basins

At Sites 832 and 833 in the North Aoba Basin (Fig. 2), we sought to investigate how arc-ridge collision has affected the development of the intra-arc basins and the evolution of the magmatic arc. In addition, we sought to determine if volcanic ash within basin rocks contains a record of the hypothesized reversal in arc polarity.

Site 832 is located within the center of the Aoba Basin (Fig. 2), which lies beneath significantly deeper water than does any other basin near the summit of this arc. We sought to obtain the age of a major unconformity that likely correlates with the onset of arc-ridge collision and should provide one of the better estimates of when this onset occurred. The chemistry of Quaternary volcanic ashes will be used to show if the magmatic arc has been affected by subduction of the DEZ.

Site 833 is located along the eastern flank of the Aoba Basin (Fig. 2), where basin rocks include two unconformities. The shallower one provided temporal constraints on backarc deformation, possibly as a direct result of the collision. The deeper unconformity lies along the top of the oldest basin rocks, and drilling was aimed at helping understand the late Cenozoic evolution of the magmatic arc. The chemistry of volcanic ash should show whether the magmatic arc was affected by the arc polarity change.

SITE 827

Site 827 (proposed Site DEZ-2) is located within the collision zone of the d'Entrecasteaux Zone (DEZ), along the forearc slope of the New Hebrides Arc, 35 km west of the western shore of Espiritu Santo Island (Fig. 2). A short geophysical survey was undertaken to locate a flat, sedimented area to spud into; the site was finally selected within a fairly small, flat, yet hummocky-surfaced plateau 4 km east of the trace of the subduction zone, an area that appears to have dammed and ponded sediment being transported downslope from the island. Here the North d'Entrecasteaux Ridge (NDR) is impinging upon the arc slope and has formed a tectonic front of lobate morphology that is composed of sheared and fractured accreted(?) and arc-derived material. This collision has produced an unstable slope prone to mass wasting and shearing from arcward-dipping thrust faults. Site 827 is located upon a thrust sheet or slump block that has been severely deformed by the active convergent tectonic processes. The site was chosen to penetrate the lower forearc slope where rocks of the overriding plate are thin in anticipation of drilling through the décollement and rock units of the underlying NDR. Our intent was to define the lithology, composition, age, and mechanical properties of rocks drilled to determine the degree and rate of material transfer from one plate to another, the timing of collision, the present-day stress field, and the composition and role of fluid circulation in the collision process.

We cored 110.6 m and recovered 100.76 m of sediment in Hole 827A for a 91.1% core recovery, and drilled and cored 400.4 m to recover 119.04 m of sediment and rock in Hole 827B for a 41.4% core recovery (Table 1).

Four lithostratigraphic units have been described (Fig. 3). Unit I (0-86 mbsf) consists of Pleistocene volcanic silt interbedded with normally graded, sandy volcanic silt beds (turbidites). This unit is subdivided into three subunits based on the concentrations of turbidite layers. Subunit IA (0-40 mbsf) is a volcanic siltstone with a few distinct turbidite layers whereas Subunit IB (40-66 mbsf) is a volcanic siltstone with many turbidite layers, and Subunit IC (66-86 mbsf) is a volcanic siltstone with fewer concentrated turbidite layers than are found in Subunit IB.

Unit II (86-141 mbsf) is a sequence of upper Pliocene to Pleistocene(?) volcanic silt and siltstones with varying components of clay and sand.

Unit III (141-252 mbsf) contains upper Pliocene to middle Pleistocene(?) highly bioturbated, partially lithified calcareous volcanic siltstone with intervals of sed-lithic conglomerate. Unit III can be divided into three subunits consisting of an upper 59 m of tectonically disturbed, highly bioturbated, sandy to clayey volcanic siltstone (Subunit IIIA, 141-200 mbsf), an intermediate 18 m of sed-lithic conglomerate/breccia (Subunit IIIB, 200-218 mbsf), and a lower 34 m of volcanic siltstone and foraminiferal and nannofossil ooze interbedded with ash and a highly sheared, variegated lustrous zone that appears rich in chlorite or some other micaceous mineral (Subunit IIIC, 218-252 mbsf).

Unit IV (252-400.4 mbsf) comprises only clasts ranging in size from pebbles to the maximum diameter that can fit into the core barrel. These clasts consist of very well-lithified volcanic siltstone and sandstone, lithified breccias, and coarse sandstone containing a preponderance of igneous-rock fragments and crystals. These clasts are mixed into a highly sheared and fractured matrix; the rock as a whole is called a partially lithified, matrix-supported sed-lithic conglomerate.

Initial interpretations of the core suggest that Unit I, which consists almost entirely of graded beds of volcanic silt and sandy silt containing both Pleistocene microfossils and reworked Miocene microfossils, was most likely derived from Espiritu Santo Island and transported to the site by turbidity currents. This unit contains plant-debris fragments and coincides with a stratigraphic interval where benthic foraminifers suggest low-oxygen conditions, as would be expected in an environment where rapid burial by turbidity currents suppresses burrowing organisms that would otherwise consume and oxidize the organic matter. Unit II is similar in lithology but is of late Pliocene to Pleistocene(?) age and devoid of graded bedding and is interpreted as a hemipelagic deposit. The coarse-grained and debris-like sediments of Unit III probably were deposited in a high-energy, deep-water (middle bathyal zone) environment close to a volcanic-island source; this unit was then severely sheared and fractured by the collision of the NDR. Unit IV is difficult to interpret because of the poor recovery; however, the depositional environment for such material must be proximal to the source because the material is very poorly sorted and the clasts are angular to subrounded.

Foraminifers and nannofossils provided the best source of age information. The sedimentary samples recovered were predominantly of Pleistocene to late Pliocene(?) age, with reworked late Miocene fauna. Paleomagnetic results from Hole 827A indicate that the cored samples were well within the Brunhes; cores from Hole 827B were too disturbed for paleomagnetic analysis.

Analyses of fluids from whole-round samples of the core indicate that chlorinity and salinity increase with depth to values 10% to 15% higher than seawater concentrations at 250 mbsf. Both potassium and sodium decrease to 40% to 50% of seawater values at 250 mbsf. Calcium concentrations increase strongly with depth to 250 mbsf but display a very slight minimum at about 75 mbsf. Overall concentrations of nutrients are low and silica concentrations are variable. Sulfate reduction is complete by 50 mbsf, but sulfate concentrations subsequently increase with depth to values equal to about 30% of seawater. Methane concentrations are near zero except for a strong, sharp maximum at about 75 mbsf. A significant finding is that the methane peak is probably not a result of organic-matter diagenesis because (1) it appears too large relative to increases in the nutrients and (2) it is located below the maxima in nutrient concentrations. This peak suggests that there may be "exotic" fluids in that zone. This fluid appears to have lower chlorinity, lower salinity, higher sodium and potassium concentrations, and lower magnesium concentrations. The calcium concentrations in this zone are controlled more by the steep depth gradients and thus exhibit no maxima or minima. This level also marks the first appearance of sulfate below the sulfate-reduction zones. Low chlorinity concentrations, high methane concentrations, and sulfate below the zone of complete sulfate reduction are attributes of fluids in the Barbados and Nankai décollement zones (Mascle, Moore, et al., 1988; Taira, Hill et al., in press).

Physical properties correlate well with the lithologic units. In the upper unit (Unit I) the water content and porosity of the sediments decrease rapidly from a water content of 55% a few meters below the seafloor to below 40% at 40 mbsf. Bulk densities and velocities also agree, showing the second unit (Unit II) to be a denser, less porous unit in which sonic velocities increase significantly to more than 1920 m/s before dropping rapidly in the third unit as water content and porosity increase to 60% or more. Sonic velocities decrease further in the hard-rock breccia of Unit IV. Due to hole collapse, logging was not undertaken.

SITE 828

Site 828 (proposed site DEZ-1) is located at 15°17.34'S, 166°17.04'E, on the Australia-India Plate, along the northeastern flank of the NDR about 2 km west of the active convergent margin that separates the Australia-India Plate from the Pacific Plate (New Hebrides microplate). The site lies 150 km west of the active volcanic chain of the central New Hebrides Island Arc (Vanuatu) and about 40 km west of the western coast of Espiritu Santo Island, one of several islands associated with the lower Miocene Western Belt of islands (Fig. 2). Site 828 is located on a flat, terrace-like feature that projects out from the otherwise steeply dipping slope in a water depth of 3086.7 m. It lies near the collision zone of the NDR with the arc, an area where the Australia-India Plate seafloor is bending down into the eastward-dipping subduction zone. In response to this curvature the terrace-like feature on which Site 828 lies has been faulted, and may be part of a series of structural features oriented northwest-southeast that step down to the east. Site 827 is 4 km east of Site 828, across the convergence boundary where the forearc is deformed from the collision of the NDR and subduction.

Two holes were drilled at Site 828. Hole 828A was drilled and cored with the APC and XBC to 111.4 mbsf, with 101.34 m of core obtained for a recovery of 91%. Hole 828B, offset approximately 214 m to the northwest of Hole 828A, was drilled using the RCB to a depth of 129 mbsf, coring 39 m, with 7.92 m of core obtained for a recovery of 20.3% (Table 1).

Four lithostratigraphic units were defined and described for this site (Fig. 3). Unit I (0-58.7 mbsf) is a 58.7-m-thick Pleistocene dark greenish gray volcanic silt with foraminiferal sand interbeds; the contact with underlying Unit II is marked by a dark brown bioturbated ash bed.

Unit II (58.7-69.3 mbsf) is a 10.6-m-thick lower Pliocene to Pleistocene foraminiferal ooze divided into two subunits. Subunit IIA (58.7-61.9 mbsf) is a 3.2-m-thick Pleistocene light brownish gray to very pale brown foraminiferal ooze with nannofossils and alternating layers of silt and ash with firm-to-soupy foraminiferal sands. Subunit IIB (61.9-69.3 mbsf) is a 7.4-m-thick lower Pliocene to upper Miocene very pale brown to white unconsolidated foraminiferal ooze separated from Subunit IIA by an unconformity(?) and a sharp color change, marking the end of the volcanic components of the overlying sediment.

Unit III (69.3-90.8 mbsf) is a 21.5-m-thick lower to upper Oligocene highly bioturbated light yellowish brown nannofossil chalk that unconformably underlies Subunit IIB.

Unit IV (90.8-111.4 mbsf) is at least 20.6 m thick and consists of upper Eocene to lower Oligocene volcanic breccia, abrecciated lava-flow deposit, and brecciated aphyric basalt and diabase. The clasts and matrix range in color from light greenish gray to dusky red.

Drilling at Site 828 revealed a 91-m-thick lower Oligocene to Pleistocene marine sedimentary sequence unconformably(?) overlying a brecciated lava flow and a volcanic breccia that may have been subaerially altered. Hole collapse prevented penetration of basement rocks of the NDR, although the igneous rocks recovered are believed to be the eroded and weathered detritus of a volcanic basement complex. The rocks exhibit a blotchy red and greenish color that suggests extensive oxidation and alteration, possibly in association with a volcanic island. The upper part of Unit IV included weathered clasts of fairly differentiated igneous material within a coarse-grained breccia; one clast is called a trachyte, although further analyses may prove it to be a mugearite. Beneath the breccia, rubbly, weathered, aphyric, fine-grained, vesicular basalts and andesites were encountered. One piece of olivine dolerite was found in Hole 828B. In contrast to the volcanic rocks recovered at Site 827, igneous rocks at Site 828 appear more mafic and contain less silica and do not contain phenocryst-sized orthopyroxene and hornblende. Initial geochemical analyses indicate that the basaltic rocks share a magmatic affinity intermediate between MORB and volcanic island-arc rocks (island-arc tholeiite), perhaps associated with a subduction-related magma source.

At least three unconformities (61.9, 69.3, and 90.8 mbsf), two of which are questionable (61.9 and 90.8 mbsf), interrupt the marine sedimentary sequence above the igneous rocks of Unit IV. These unconformities bound lithologic units that vary considerably in lithology and give clues about the tectonic development of the region. All of the unconformities are restricted to the lower part of the sedimentary sequence, beneath 58 mbsf.

Nannofossil chalk of Unit III appears to be in unconformable contact with volcanic breccia of Unit IV. This contact may be a subaerially eroded surface. The chalk is of early to late Oligocene age compared to the late Eocene-early Oligocene age of Unit IV. Sediments of Unit III exhibit bioturbation and abundant dewatering structures.

Unconformably overlying Unit III is the upper Miocene to lower Pliocene foraminiferal ooze of Subunit IIB. The unconformity represents a major hiatus (~69 mbsf) of about 18 m.y., extending from the late Oligocene (~24 Ma) to the early Pliocene (~6 Ma); missing are deposits of the latest Oligocene and almost the entire Miocene epochs. At DSDP Site 286 (Fig. 1), located in the North Loyalty Basin approximately 120 km south of Site 828, the absence of Miocene strata indicates an important hiatus between 13 and 5 Ma (Andrews, Packham, et al 1975), suggesting a regional elevation of the seafloor to a level where erosion occurred or deposition was curtailed. Subunit IIB is a very soupy foraminiferal ooze of late Miocene to early Pliocene age (6-4 Ma) that is unconformably(?) overlain by foraminiferal ooze of Subunit IIA, which is late Pleistocene (<1 Ma) in age. A hiatus of 3-5 m.y. may exist at 62 mbsf where sediments of middle Pliocene to middle Pleistocene age are missing. At least five paleomagnetic reversals have been recorded in the sediments of Units II and III. Units II through III were deposited in a lower bathyal environment during a time of low sedimentation rates, between 2 and 7 m/m.y., as calculated from the microfossil analyses. Above Subunit IIA a major lithologic change occurs from the foraminiferal ooze and nannofossil chalks of Units II and III to the volcanic siltstones of Unit I, although the depositional environment remains lower bathyal. Unit I was deposited during the Brunhes Chron (within the last 700,000 years) at a time of very high sedimentation rate (~60 m/m.y.). It consists primarily of Pleistocene volcanic silt interlayered with ash. Many interbeds occur, some with scoured bases, of normally graded, sandy volcanic silt with foraminifers occur indicating sedimentation on a slope with possible turbidity transport. A greater influence of volcanic sedimentation, as indicated by ash layers, appears to have occurred at Site 828 during the Pleistocene, indicating proximity to a volcanic source.

Although logging was not done at Site 828 because of hole problems, physical-properties measurements and fluid chemistry assisted in the definition of the lithostratigraphic units. Magnetic susceptibility and porosity curves correlate well with the four lithostratigraphic units. Distinct "kicks" are given on both curves, and magnetic susceptibility remains high throughout Unit I, reaching zero at Unit II, increasing slightly through Unit III, and becoming high again in Unit IV. Porosity increases slightly in Unit I from about 61% to 63% with an anomalous low peak at about 18 mbsf, varying considerably from 50% to 93% in the soupy foraminiferal ooze of Unit II, remaining fairly constant between 62% to 64% in the nannofossil chert of Unit III, and exhibiting a sharp divergence of 66% to about 36% in volcanic breccia of Unit IV.

Interstitial fluids of Hole 828A have chloride concentrations that reach values at 50 mbsf of 570 mM, approximately 2% higher than seawater, which may result from local ash alteration or perhaps mixing with chloride-rich fluids from the accretionary wedge. Potassium, sodium, and magnesium decrease with depth, whereas calcium concentrations increase. This may result from diagenetic exchange reactions with the volcanic-ash-rich sediments and basement igneous rocks.

Initial examination of the cores from Site 828 suggests that the eastern terminus of the NDR formed in close association with a volcanic island arc. Igneous rocks recovered in both Hole 828A and Hole 828B indicate that the ridge may have originated along a subduction zone as proposed by Daniel et al. (1977) and Maillet et al. (1983). From late Eocene to early Oligocene time, volcanic breccia and lava flows built up the flank of the ridge of Site 828 where the highly oxidized volcanic rubble was drilled. Subsidence of the ridge then occurred, followed by the deposition of over 21 m of pelagic nannofossil ooze during early to late Oligocene time (~7-12 Ma.). This was a time of low deposition rate as indicated by the ~5 m/yr average sediment accumulation rate and the presence of small manganese nodules found in Unit III. At some point between late Oligocene and late Miocene time, probable elevation, and perhaps emergence, of the NDR took place, causing complete removal or nondeposition of sediment, thus producing the 18-m.y. hiatus.

Subsidence recurred with slow deposition of the pelagic foraminiferal ooze during late Miocene to early Pliocene time. This unconsolidated, highly permeable unit is an aquifer that may facilitate transport of fluids away from the subduction zone. Sometime during the Pliocene, sea level fell or elevation may have once again occurred, perhaps in association with the arrival of the present eastern terminus of the NDR, including the location of Site 828, at the outer bulge, causing erosion or preventing deposition to produce the hiatus of 3-5 m.y.

The sedimentation rate during the Pleistocene increased considerably to ~60 m/m.y. with the influx of volcanic silts and ash. This was most likely in response to the convergence of the NDR, including Site 828, with the New Hebrides Island Arc. Sedimentation was influenced both by ash fall and hemipelagic contribution from the active volcanoes of the arc. Geochemical analyses of some of the Pleistocene ashes indicate that they originated from explosive events associated with the volcanically active Central Chain, some 150 km to the southeast. Site 828 is currently about to be subducted beneath the forearc of the central New Hebrides Island Arc and appears to be undergoing initial tensional faulting in response to the bending of the lithosphere in this area.

SITE 829

We arrived at Site 829 (proposed side DEZ-2) on 27 October 1990 at 1930 UTC. After 10 days and 1.5 hrs on site drilling three holes (Holes 829A, 829B, and 829C) we departed Site 829 at 1230 UTC on 5 November 1990. We were forced to abandon Hole 829A because of hole collapse and filling problems at a depth of 590.3 mbsf. Hole 829B was aborted because a core barrel bent on the steeply sloping seafloor. Hole 829C was completed in a hard zone (58.4 mbsf) where the APC could not penetrate further.

Site 829 is located within the collision zone of the DEZ along the forearc slope of the New Hebrides Island Arc where the North d'Entrecasteaux Ridge (NDR) impinges upon the arc-slope, approximately 3 km south of Site 827 and about 35 km west of Espiritu Santo Island, Vanuatu (Fig. 2). This site was located very close to the original proposed site (DEZ-2) along a single-channel seismic-reflection line surveyed by the *JOIDES Resolution* prior to spudding in at Site 827. The site selected lies on a very narrow (~200-m-wide) shelf protruding out from a 10° slope. We were able to spud in without difficulty on our first try, and cored to 590.3 mbsf, recovering 197.44 m of core for a recovery rate of 33.4%. Hole 829B was drilled and cored to 19.5 mbsf, recovering 15.59 m for an 80% recovery rate; Hole 829C was cored to 58.4 mbsf, recovering 52.67 m of core for a 90.2% recovery rate (Table 1). The intent of drilling a second and third hole at this site was to recover cores with the APC in the upper 100 m of section that was poorly recovered during the RCB-drilling of Hole 829A. Oriented cores for paleomagnetic analyses and structural examinations were taken, and whole-round core samples for both fluid analyses and physical-properties measurements were obtained. This was our second attempt to drill to the décollement in the DEZ-New Hebrides Island Arc collision zone. Although hole collapse prevented the penetration of the décollement, we successfully cored the overlying thrust sheets and accretionary prism and may have entered the upper reaches of the décollement zone.

Lithostratigraphic examination of the sedimentary and igneous rocks recovered at Site 829 indicate that the sequence can be divided into 21 lithostratigraphic units (Units I-XXI) that are repeated throughout the core. Because of these repetitions, the lithostratigraphic units can be divided into four composite units (Bigwan Wan, Bigwan Tu, Bigwan Tri, and Bigwan Fo named in Bislama, the official language of Vanuatu). These composite units are defined on the basis of age and lithologies. Bigwan Wan is a Pleistocene volcanic silt, sandstone, and gray silty chalk. Bigwan Tu is an upper Oligocene to lower Miocene foraminiferal and calcareous chalk. Bigwan Tri is an upper Pliocene or Pleistocene chalk breccia with upper Oligocene to lower Miocene clasts. Bigwan Fo is a volcanic breccia of unknown age with clasts of volcanic-rock fragments, microgabbros, gabbros, and basalts. At least 5 major thrust faults and 7 minor thrust faults separate the lithologic units within the sequence and bound 7 tectonic units (A-G); tectonic Unit E is subdivided into 2 subunits (Subunits E_1 and E_2), based on the presence of major thrust faults. These tectonic units are progressively more deformed downhole.

The lithologic units are defined on the basis of lithology, carbonate vs. volcanic composition, and structural relationships. Lithostratigraphic units are numbered consecutively starting with Hole 829A and ending with Hole 829C. In Hole 829A, lithostratigraphic Unit I (0-60.5 mbsf; Bigwan Wan, tectonic Unit A) is composed of Pleistocene clayey volcanic silt, siltstone, and sandstone. Lithostratigraphic Unit II (60.5-

99.4 mbsf; Bigwan Tu, tectonic Unit A), based on fragments recovered from a poorly recovered zone, is an upper Oligocene to lower Miocene foraminiferal chalk. Lithostratigraphic Unit III (99.4-171.9 mbsf; Bigwan Wan, tectonic Unit B) is a Pleistocene clayey volcanic silt and sandstone. Lithostratigraphic Unit IV (171.9-205.2 mbsf; Bigwan Tri, tectonic Unit C) is a siltstone chalk breccia composed of angular clasts of calcareous volcanic sandy siltstone and calcareous chalk that is separated from overlying Unit III by a minor thrust-faulted contact.

Lithostratigraphic Unit V (205.2-301.3 mbsf; Bigwan Tri, tectonic Unit C) consists of upper Pliocene or Pleistocene breccia with upper Oligocene to lower Miocene clasts. Lithostratigraphic Unit VI (301.3-397.5 mbsf; Bigwan Tu, tectonic Unit D) consists of middle Oligocene to lower Miocene calcareous chalk that is separated from underlying Unit VII by brown clay laminae.

Lithostratigraphic Unit VII (397.5-407.4 mbsf; Bigwan Fo, tectonic Unit D), a volcanic breccia of unknown age, is composed of igneous rock clasts in a matrix of calcareous silty clay with sedimentary fragments. The igneous clasts include aphyric to sparsely phyric basalts, pyroxenite, and serpentinite. It is a poorly recovered zone that appears to be highly sheared and fractured, exhibiting microfolds and reverse faults with a major thrust located near the base of the unit.

Lithostratigraphic Unit VIII (407.4-408.0 mbsf; Bigwan Tri?, tectonic Unit E_1) is a small (0.6-m-thick) sliver of lower Pliocene chalk. Lithostratigraphic Unit IX (408.0-421.5 mbsf; Bigwan Tu, tectonic Unit E_1) is a Pleistocene calcareous silty mixed sediment. Lithostratigraphic Unit X (421.5-427.4 mbsf; Bigwan Tu, tectonic Unit E_1) is a highly tectonized pale brown Oligocene chalk with a 14-cm-thick brown clay layer that marks a major thrust fault at the base of the unit.

Lithostratigraphic Unit XI (427.9-445.8 mbsf; Bigwan Wan, tectonic Unit E_2) is a Pliocene(?) or Pleistocene dark gray silty chalk. Lithostratigraphic Unit XII (445.8-463.0 mbsf; Bigwan Tu, Tectonic Unit E_2) is an Oligocene pale brown chalk with brown clay laminae at its base and lies within a major northeast-dipping thrust-fault zone. Beneath this thrust contact lies lithostratigraphic Unit XIII (463.0-484.6 mbsf; Bigwan Wan, tectonic Unit F), a Pliocene or Pleistocene calcareous volcanic sandstone with sand-sized clasts of pumice, wood, and chalk, some of Oligocene age. Lithostratigraphic Unit XIV (484.6-494.1 mbsf; Bigwan Tu, tectonic Unit F) is an Oligocene brown, white, and pale brown chalk and brown mixed sediment with a major thrust fault at its base that separates this unit from underlying Unit XV. Lithostratigraphic Unit XV (494.1-517.2 mbsf Bigwan Wan, tectonic Unit G) is a sandy volcanic siltstone of Pliocene or Pleistocene age and is separated from underlying Unit XVI by an interval of sandy brown clay.

The final unit in Hole 829A is lithostratigraphic Unit XVI (517.2-590.3 mbsf; Bigwan Fo, tectonic Units G and H), an interval of unknown age that is composed of alternating layers of sed-lithic breccia with igneous fragments and basalts, microgabbro, and gabbro. Preliminary geochemical studies suggest affinities with the igneous rocks from Site 828 on the North d'Entrecasteaux Ridge. Thus, we suspect that the drill may have penetrated the upper surface of the décollement, or was quite close to it.

Lithostratigraphic Unit XVII (0-19.5 mbsf; Bigwan Wan, tectonic Unit A), the only unit defined in Hole 829B, is a Pleistocene clayey sandy volcanic silt that may be correlated with lithostratigraphic Unit I.

In Hole 829C, four additional lithostratigraphic units are defined (Units XVIII-XXI). Lithostratigraphic Unit XVIII (19.7-53.0 mbsf) contains Pleistocene clayey, sandy, volcanic silt and clayey volcanic silt with a basal interval of silty foraminiferal mixed sediment; this unit correlates with Unit I of Hole 829A and is a member of Bigwan Wan and tectonic Unit A. Lithostratigraphic Unit XIX (53.0-57.3 mbsf) is a lower Miocene foraminiferal ooze; this unit is correlatable with lithostratigraphic Unit II in Hole 829A and is a member of Bigwan Tu and tectonic Unit A. Lithostratigraphic Unit XX (57.3-58.4 mbsf) is a Pliocene(?) silty foraminiferal mixed sediment that belongs to Bigwan Wan and tectonic Unit A. Lithostratigraphic Unit XXI (58.4-58.8 mbsf) is a foraminiferal chalk found at the total depth of Hole 829C.

Initial interpretations of the cores suggest that many of the units identified in Hole 829A are similar to those observed in Hole 828A. For example, the calcareous chalk and the pale brown chalk of Bigwan Tu are similar in age and lithology to the nannofossil chalk of lithostratigraphic Unit III from Hole 828A. Igneous rocks collected at both Sites 828 and 829 are similar. Therefore, we tentatively conclude that we drilled through an accretionary prism that is composed in part of offscraped rocks and sediments from the downgoing NDR. As at Site 828, a middle-upper Miocene hiatus appears to exist at Site 829.

Foraminifers and nannofossils provided the best source of age information, based primarily on core-catcher samples. Unconsolidated samples recovered were principally of Pleistocene age; some material of Pliocene age was also found. The more lithified samples of calcareous chalk revealed an age of Oligocene to possible early Miocene and Eocene. Paleomagnetic polarity is normal (Bruhnes chron) from 0 to 50 mbsf; below this depth cores were too tectonically deformed for accurate measurements to be made. At a depth of about 400 to 460 mbsf, viscous remanent magnetization was used to orient cores. At 100-150 mbsf the volcanic silt (Subunit IA) showed very high magnetic-susceptibility values; susceptibilities of different lithologic units are quite distinct.

Analyses of fluids from whole-round samples of the core indicate a sharp decrease in magnesium concentration within the upper 10 m, suggesting a high fluid flux up through the sediments. Chloride was constant from 0 to 250 mbsf. Solutes related to organic carbon appear low in the upper 100 m of core (in lithostratigraphic Units I and II) but increase in concentration beneath the thrust fault that separates Units I and II. Beneath this fault, to a depth of about 500 mbsf, the core is extremely dry and devoid of water. However, below this depth, the fluid content increases, minor amounts of methane occur, and chloride concentrations are low. Initial interpretations indicate that Hole 829A may have terminated close to the décollement because the fluid chemistry, showing an increase in methane accompanying low chloride concentration, is similar to that found along other subduction zones such as Barbados (Mascle, Moore, et al., 1988) and Nankai (Taira, Hill, et al., in press). The brecciated sequence (Unit XVI, 517.2-590.3 mbsf) may then represent the sheared and deformed rocks that lie within the décollement just above the basement rocks of the NDR. Above the wet zone, the area of dry rocks suggests that dewatering has taken place here, being the result of compressional pressures exerted onto the forearc slope by the impingement of the NDR. Fluid migration may be taking place along the thrust fault (100 mbsf) that separates Unit II from Unit III.

Extensive logging was done in Hole 829A and provided excellent results. The digital borehole televiewer (BHTV) and magnetic susceptibility tool were run for the first time in ODP and resulted in the collection of good data that appear to correlate well with the formation microscanner (FMS) and other logging tools. The FMS, seismic stratigraphy combination, and geochemical tools correlated very well with each other and the lithostratigraphic units. Thrust faults and lithologic contacts were well defined in all logs collected. Physical-property measurements of the cores in Hole 829A also show excellent correlation with the lithostratigraphic units. Calcium carbonate measurements correlate well with water-rich zones defined by the fluid analyses.

SITE 830

Site 830 (proposed site DEZ-4) is located at 15°57.00'S, 166°46.78'E to 15°57.00'S, 166°46.70'E in water depths ranging from 1018.4 to 1008.9 mbsl. This site is located on the forearc slope of the central New Hebrides Island Arc immediately east of where the Bougainville Guyot is impinging upon the forearc slope, 30 km south of the southern tip of Espiritu Santo Island and 6.5 km east of the Australia-India convergence boundary (Fig. 2). Here the d'Entrecasteaux Zone (DEZ) is colliding with the arc. East of the point of impingement, the upper forearc slope is folded and faulted, with the most intense area of deformation being immediately east of the impact zone, in an area that exhibits an anticlinal dome. To the east of the anticlinal dome a series of imbricate thrust sheets, gently dipping to the east, can be seen in the seismic reflection profiles. Site 830 is located just east of the anticlinal dome and at the westward toe of the most westerly thrust sheet.

Three holes were drilled at Site 830. Hole 830A was drilled and cored with the APC and XCB to 96.9 mbsf, recovering 53.77 m for a recovery rate of 55.5%. Hole 830B was washed to 48.5 mbsf and drilled with RCB to a total depth (TD) of 281.7 mbsf, but cored only 233.2 m, recovering 48.77 m for a recovery rate of 20.9%. Hole 830C was washed to 235.0 mbsf and drilled with RCB to a TD of 350.6 mbsf, cored 115.6 m, recovering 19.4 m for a 16.8% core-recovery rate (Table 1).

Two major lithostratigraphic units were defined and described for this site (Fig. 3). Lithostratigraphic Unit I (0-174.9 mbsf) is a very dark gray volcanic silt and siltstone of Pleistocene age that is subdivided into three subunits. Subunit IA consists of a 21-m-thick fine-grained, nearly structureless, unlithified silt; it appears to represent a near sea-surface, oxidized former sediment/water interface overlain by a turbidite, the upper 9.5 m being a calcareous volcanic silt. Subunit IB is a 26.5-m-thick clayey sandy silt with numerous normally graded interbeds of black sand. Subunit IC is a 127.4-m-thick sequence of interbedded sandy silt and sands.

Lithostratigraphic Unit II (174.9-350.6 mbsf) is a colorful sequence of partially lithified, very poorly sorted, very coarse, volcaniclastic, silty sed-lithic sandstone. The sequence is highly altered and contains intervals of grayish green to greenish gray and reddish black clayey silts, isolated pebbles of volcanic rocks, and fine-grained, well-lithified volcanic sandstone and breccias. The upper (174.9-184.9 mbsf) part of the unit is a volcanic breccia with 3-5-cm-sized clasts of breccia and sandstone. Two types of igneous rocks are found in Unit II, lavas and volcanic breccia. The lavas are commonly andesite, but moderately olivine-clinopyroxene-phyric basalts are also included. The volcanic breccia is composed of volcanic-rock fragments; two fragments of fine-grained gabbro were found within this breccia. Rocks of Unit II appear to be the product of explosive events, based on the brecciated and quenched nature of the rock, perhaps formed in association with the volcanic activity that built Espiritu Santo and Malakula islands. The petrology of Unit II is similar to the monolithic volcaniclastic coarse breccias of the lower Miocene Buvo Division of the Lower Santo Volcanics Subgroup exposed along the southwest end of Espiritu Santo Island that were derived by fragmentation of basaltic and andesitic lavas and regarded as submarine accumulations near volcanic source vents (Mallick and Greenbaum, 1977). Similar types of rocks were formed in the central region of Malakula Island and consist of volcanic breccias and sorted and unstratified submarine and subaerial autobreccias of the lower Miocene Matanui Volcanic Series, which are the product of submarine volcanoes (Mitchell, 1971). In addition, patches of highly oxidized volcanic matrix observed throughout Unit II suggest that subaerial erosion may have taken place.

Structural analyses of cores obtained at Site 830 indicate that the stratigraphy can be divided into two tectonic units. These tectonic units correlate well with the lithostratigraphic units; tectonic Unit A corresponds with lithostratigraphic Unit I, and tectonic Unit B corresponds with lithostratigraphic Unit II, the boundary of the two units being at 174.9 mbsf. Tectonic Unit A is disturbed only by minor, steeply dipping faults and fractures, whereas tectonic Unit B has undergone cataclastic deformation. In the upper part of tectonic Unit A, bedding attitudes vary from horizontal at 15 mbsf and 45° to 80 mbsf to a range of 5°-40° SE dip at 15 to 45 mbsf, based on structural analyses. Tectonic Unit B (lithostratigraphic Unit II) is a coarse-grained, volcaniclastic, silty sed-lithic sandstone that has undergone brittle deformation and is considered a cataclasite. The distinct differences in the tectonic style of the two units at this site suggest that either tectonic Unit A (lithostratigraphic Unit II) was structurally deformed before deposition of tectonic Unit B (lithostratigraphic Unit I) or that differential deformation of both units may have occurred within a common stress field.

Nannofossil and foraminiferal biostratigraphic analyses indicated that lithostratigraphic Unit I is Pleistocene in age; however, due to barren samples in Unit II, age could not be determined. Both reworked Pliocene foraminifers and reworked Miocene and Pliocene nannofossils were found throughout the samples examined at Site 830. Paleomagnetic studies indicate that strata cored within lithostratigraphic Unit I (0-30 mbsf) were deposited during the Brunhes Chron. On the basis of benthic foraminifers the depositional environment of lithostratigraphic Unit I appears to have been in the middle bathyal zone. Because of the poor age calls, accurate sediment-accumulation rates could not be determined.

Initial interpretation of the cores obtained at Site 830 and preliminary comparison with rock units defined on the islands (Mitchell, 1971; Mallick and Greenbaum, 1977) indicate that the sedimentary rocks penetrated by the drill are derived from the New Hebrides Island Arc and appear to have been deformed by the collision of the DEZ, and more recently by the Bougainville Guyot. Seismic-reflection profiles show the location of this site to be near the western edge of a gentle, easterly dipping thrust sheet, one of several imbricated thrusts that accommodate the foreshortening of the forearc slope by collisional processes. A series of east-dipping reflectors exists at the site, and two strong reflectors, one at 1.5 s and another at 2.0 s (two-way traveltime), were the objectives of drilling. These reflectors are interpreted as stratigraphic horizons, wholly within arc rocks and disrupted by thrust faulting, that represent surfaces of carbonate blocks or the debris apron of the subducted and buried eastern part of the guyot accreted to the arc. Due to hole collapse, we were unable to reach these deeper reflectors and confirm the existence of guyot fragments. However, we did penetrate the upper surface of the shallower strong reflector (1.5 s). The existence of a cataclasite at this horizon suggests that severe mechanical stress has occurred here, perhaps along the plane of the stratigraphic horizon (bedding plane movement) and in association with the foreshortening of the forearc.

Lithostratigraphic Unit II is a very poorly sorted, very coarse volcaniclastic sand with an overlying volcanic breccia and sandstone of unknown age that has been subjected to cataclastic deformation. Severe mechanical stress within Unit II has sheared fractured New Hebrides Island Arc rocks, and most likely this unit represents a primary deformation zone associated with the foreshortening of the arc slope. Lithostratigraphic Unit I overlying the cataclasite appears to represent volcanic silts and sands that have been eroded from the arc and deposited along its forearc by turbidity currents during Pleistocene time. Alternating grain size suggests either changes in source or shifts in the slope where deposition took place. Although tectonic deformation observed in the lithostratigraphy of Site 830 appears to be associated with the collision of the DEZ, and more recently, perhaps, with the Bougainville Guyot, actual timing of this deformation is difficult to determine based on the data available solely from this site.

The study of pore fluids in samples obtained from the cores at Site 830 were found to be significant in the understanding of diagenetic and hydrologic origins of fluids in accretionary wedges. Similar to what has been found in other accretionary wedges, such as in the Barbados (Biju-Duval, Moore, et al., 1983; Mascle, Moore, et al., 1988) and Nankai (Taira, Hill, et al., in press) regions, dewatering of the sediments appears to have occurred as the water yield decreased sharply from the seawater interface to 50 mbsf, but chlorides increased in Hole 830B to 620 mM at 214 mbsf in lithostratigraphic Unit II, within the cataclasite of tectonic Unit B. Methane concentrations from headspace samples were higher at this site than those observed in any of the previous sites of this leg. This methane was found within lithostratigraphic Unit I, but not along the cataclastic zone. Along with this methane, at 30-90 mbsf, heavier hydrocarbons (ethane and propane) were found; another strong maximum of methane, without the heavier hydrocarbons, however, was also found at 145 mbsf. At these depths the foraminifer Bulimina striata, which may indicate the existence of methane during the time of deposition (Akimoto, 1990), was found in the cores as well. The steepest concentration gradients of magnesium, calcium, sodium, and potassium found at Site 830 occurs across the contact of lithologic Units I and II. This is attributed to the alteration of volcanic ash and basement rocks beneath the contact with diffusion away from the zones of intense reaction. The deepest sample taken at this site contains an extraordinarily high calcium concentration of 229.2 mM.

The extreme fluid compositions witnessed at Site 830 may result from the intense tectonic deformation that is occurring from the impact of the Bougainville Guyot with the New Hebrides Island Arc. A strong decrease in water content downsection implies compressional dewatering. Fracturing of volcanic rocks from collision facilitates increased alteration and fluid flow. Foreshortening of the forearc, resulting in the formation of imbricate thrust sheets, appears to have stacked small fragments of highly fractured basement rocks on fluid-rich sediments. The sandy intervals then form conduits for flow of the mineral-rich fluids, and the thrust zones themselves also act as conduits.

SITE 831

Site 831 (proposed site DEZ-5) is located at 16°00.56'S, 166°40.36'E in water depth of 1066.4 mbsl. This site is located in the center of the summit platform of Bougainville Guyot, about 42 km southwest of the southern tip of Espiritu Santo Island, about 5 km west of the collision zone between the Bougainville Guyot and the New Hebrides Island Arc and approximately 15 km due west of Site 830 (Fig. 2). The Bougainville Guyot is a carbonate-capped, flat-topped seamount that represents the eastern end of the South d'Entrecasteaux Chain (SDC). It is being subducted beneath, or accreted to, the New Hebrides Island Arc where it impinges upon the forearc slope, forming a 10-km indentation. In response to the eastward-dipping subduction zone, the carbonate cap of the guyot is tilted ~5° to the east. Seismic-reflection profiles indicate that about one-third of the guyot is buried beneath sediments of the forearc (Fisher, M. A., et al., in press.). Seismic-reflection data also show that about 700 m of well-layered sediments make up the carbonate cap, and these data, along with SeaBeam data, dredge samples, and submersible observations and sampling, show the cap to be lagoonal deposits in an atoll setting (Daniel et al., 1986; Collot et al., 1989; Fisher et al., in press.). Site 831 drilled this lagoon.

Two holes were drilled at Site 831. Hole 831A was drilled to a total depth (TD) of 116.5 mbsf with 115.5 mbsf cored and only 25.85 m of core recovered for a recovery rate of 22.4%. Hole 831B was drilled to a TD of 852 mbsf, washed down to 102.4 mbsf and cored for 749.6 m recovering only 87.25 m of core for an 11.6% core-recovery rate (Table 1).

Four major lithostratigraphic units were defined and described from the two holes of Site 831 (Fig. 3). Lithostratigraphic Unit I (0-16.8 mbsf) is a 16.8-m-thick Pleistocene pelagic, brown foraminiferal ooze with partially lithified grainstone clasts. This unit has an upper (0.4-3.0 mbsf) sed-lithic conglomerate layer and grades downhole into a light yellowish brown bioclastic foraminiferal ooze. Pteropods are especially abundant in the upper part of Hole 831A and were found to constitute an ooze that contains thin laminae of volcanic ash. A prominent black ash layer is present at 14.4 mbsf and is composed of pale brown glass (53%) and opaque grains (25%) that may have resulted from reworking or fractionation during subaerial or submarine settling. The contact between lithostratigraphic Units I and II is marked by an abrupt faunal transition from pelagic microfossils of Unit I to neritic microfossils of Unit II.

Lithostratigraphic Unit II (16.8-429.6 mbsf; 429.6 m thick) is identified and described from both holes at Site 831 (16.8-100 mbsf, Hole 831A; 102.4-256.0 mbsf, Hole 831B) and is a neritic carbonate deposit with a wide diversity of shallow-water organisms. The unit has also been divided into four subdivisions. Subunit IIA (16.8-100 mbsf) is an 83.2-m-thick Pleistocene white coral and bioclastic grainstone and foraminiferal wackestone; it contains specimens of *Acropora* and *Porites* corals. Subunit IIB (102.4-256.0 mbsf) is a 153.6-m-thick Pliocene(?) to Pleistocene coral rudstone and mollusc floatstone with fragments of white *Acropora* and *Porites* corals and a large fragment of a tridacnid shell; the mollusc floatstone is partially lithified by marine cementation and has abundant primary porosity. Subunit IIC (256.0-352.3 mbsf) is a 96.3-m-thick coral rudstone and mollusc floatstone of indeterminate age with extensive carbonate dissolution (moldic and vuggy porosity forms 10%-15% of the rock); a well-preserved *Porites* head coral and tridacnid shell fragment were recovered from this unit. Subunit IID (352.3-429.6 mbsf) is a 77-m-thick white well-lithified bioclastic floatstone of indeterminate age with marine and abundant secondary carbonate cement that may have been deposited by meteoric waters.

Lithostratigraphic Unit III (429.6-727.5 mbsf) is a 297.9-m-thick neritic carbonate rock that contains an abundance of molluscs and large benthic foraminifers. The contact between lithostratigraphic Units II and III is a distinct facies change; Unit II is a coral- and mollusc-rich facies, and Unit III is a mollusc- and foraminifer-rich facies. This contact is also distinguishable by a sharp increase in carbonate dissolution and cementation. Lithostratigraphic Unit III is further subdivided into four subunits. Subunit IIIA (429.6-592.6 mbsf) is a 163-m-thick white bioclastic floatstone of indeterminate age that is highly altered and extensively dissolved with abundant secondary cement and contains coralline algae; this subunit was hard to drill. Subunit IIIB (592.6-621.6 mbsf) is a 29-m-thick lower Miocene well-cemented bioclastic floatstone and foraminiferal grainstone with abundant vuggy and moldic porosity; mottling suggests burrowing (bioturbation); this subunit was easily drilled compared to Subunits IIIA and IIIC. Subunit IIIC (621.6-669.2 mbsf) is a 47.6-m-thick upper Oligocene white to very pale brown bioclastic and foraminiferal grainstone with minor amounts of moldic porosity; this subunit was hard, and drilling was slow. Subunit IIID (669.2-727.5 mbsf) is a 58.3-m-thick upper Oligocene well-lithified bioclastic and algal packstone and foraminiferal grainstone with distinct burrowing in the packstone. This subunit has marine cement and abundant veins of chlorite; 40% of the rock is composed of coralline algae (both encrusting and branching forms), and 15% of the rock shows moldic and vuggy porosity. Two soil horizons occur within Subunit IIID: the first consists of a reddish brown silty clay, *sensu stricto* terra rosa, with high water content (45%) and porosity (57.7%) and a low bulk density (1.90 Mg/m^3) at 688.3 mbsf, and the second horizon is a very pale brown foraminiferal wackestone with yellowish brown and red streaked clays at 707.3 mbsf that has a lower water content (11.8%) and porosity (25.5%) and a higher bulk density (2.46 Mg/m^3) than the upper soil horizon.

Lithostratigraphic Unit IV (727.5-852 mbsf) is an andesitic hyalo-breccia composed of two-pyroxene andesite clasts or blebs in a matrix of lithic fragments, crystals, and glass; in places it is a palagonite breccia. Hole 831B penetrated 125 m of the andesites; the TD of the hole is within this unit at 852 mbsf. Unit IV is barren of microfossils, and hence its age cannot be determined. Five subunits were defined for Unit IV based on what appears to be a cyclicity of eruptive events or depositional conditions. Subunit IVA (727-741 mbsf) is a 14-m-thick andesitic breccia with thin beds of reworked grit and sandstone, strongly oxidized at the top of the subunit (probably the result of subaerial weathering); large clasts of volcanic fragments become progressively more abundant (20%) near the bottom of the subunit. Subunit IVB (741-789 mbsf) is a 48-m-thick andesite breccia composed of subrounded, wispy andesite blebs within a pale green matrix. Subunit IVC (789-822.3 mbsf) is a 33.3-m-thick coarse-grained breccia that includes pale reddish fragments interbedded with grits and sandstone. Subunit IVD (822.3-838 mbsf) is a 9.7-m-thick breccia that consists almost exclusively of well-defined gray, fresh andesite blebs with distinct coronas or reaction rims in a grayish matrix; near the base (837 mbsf), blebs become more diffuse and exhibit irregular or wispy outlines. Subunit IVE (838-852 mbsf) is a 14-m-thick breccia with reddish lava fragments in a pale green matrix that includes abundant sand-sized fragments of lava with varying degrees of oxidation. Cross-bedded sandstone and grits mark the base of this subunit.

Nannofossils and foraminifers, including large foraminifers preserved in the neritic carbonate rocks, are the best indicators of age. However, due to the soupy nature of much of the pelagic carbonate sequence and poor core recovery of the neritic carbonate sequence, dating of cores was sketchy at best. Only the upper 20 m could be dated by both nannofossils and foraminifers. Assemblages of microfossils analyzed in cores from Site 831 revealed an age of Pleistocene for lithostratigraphic Unit I (0-16.8 mbsf) and the upper part (16.8-20 mbsf) of Unit II. The middle part of Unit II (20-246.4 mbsf) was dated as Pliocene or Pleistocene. From 246 to 563.6 mbsf (the lower part of lithostratigraphic Unit II to the upper part of Subunit IIIA) the cores were barren of microfossils, and their age cannot be determined. From 563.6 to 621.6 mbsf (lithostratigraphic Unit III, from the lower part of Subunit IIIA through Subunit IIIB) an early Miocene (~21.8-23.6 Ma) age was determined based on large foraminifers. Finally, from 621 to 735.7 mbsf (lithostratigraphic Units III and IV, Subunits IIIC, IIID, and the upper part of IVA) a late Oligocene (~23.6-28.2 Ma) age was made based on large foraminifers; this interval includes the base of the carbonate sequence and the upper surface of the andesite basement rocks.

Depositional environments for the 727.5 m of epiclastic, hemipelagic, and carbonate sediments overlying the andesitic basement rocks of Bougainville Guyot were determined using benthic foraminifers in epiclastic and hemipelagic sequence, and corals and larger foraminifers as well as the type of carbonate cementation (marine or meteoric) within the carbonate sequence. The Pleistocene pelagic sediments in the upper part (0-6.4 mbsf) of lithostratigraphic Unit I (Subunit IA) were deposited in the middle bathyal zone (500-2000 mbsl) and Subunit IA sediments from 6.4 to 15.0 mbsf were deposited in an outer sublittoral zone. At 16.9 mbsf, foraminifers indicate that a shallow lagoon environment existed prior to the drowning of the guyot. From 16.9 to 246.4 mbsf, Subunits IIA and IIB were deposited in an inner sublittoral environment. Below 246.4 mbsf, an inner or outer sublittoral zone appears to be the depositional environment based on both smaller and larger foraminifers. Lithostratigraphic Subunits IIC and IID (256-429 mbsf) appear to have been deposited in a shallow-water environment based on the presence of shallow-water fauna. At 612 mbsf, a foraminiferal assemblage indicates an inner shallow platform condition. Pervasive alteration and abundant secondary cement within lithostratigraphic Unit III (429.5-592.5 mbsf) suggest subaerial or near-surface conditions with alteration from meteoric processes.

Only two pore-fluid samples were collected from cores obtained at Site 83l. Both samples exhibited solutes that approximate seawater concentrations with the exception of magnesium, calcium and sulfate. Calcium is slightly enriched at 135 mbsf, and magnesium is depleted, suggesting calcium carbonate diagenesis. Organic-carbon contents are low, which may account for the minor sulfate reduction.

Based on the preliminary interpretation of the drilling results from Site 831 a general geologic history of the Bougainville Guyot can be inferred. In late Oligocene time, or sometime prior to this time, late-stage volcanic eruptions completed the building of the submarine edifice or island that has become Bougainville Guyot. Andesitic hyalo-breccias were emplaced in a manner similar to the formation of pillow lavas and the associated hyaloclastic deposition. Chilled margins or coronas around the clasts of the breccia suggest that miniature pillows developed and that the quenching in seawater caused chilled rinds to spall and to be incorporated into a glassy matrix. Oxidized clasts and more vesicular fragments suggest a shallow-water origin and perhaps the input of subaerial material from an island source. The minimum depth of deposition is, therefore, estimated to be around a few hundred meters. The wispy shapes of the blebs suggest that the magma was still reasonably fluid or plastic at the time of deposition. Deposition of this volcanic rock probably formed an apron around the submarine volcano with some of the more chaotic breccias having been deposited by avalanches or debris flows. Petrographic characteristics of the two-pyroxene andesites show calc-alkaline or island-arc tholeiite affinity, indicating that the guyot is unequivocally of island-arc origin.

The Bougainville Guyot appears to have formed along a volcanic island arc that is represented by the SDC. As proposed by Daniel et al. (1977) and Maillet et al. (1983), the DEZ may be an Eocene subduction/obduction zone. The oxidized andesitic rocks of the guyot indicate that the guyot was probably an island prior to subsidence in late Oligocene time, when it started accumulating the 727.5 m of carbonate rocks. Neritic carbonate sediments were deposited from Oligocene to early Miocene time, and at least two episodes of emergence, as indicated by the soil horizons at 688.3 and 707.3 mbsf, occurred during this time. No middle to upper Miocene sediments were identified; the possible absence of these sediments on the guyot implies the presence of a major Miocene hiatus similar to that observed at Site 828 and at DSDP Site 286 (Andrews, Packham, et al., 1975). This hiatus may coincide with a facies change in the neritic carbonate sequence at 429.6 mbsf: a coral and mollusc facies (20-429.6 mbsf) overlying a mollusc and foraminifer facies (429.6-727.5 mbsf). The Pliocene to Pleistocene neritic carbonates represent lagoonal sediments associated with an atoll. Eastward transport of the guyot upon the Australia-India Plate is documented by its submergence/emergence history. As the guyot approached the outer rise of the New Hebrides Island Arc it became quite shallow, similar to the condition that Sabine Bank is experiencing today (Dubois et al., 1988). Then, in late Pliocene (~2 Ma) or early Pleistocene time, the shallow-water carbonate platform drowned as indicated by the foraminiferal assemblage recovered from 30 mbsf. Foraminiferal assemblages examined from cores at 20 mbsf indicated that paleodepths were no greater than about 100 mbsl. Major subsidence, or sea-level rise, and pelagic sedimentation occurred throughout the Pleistocene as indicated by the foraminiferal assemblages examined from 20 to 4.5 mbsf. Ash layers found within the pelagic sediments between 0 and 15 mbsf exhibit the influence of volcanic events along the Central Chain of the New Hebrides Island Arc on the guyot. Pelagic deposition and continued subsidence represent the transport of the guyot away from the outer rise and down the subduction zone to its present position on the forearc slope.

SITE 832

We arrived at Site 832 (proposed site IAB-1) on 21 November 1990 at 0645 UTC. After 10 days and 15.5 hr on site drilling two holes (Holes 832A and 832B) we departed Site 832 at 2215 UTC on 1 December 1990. Because we penetrated into older sedimentary rocks sooner than expected in Hole 832B and were having good core recovery, we requested and received permission to drill past 700 mbsf. The early recovery of upper Pliocene or lower Pleistocene sediments at about 550 m suggested that the intra-arc basin of the central New Hebrides Island Arc may have formed earlier than most workers anticipated. We were unable to log Hole 832B as fully as desired because of infilling problems in the upper part of the hole, near the seafloor.

Site 832 is located on the flat intra-arc basin floor at 3089.3 mbsl in the central part of the North Aoba Basin (NAB), approximately 50 km northeast of the Queiros Peninsula of Espiritu Santo Island and 45 km due south of the smoking volcanic island of Santa Maria (Gaua) (Fig. 2). The NAB lies between uplifted bedrock masses of Espiritu Santo and Maewo islands and is separated from the northern Vanikolo summit basin by Santa Maria Island and from the South Aoba Basin (SAB) by the active volcanic island of Aoba.

After a brief seismic-reflection survey to confirm site location, we began drilling without problems. In Hole 832A we cored 215.9 mbsf and recovered 146.26 m of core for a recovery rate of 67.8%. Hole 832B was drilled to a total depth (TD) of 1106.7 mbsf, coring 962.3 m and recovering 450.95 m of core for a recovery rate of 46.9% (Table 1).

Seven lithostratigraphic units were identified in the cores collected at Site 832 (Fig. 3). Lithostratigraphic Unit I (0-206.2 mbsf in Hole 832A; 144.4-385.6 mbsf in Hole 832B) is a 385.6-m-thick series of Pleistocene volcanic clays, silts, and sands; it was subdivided into two subunits (Subunits IA and IB) based on differences in grain size. Subunit IA (0-141.0 mbsf) is a 141-m-thick coarse vitric volcanic-ash layer with sandy to clayey volcanic silts. Subunit IB (141.0-206.2 mbsf in Hole 832A; 144.4-385.6 mbsf in Hole 832B) is a 244.6-m-thick unit similar to Subunit IA but with finer vitric ashes.

Lithostratigraphic Unit II (385.6-461.5 mbsf) is a 75-m-thick Pleistocene sequence of sandstone, siltstone, and claystone largely volcanic in the upper part and more calcareous in the lower part. Lithostratigraphic Unit II is a transitional unit between a more volcanic unit above and a more calcareous unit below.

Lithostratigraphic Unit III (461.5-625.7 mbsf) is a 164.2-m-thick upper Pliocene or lower Pleistocene sequence of chalk, limestone, and calcareous mixed sedimentary rocks interbedded with volcanic siltstone, sandstone and sed-lithic breccia containing volcanic clasts.

Lithostratigraphic Unit IV (625.7-702.0 mbsf) is a 76.3-m-thick upper Pliocene or Pleistocene sequence of basaltic breccias with subordinate volcanic siltstone and sandstone.

Lithostratigraphic Unit V (702.0-865.7 mbsf) is a 163.7-m-thick upper Miocene to upper Pliocene sequence of foraminiferal, nannnofossil, calcareous, and silty limestone with some clayey siltstone, mixed sedimentary rocks, and vitric-ash layers overlying a 1.5-m-thick basaltic breccia.

Lithostratigraphic Unit VI (865.7-952.6 mbsf) is an 86.9-m-thick middle to upper(?) Miocene lithified volcanic sandstone that grades downward to coarser material.

Lithostratigraphic Unit VII (952.6-1106.7 mbsf) is a 154.1-m-thick layer of lithified basaltic breccia with subordinate lithified volcanic sandstone, siltstone, and vitric-ash; the top of the unit is latest early Miocene in age.

Foraminifers and nannofossils were the best source of age information. Abundant to common, well-preserved foraminiferal and nannofossil assemblages were recovered between the seafloor and 840 mbsf in both Holes 832A and 832B. Below this depth only scattered samples of moderately to poorly preserved foraminifers and nannofossils were reported. Two barren intervals were identified (856-923 mbsf and 972-1106 mbsf). Ages assigned to sediments at Site 832 are as follows: Pleistocene (0-~600 mbsf), late Pliocene or early Pleistocene(?) (600-711 mbsf), late Pliocene (711-740 mbsf), early Pliocene (740-856 mbsf), earliest middle Miocene (952-962 mbsf), and latest early Miocene (962-~1000 mbsf). However, the presence of reworked specimens of the larger benthic foraminifers and calcareous nannofossils in samples below 952 mbsf suggests that the host rock may be younger than early Miocene.

Sediment-accumulation rates determined from the biostratigraphic data indicate an important change at ~700 mbsf, where the rates vary from approximately 50 m/m.y. below this depth to greater than 100 m/m.y. above this depth. Interpretations of seismic-reflection profiles and lithostratigraphic examinations of cores from Hole 832B indicate an unconformity at about 700 mbsf, but the biostratigraphic data do not indicate a hiatus that would be longer than about 0.2 m.y. Between the lower Pliocene at 856 mbsf and the lowermost Miocene at 952 mbsf there may be another unconformity.

Correlation between biostratigraphic and paleomagnetic data suggests that the lower boundary of the Olduvai is near 707 mbsf and consequently that the Matuyama Brunhes transition (early Pleistocene) is missing between 640 and 700 mbsf. Several other magnetic reversals that were observed between 707 mbsf and the TD of Hole 832B appear to correlate with Pliocene to late Miocene ages. Benthic foraminifers, where found, indicate that sediments of Site 832 were deposited in the lower bathyal zone.

More than 10 volcanic-ash layers >3 cm thick and several tens of reworked volcanic-ash layers were recovered at Site 832. Fragments of clinopyroxene-phyric basalt or ankaramite were found in the cores between 395 and 1100 mbsf and show vesicular texture and little oxidation, indicating that they underwent little weathering or seawater alteration before burial. Between 1050 and 1100 mbsf, the altered volcanic breccia of lithostratigraphic Unit VII consists of clasts of scoria and lavas within a matrix of chloritized glass, clay minerals, and zeolite. This volcanic breccia was probably derived from submarine volcanism, as suggested by the abundant alteration products contained in the matrix.

Structural studies indicate that deformation observed in cores from Site 832 appears to result from small- to large-scale slumping, normal microfaulting, and compaction processes. Five structural units were identified. Structural Unit A (0-420 mbsf) includes lithostratigraphic Unit I and the upper part of Unit II and is characterized by subhorizontal bedding, rare slump features, vertical normal microfaults, contorted bedding, and load features that developed in a finely laminated siltstone. Structural Unit B (420-621 mbsf) includes the lower part of lithostratigraphic Unit II and all of lithostratigraphic Unit III, which is characterized by abundant slump folds. Structural Unit C (621-695 mbsf) corresponds to Lithostratigraphic Unit IV, which has laminated siltstone beds dipping 30°-65°, suggesting the presence of slumps. Structural Unit D (695-851 mbsf) corresponds to lithostratigraphic Unit V and exhibits mainly horizontal bedding, a few veins filled with gypsum, and normal microfaults with well-developed slickensides. Some sigmoidal features oblique to the bedding are interpreted as forming in response to bedding-parallel extension. Structural Unit E (851-1107 mbsf) corresponds to lithostratigraphic Units VI and VII and is characterized by rarely observable bedding that dips between 20° and 40° microfaults and an overturned layer are indicative of slumping.

The concentrations of all measured solutes at Site 832 range widely, particularly those of calcium (1.9-215.9 mM), magnesium (0-50.6 mM), sodium (344-501 mM), potassium (2.3-15.2 mM) and chloride (551-742 mM). Each solute exhibits distinct maxima and minima, and the calcium minimum corresponds to the maxima in the concentrations of other solutes. The changes in concentrations probably result from diagenetic alteration of volcanogenic material and from precipitation of authigenic carbonate and phosphate minerals. Sulfate concentration decreases to 0.6 mM in the upper 40 mbsf, but exhibits two maxima at 520.7 mbsf (23.8 mM) and 802.3 mbsf (22.9 mM), which correspond to the calcium minimum and the sodium, potassium, magnesium, and chloride maxima. Accompanying the decrease in sulfate at approximately 75 mbsf, resulting from sulfate reduction, are maxima of phosphate, ammonia, methane, and alkalinity. These maxima probably reflect organic-matter diagenesis, and the solutes may provide a source of phosphate and bicarbonate for the authigenic minerals. Organic-carbon contents are low, mostly less than 0.5%, but rapid sediment-accumulation rates cause high concentrations of the various solutes.

Physical-property measurements at Site 832 were constant from the mud line to below 300 mbsf. This uniformity and the constancy of shear-strength values (around 50 kPa from 0 to 260 mbsf) indicate underconsolidation, which is typical of an area of rapid sedimentation. Porosity and water content have high values that vary from 50% to 80%. Silty-ash layers of lithostratigraphic Unit I are the most porous, least consolidated, and contain the greatest amount of fluid of all material at Site 832. Below 300 mbsf, downhole porosity and water content decrease but maintain high values that rarely are below 40% and 25%. Bulk density increases from 1.60 Mg/m^3 to 2.00 Mg/m^3 in the upper 300 mbsf of Hole 832B and varies between 2.00 Mg/m^3 and 2.40 Mg/m^3 from 300 to 1103 mbsf. A decrease in porosity (~20%) and an increase in bulk density (>2.50 Mg/m^3) are associated with the breccias and sandstones of in lithostratigraphic Units II and IV between 300 and 400 mbsf and 600 and 700 mbsf. Sonic velocities are generally low in the upper silty ash of lithostratigraphic Unit I, where they range from 1520 m/s near the seafloor to 1600 m/s at 260 mbsf. Velocity varies between 2000 and 3500 m/s from 260 mbsf to the TD of Hole 832B at 1103.3 mbsf. However, the interval between 600 and 700 mbsf exhibits an increase in velocity to over 4000 m/s, which correlates with a bulk-density increase and the presence of a volcanic sandstone in lithostratigraphic Unit IV.

Because of deteriorating hole conditions, including bridging and rapid infilling from the upper parts, the complete complement of logging tools could not be used. However, the geophysical string and the formation microscanner (FMS) were run and produced good data.

Initial heat-flow analyses indicate that a high thermal gradient exists within the intra-arc basin, and this, along with porous and fractured volcaniclastic rocks, caused the anomalous alteration and diagenesis reported above. The volcaniclastic rocks encountered at this site are surprisingly unlithified with the exception of isolated layers, as indicated by the high porosity and water content.

SITE 833

We arrived at Site 833 (proposed site IAB-2) on 2 December 1990 at 0500 UTC. While on site we drilled two holes (Holes 833A and 833B). We departed Site 833 at 0030 UTC 14 December 1990. Site 833 (proposed site IAB-2) is located on the lower east-central flank of the North Aoba Basin (NAB), along the northwestern flank of Maewo Island, approximately 24 km northwest of the northern tip of Maewo Island and about 72 km southeast of the active volcanic island of Santa Maria (Fig. 2), which was observed on 4-5 December 1990 to be emitting whitish-gray smoke from a vent near Mount Garat. The NAB lies between uplifted bedrock masses of Espiritu Santo and Maewo islands and is separated from the northern Vanikolo Basin to the north by Santa Maria Island and from the South Aoba Basin (SAB) to the south by the volcanic island of Aoba.

After a seismic-reflection transect across the NAB connecting Site 832 with Site 833 and a brief survey around Site 833, we began drilling without any problem. In Hole 833A we cored 199.5 mbsf and recovered 97.75 m of core for a core recovery rate of 49.0%. Hole 833B was drilled to a total depth (TD) of 1001.1 mbsf, coring 923.7 m and recovering 519.54 m of core for a recovery rate of 56.2% (Table 1).

Five lithostratigraphic units were identified in the cores collected at Site 833 (Fig. 3). Lithostratigraphic Unit I (0-84.0 mbsf, Hole 833A) consists of numerous interbedded unlithified volcanic ashes and volcanic silt; ash layers are thinner and more numerous in the upper part of the unit, and the carbonate content increases to about 15% near the seafloor.

Lithostratigraphic Unit II (84.0-199.5 mbsf in Hole 833A and 77.4-375.8 mbsf in Hole 833B) contains calcareous siltstones and claystones that are highly bioturbated; the unit is more lithified and finer grained than Unit I. Volcanic ash and volcanic sand are negligible, suggesting a period of fairly slow sedimentation and minimal volcanic activity.

Lithostratigraphic Unit III (375.8-577.8 mbsf) is composed of black volcanic sand and fine-grained basaltic breccia with a low carbonate content. Sediment-accumulation rates average 313 m/m.y.

Lithostratigraphic Unit IV (577.8-830.0 mbsf) is composed of black volcanic sandstones and siltstones interbedded with sandstones, siltstones, and claystones that are both finer grained and more calcareous than the volcaniclastic sedimentary rocks. Packages (30 cm to several meters in thickness) of fining-upward sequences of volcanic sediment with coarser grained basal layers and sharp top and bottom boundaries characterize this unit.

Lithostratigraphic Unit V (830.0-1001.1 mbsf) is characterized by sediments similar to those in Unit IV except that the sediments in Unit V are interbedded with basaltic sills with thicknesses of 65 m or more. Sedimentary rocks in Unit V show minimal structural deformation; minor evidence of contact metamorphism is exhibited primarily by the increase in chlorite content of intruded calcareous volcanic siltstone.

The keys to the divisions within the lithostratigraphic units include the grain size of volcanic ash and epiclastic volcanic sediments, carbonate content, and bioturbation. These characteristics are closely related. When the sediment-accumulation rates of volcanic ash and sand are high, the carbonate content is low because dilution of the volcanic sediments and bioturbation are suppressed. When the volcanic-ash input decreases, sediment-accumulation rates are low (97 m/m.y.), and volcanic silt and clay dominate. Carbonate sediments then form a significant portion of the total sediment accumulation, and burrowing organisms have sufficient time to rework the sediments.

Three structual units were defined at Site 833. Structural Unit A (0-620 mbsf) includes lithostratigraphic Units I, II, III, and the upper part of IV and contains only a few structures resulting from structural deformation. Structural Unit B (620-830 mbsf) includes the lower part of lithostratigraphic Unit IV and is defined by an abundance of normal faults with well-defined slickensides, some overprinted with faults indicating sinistral strike-slip. Structural Unit C (830-1001.1 mbsf) is also defined on the existence of faults, but these faults differ from Structural Unit B in that they are strike-slip faults that primarily exhibit an oblique (reverse) sense of movement.

Volcanic-ash layers are abundant in the upper 150 m of Site 833, becoming increasingly sporadic downhole. These are potassium-rich pyroclastic sediments similar to those found at Site 832,and are attributed to eruptions from the Central Chain of volcanoes. Deeper in Hole 833B scattered basaltic tuffs were recovered from between 308 and 317 mbsf: these are of a different type, having low-potassium, island-arc tholeiite affinity. Volcanic clasts from the coarse sandstones and breccias at about 400 mbsf include ankaramitic basalts, resembling those of Site 832, and these are also of the island-arc tholeiite type. At 830 mbsf, calcareous volcanic siltstones are cut by a highly plagioclase-phyric (highly potassic) basaltic sill with a distinctly chilled upper contact. Basaltic sills of similar composition make up much of the succession below this and are interstratified with calcareous volcanic siltstones and bioturbated mixed sedimentary rocks. There is sufficient evidence of chilling to establish the intrusive nature of the basalt. Although the sills could be interpreted as a series of separate intrusions their compositional uniformity suggests that a large body of magma may have invaded the unlithified sediments simultaneously at a number of the upper stratigraphic levels.

Foraminifers and nannofossils were again the best source for age information. An age of late Pleistocene to Holocene is assigned to the interval from 0 to 183.5 mbsf (in both Holes 833A and 833B), early Pleistocene for the interval from 193.1 to 375.8 mbsf, late Pliocene for the interval from 385.5 to 635.6 mbsf, and early Pliocene for the interval from 635.6 to 952.9 mbsf. The Pliocene/Pleistocene boundary lies in the interval from 250 to 375.8 mbsf, but the exact location is uncertain. Further uncertainty arises from the assignment of the lowermost part of Hole 833B to foraminifer Zone N19, which is early Pliocene.

For the overall sedimentary sequence above the sill a very high sediment-accumulation rate of 97-322 m/m.y. was determined, using mainly the first-appearance datums of foraminifers and nannofossils in sequences where reworking is common. Analyses of benthic foraminifers indicate that most of the sediments found at Site 833 were deposited in the lower bathyal zone; however, some shallow-water fauna were found sporadically throughout Hole 833B.

All undisturbed cores from Hole 833A and most consolidated sediments in Hole 833B were measured with the cryogenic magnetometer and AF demagnetized at 10 mT. Paleomagnetic results at Site 833 show normal polarity from 0 to 80 mbsf. Because of poor core recovery, few magnetic measurements could be obtained from 80 to 200 mbsf, and no evidence for reversed polarity exists in this interval. The first interval of reversed magnetic polarity was found between 220 and 250 mbsf, and the transition from the Matuyama to the Brunhes (0.73 Ma) may be represented between 210 and 220 mbsf. Intervals of positive or negative inclinations are found between 250 and 430 mbsf. From 435 to 655 mbsf, only normal polarity was found.

Magnetic susceptibility in the volcanic sandstone at Site 833 is high (0.02 SI), and this nearly normal magnetization may have been acquired during diagenesis and consolidation; viscous magnetization of these rocks appears to be quite strong as well. The interbedded sills at the bottom of Hole 833B also have high magnetic susceptibility (0.04-0.08 SI) and a high intensity (100 A/m) of magnetization. However, this magnetization is very soft and easily removed with low AF demagnetization. Results from the most stable samples indicate a shallow positive inclination that may correspond to a reversed polarity.

Fluid geochemistry at Site 833 revealed extremely wide-ranging values in chloride (568-1241 mM), sodium (150-534 mM), potassium (0.4-14.7 mM), magnesium (0-39.7 mM), and calcium (2.6-548.5 mM) concentrations in the pore fluids. Each of these solutes is characterized by either its maximum (chloride and calcium) or minimum (sodium, potassium, and magnesium) value at sub-bottom depths between 490 and 630 mbsf. These depths correspond to the location of the well-cemented volcanic sandstone and sed-lithic rocks. Diagenesis and cementation of the volcanogenic sediment presumably cause the variations in solute concentrations. These are similar to the diagenesis observed at Site 832, but the most altered calcium, chloride, and sodium concentrations are nearly 2 times more extreme at 833. The maximum concentrations of alkalinity (19.9 mM), phosphate (55.2 mM), and ammonia (1794) occur between depths of 20 and 40 mbsf. The concentrations are not extremely high, probably reflecting the low (generally <0.5%) organic-carbon content of the sediments and slightly lower sediment-accumulation rate at this site.

Similar to Site 832, physical-properties measurements of cores at Site 833 correlate well with the lithostratigraphic units. Values of index properties vs. depth for the upper 375 mbsf show porosity and water content from 50% to 80% and low shear strengths. Sediments at Site 833 are slightly drier and less porous than at Site 832. From 200-375 mbsf bulk density increases from 1.60 to 2.00 Mg/m^3. At 376 mbsf a distinct sharp decrease in porosity to 20% and a sharp increase in bulk density to 2.50 Mg/m^3 occurs and is associated with a lithologic change from Pleistocene volcanic siltstone and calcareous claystone to upper Pliocene coarse volcanic sandstone and basaltic breccia. From 600 to 830 mbsf, porosity increases to 40% or more and bulk density drops to about 2.00 Mg/m^3. At 830 mbsf, at the upper contact of the basaltic sill, bulk density sharply increases to 2.60 Mg/m^3 with porosity and water content dropping to less than 5%.

Sonic velocities at Site 833 range from 1535 m/s at the seafloor to 2038 m/s at 377 mbsf. From 379 to 600 mbsf, velocities increase sharply to between 3000 and 4500 m/s in volcanic sandstone breccia. They increase sharply again, to above 5000 m/s, in the basaltic sill from 830 to 1000 mbsf.

Due to partial hole collapse and filling problems after drilling ceased, not all of the hole could be logged, and constraints on time prevented us from using the complete complement of logging tools. However, good results were obtained from the geophysical and geochemical tools between 250 and 900 mbsf, with distinct increases in resistivity and velocities taking place between 380 and 430 mbsf, which correlates with volcanic sandstones and breccia at these depths. The contact of the basaltic sill with the overlying sedimentary rocks is easily distinguished in the logs, with sharp increases in resistivity, velocities, thorium, and potassium at 830 mbsf.

Initial interpretations of the drilling data at Site 833 indicate that a thick (nearly 400-m-thick) Pleistocene volcanic sandstone and ash sequence exists. Although not as thick as that found at Site 832 (<600 m), this sequence represents a rapid accumulation of Pleistocene effusive volcanic material, explosively released from the active Central Chain volcanoes. The existence of volcanic breccia at about 400 to 560 mbsf suggests uplift and erosion of volcanic rocks on Maewo Island. A much thicker (>350 m) Pliocene sequence exists at Site 833 compared to only about 70 m recovered at Site 832; however, nearly half of this sequence is composed of basaltic sills that may have been intruded into the Pliocene sedimentary rocks as late as Pleistocene time. Initial evaluation of this sill complex indicates that the rocks are highly potassic and share similar petrology with the Central Chain.

SUMMARY

Tentative interpretations of the drilling results from ODP Leg 134 in the collision zone of the central New Hebrides Island Arc suggest that each ridge of the twin-ridge DEZ causes different forearc deformation. The sedimentary and surficial basement rocks of the more continuous and morphologically streamlined NDR, whose basement rocks (MORB) are denser than those of the Bougainville Guyot, appear to have been scraped off and accreted to the forearc during its passage down the subduction zone and beneath the forearc. This accretion has formed the Wousi Bank, which consists of uplifted forearc rocks and stacked thrust sheets. The SDC impacts the forearc in a different manner: drilling in this collision zone reveals little deformation compared to the NDR collision zone, although the SDC is converging at the same rate and at the same angle as the NDR. The more buoyant andesitic island-arc basement rocks may allow the guyot to float up onto the forearc slope before being subducted or accreted to the slope.

The major compositional change to the New Hebrides pore fluid results from diagenetic alteration of volcanic sediment and is manifested in chloride and calcium concentrations greater than seawater values, and sodium, potassium, and magnesium concentrations lower than seawater values. Variations in these solute concentrations correspond to structural features, particularly across thrust faults at Site 829 and in a fractured zone at Site 830. More fluid is present below thrust faults penetrated at Site 829, which implies that the faults may channelize fluid flow similar to the Barbados accretionary wedge (Mascle, Moore, et al., 1988). Moreover, the deepest samples at Site 829 are characterized by low chloride and high methane concentrations, a covariance that also characterizes the pore-fluid chemistry within the décollement at the Barbados accretionary wedge (Gieskes et al., 1990). Thus, the fluid near the deep thrust fault at Site 829 may have been derived from the décollement and subduction related processes.

Two holes deeper than 1 km in the intra-arc basin recovered middle Miocene to Pleistocene sedimentary and volcaniclastic rocks. At Site 832 more than 1106 m of basin-fill deposits was penetrated and at Site 833 over 1001 m of basin material was drilled. A strong reflector observed in the seismic-reflection data around 700 mbsf correlates with an apparent upper Pliocene or lower Pleistocene unconformity in the sediment record.This suggests a change in the basin's base and may indicate that uplift of Espiritu Santo Island in response to the collision of the DEZ occurred then. Beneath this unconformity, calcareous siltstone and chalk beds with scattered ash layers suggest deposition in fairly quiet water during a time of possibly waning Eastern Belt volcanism, which may have produced the volcanic breccia at the base of Hole 832B. Above the unconformity a thick sequence (150 m) of igneous breccia and interlayered breccia with calcareous siltstones indicates increased erosion of Espiritu Santo Island after initial DEZ collision, followed by deposition of fine-grained material in quiet waters. Over 600 m of Pleistocene sediments was found at Site 832, with the upper 400 m apparently being the contribution of active Central Chain volcanism.

At Site 833 a volcanic sill, recovered below 840 mbsf, intrudes lower Pliocene sedimentary rocks, indicating that volcanism was active along the Eastern Belt from early Pliocene to Pleistocene time, as previously thought (Carney and Macfarlane, 1977, 1978, 1980, 1982, 1985; Carney et al., 1985; Macfarlane et al., 1988). Unlike at Site 832, where only 70 m of lower Pliocene sedimentary rocks was found, over 350 m of lower Pliocene sedimentary and volcanic rocks was penetrated at Site 833. However, an equal amount (nearly 400 m) of Pleistocene sediments was recovered at Site 833. The existence of volcanic breccia at about 450 mbsf in Hole 833B suggests uplift and erosion of the volcanic rocks of Maewo in the late Pliocene, perhaps in response to the DEZ collision.

The large quantity of mostly undiluted volcanic sediment within the NAB has been diagenetically altered, producing some of the most altered and concentrated fluids yet drilled on an ODP or DSDP leg. The concentrations of calcium, chloride, potassium, sodium, and magnesium are most affected by this alteration.

REFERENCES

Akimoto, K., Tanaka, T., Hattori, N., and Hotta, H., 1990. Recent foraminiferal assemblages around Calyptogena colony off Hattsushima Island, Sagami Bay, Central Japan: Technical Reports of the Symposium on Deep-sea Research using the Submersible Shinka: 2000 System, Japan Marine Science and Technology Center, Yokosura, Japan.

Andrews, J. E., Packham, G. H., et al., 1975. Init. Repts. DSDP, 30: Washington (U.S. Govt. Printing Office).

Backman, J., Duncan, R. A., et al., 1987 Proc. ODP, Init. Repts., 115: College Station, TX (Ocean Drilling Program).

Biju-Duval, B., Moore, J. C., et al., 1983. Init. Repts. DSDP, 78A: Washington (U.S. Govt. Printing Office).

Carney, J. N. and Macfarlane, A., 1977. Volcano-tectonic events and pre-Pliocene crustal extension in the New Hebrides. *In* International Symposium on Geodynamics in South-west Pacific, Noumea, New Caledonia, 1976: Paris (Editions Technip), 91-104.

______, 1978. Lower to middle Miocene sediments on Maewo, New Hebrides, and their relevance to the development of the Outer Melanesian Arc system. Austral., Soc. Explor. Geophys. Bull., 9:123-130.

______, 1980. A sedimentary basin in the central New Hebrides Arc. UN ESCAP, CCOP/SOPAC Tech. Bull., 3:109-120.

______, 1982. Geological evidence bearing on the Miocene to Recent structural evolution of the New Hebrides Arc. Tectonophysics, 87:147-175.

______, 1985. Geology and mineralisation of the Cumberland Peninsula, north Espiritu Santo. Vanuatu Department of Geology, Mines and Rural Water Supplies Report.

Carney, J. N., Macfarlane, A., and Mallick, D. I. J., 1985. The Vanuatu island arc -- an outline of the stratigraphy, structure, and petrology. *In* Nairn, A.E.M., Stehli, F. G., and Uyeda, S. (Eds.), The Ocean Basins and Margins - the Pacific Ocean: New York (Plenum Press), 7A:685-718.

Collot, J.-Y., Pelletier, B., Boulin, J., Daniel, J., Eissen, J.-P., Fisher, M. A., Greene, H. G., Lallemand, S., and Monzier, M., 1989. Premiers resultats des plongees de la campagne SUBSO1 dans la zone de collision des rides d'Entrecasteaux et de l'arc des Nouvelles-Hebrides. C. R. Acad. Sci., Paris, 309, serie II:1947-1954.

Daniel, J., Collot, J.-Y., Monzier, M., Pelletier, B., Butscher, J., Deplus, C., Dubois, J., Gerard, M., Maillet, P., Monjaret, M. C., Recy, J., Renard, V., Rigolot, P., and Temakon, S. J., 1986. Subduction et collisions le long de l'arc des Nouvelles-Hebrides (Vanuatu): resultats preliminaires de la campagne SEAPSO(leg l). C. R. Acad. Sci., Paris, 303, Serie II, 9.

Daniel, J., Jouannic, C., Larue, B., and Recy, J., 1977. Interpretation of d'Entrecasteaux zone (north of New Caledonia). In International Symposium on Geodynamics in South-West Pacific, Noumea, New Caledonia, 1976. Paris, Editions Technip:117-124.

Dubois, J., Deplus, C., Diament, M., Daniel, J., and Collot, J.-Y., 1988. Subduction of the Bougainville seamount (Vanuatu): mechanical and geodynamic implications. Tectonophysics, 149:111-119.

Fisher, M. A., Collot, J-Y., and Geist, E. L., in press. The collision zone between the North d'Entrecasteaux Ridge and the New Hebrides Island Arc, 2. Structure from multichannel seismic data. J. Geophys. Res.

Gieskes, J. M., Vrolijk, P. and Blanc, G., 1990. Hydrogeochemistry of the northern Barbados accretionary complex transect: Ocean Drilling Program Leg 110 J. Geophy. Res., 95:8809-8818.

Haq, B. U., von Rad, U., et al., 1988. Proc. ODP, Init. Repts., 122: College Station, TX (Ocean Drilling Program).

Kroenke, L. W., Jouannic, D., and Woodward, P., compilers, 1983. Bathymetry of the southwest Pacific. Scale 1:6, 442, 192 at 0°. Two sheets. Mercator projection: UNESCAP, CCOP/SOPAC Technical Secretariat, Suva, Fiji.

Macfarlane, A., Carney, J. N., Crawford, A. J., and Greene, H. G., 1988. Vanuatu -- a review of the onshore geology. *In* Greene, H. G., and Wong, F. L. (Eds.), Geology and Offshore Resources of Pacific Island Arcs -- Vanuatu Region. Houston, Circum-Pac. Energy and Miner. Resour. Earth Sci. Ser., 8:45-92.

Mascle A., Moore J. C., et al., 1988. Proc. ODP, Init. Repts., 110: College Station, TX (Ocean Drilling Program).

Maillet, P., Monzier, M., Selo, M., and Storzer, D., 1983. The d'Entrecasteaux zone (southwest Pacific): a petrological and geochronological reappraisal. Mar. Geol., 53:179-197.

Mallick, D.I.J., and Greenbaum, D., 1977. Geology of Southern Santo. British Service, New Hebrides.

Mitchell, A.H.G., 1971. Geology of Northern Malakula. British Service, New Hebrides.

Taira, A., Hill, I., et al., in press. Proc. ODP, Init. Repts., 131: College Station, TX (Ocean Drilling Program).

TABLE CAPTIONS

Table 1. Coring statistics, Leg 134.

FIGURE CAPTIONS

Figure 1. Regional bathymetry of the southwest Pacific (after Kroenke, Jouannic, and Woodward, 1983). ES is Espiritu Santo Island, M is Maewo Island, P is Pentecost Island, Am is Ambryn Island, NDR = North d'Éntrecasteaux Ridge.

Figure 2. Locations of sites drilled during ODP Leg 134. WTM is West Torres Massif, NDR is North d'Entrecasteaux Ridge, SDC is South d'Entrecasteaux Chain, NLB is North Loyalty Basin, NFB is North Fiji Basin, WB is Wousi Bank, NAB is North Aoba Basin, SAB is South Aoba Basin. Bathymetry in meters.

Figure 3. Geologic columns and cross sections, ODP Leg 134. Locations of cross sections are indicated on Figures 1 and 2. (1. Oceanic crust, 2. Western Belt volcanics, 3. Eastern Belt volcanics, 4. Central Chain volcanics, 5. Basin fill, 6. Guyot volcanics, 7. Volcanic sand/sandstone, 8. Volcanic silt/siltstone, 9. Volcanic sandstone/siltstone/claystone, 10. Sed-lithic breccia, 11. Volcanic breccia, 12. Basalt chalk, 13. Multiple slivers of siltstone and chalk, 14. Foraminiferal ooze, 15. Nannofossil ooze, 16. Foraminiferal chalk, 17. Nannofossil chalk, 18. Calcareous chalk, 19. Pelagic limestone, 20. Lagoonal limestone, 21. Unconformity, 22. Ash; l Pli/ e Ple is late Pliocene or early Pleistocene, l O - e M is late Oligocene to early Miocene, E is Eocene, m M is middle Miocene, NDR is North d'Entrecasteaux Ridge, BG is Bougainville Guyot, NAB is North Aoba Basin, NFB is North Fiji Basin.)

Table 1. Coring Statistics, Leg 134

Hole	Latitude (°S)	Longitude (°E)	Water Depth (m)	Number of Cores	Meters Cored	Meters Recov'd	Percent Recov'd	Total Penetr. (m)
827A	15°17.74'	166°21.11'	2803.4	15	110.6	100.76	91.1	110.6
827B	15°17.75'	166°21.11'	2803.4	31	289.8	119.04	41.4	400.4
828A	15°17.34'	166°17.04'	3086.7	15	111.4	101.34	91.0	111.4
828B	15°17.26'	166°16.96'	3082.0	4	39.0	7.92	20.3	129.0
829A	15°18.96'	166°20.70'	2905.2	64	590.3	197.44	33.4	590.3
829B	15°18.97'	166°20.70'	2909.0	3	19.5	15.59	80.0	19.5
829C	15°18.96'	166°20.70'	2910.7	11	58.4	52.67	90.2	58.4
830A	15°57.00'	166°46.79'	1018.4	11	96.9	53.77	55.5	96.9
830B	15°57.00'	166°46.78'	1018.4	24	233.2	48.77	20.9	281.7
830C	15°57.00'	166°46.71'	1008.9	12	115.6	19.40	16.8	350.6
831A	16°00.56'	166°40.34'	1066.4	15	115.5	25.85	22.4	116.5
831B	16°00.56'	166°40.36'	1066.4	84	749.6	87.25	11.6	852.0
832A	14°47.78'	167°34.35'	3089.3	27	215.9	146.26	67.8	215.9
832B	14°47.77'	167°34.35'	3089.3	100	962.3	450.95	46.9	1106.7
833A	14°52.57'	167°52.78'	2628.5	26	199.5	97.75	49.0	199.5
833B	14°52.56'	167°52.78'	2629.0	99	923.7	519.54	56.2	1001.1

Note: Water depths are in meters below sea level; operatons water depths are reported in meters below rig floor (rig floor datum is ~11 m above seal level).

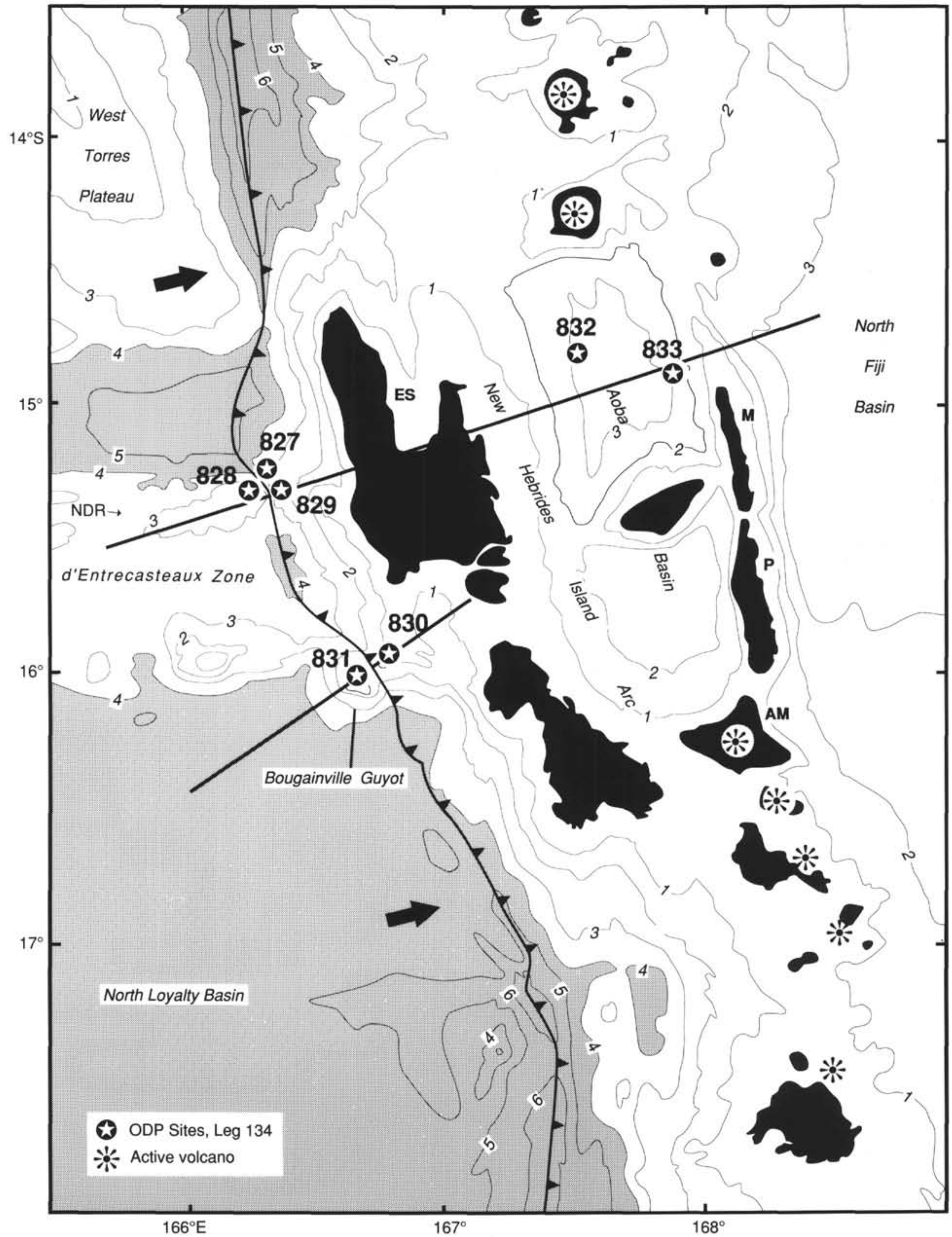

West
Torres
Plateau
14°S
15°
16°
17°
166°E
167°
168°
North
Fiji
Basin
832
833
827
828
829
830
831
ES
M
P
AM
New
Hebrides
Island
Arc
Aoba
Basin
NDR→
d'Entrecasteaux Zone
Bougainville Guyot
North Loyalty Basin
ODP Sites, Leg 134
Active volcano

Figure 1

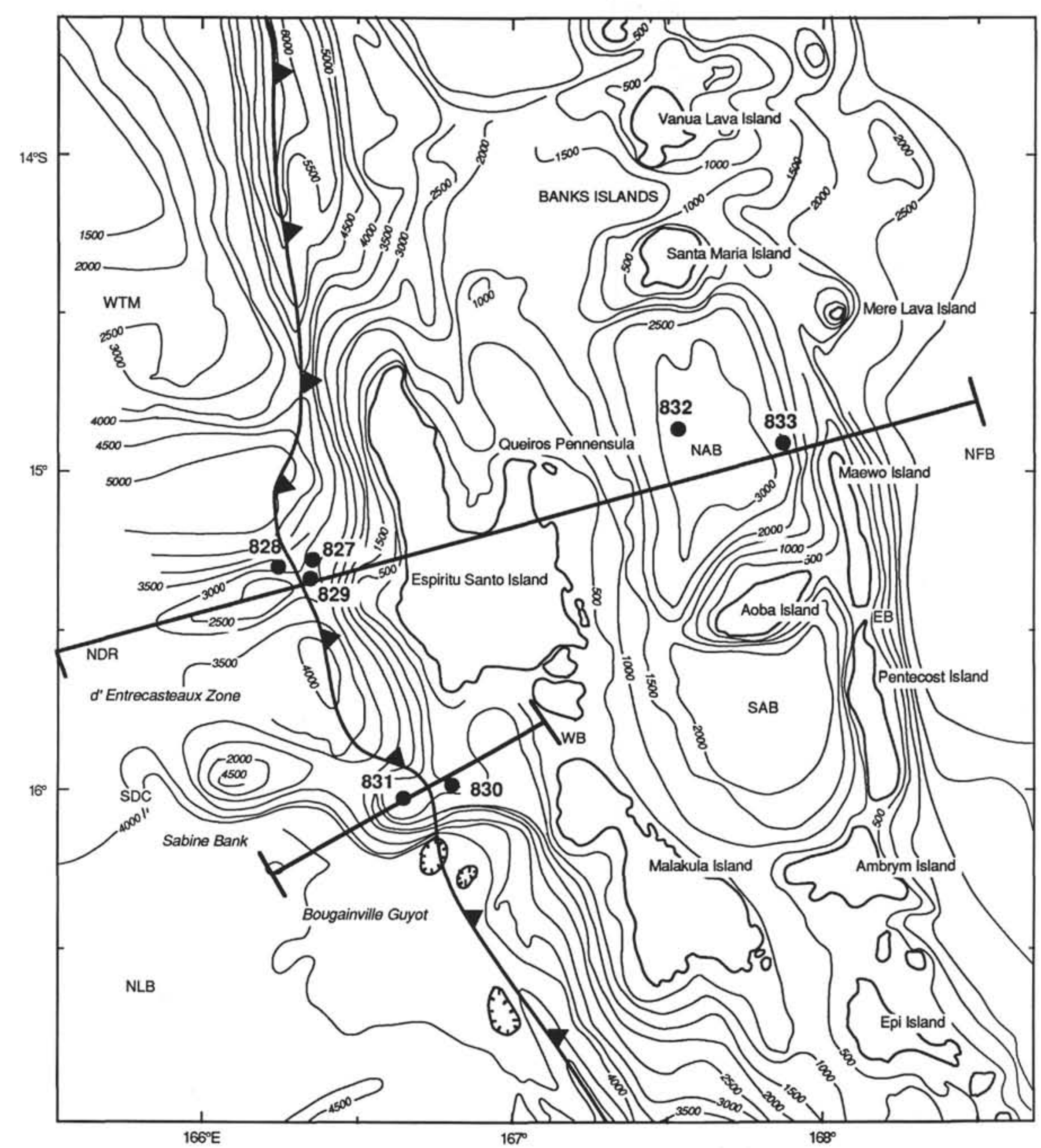
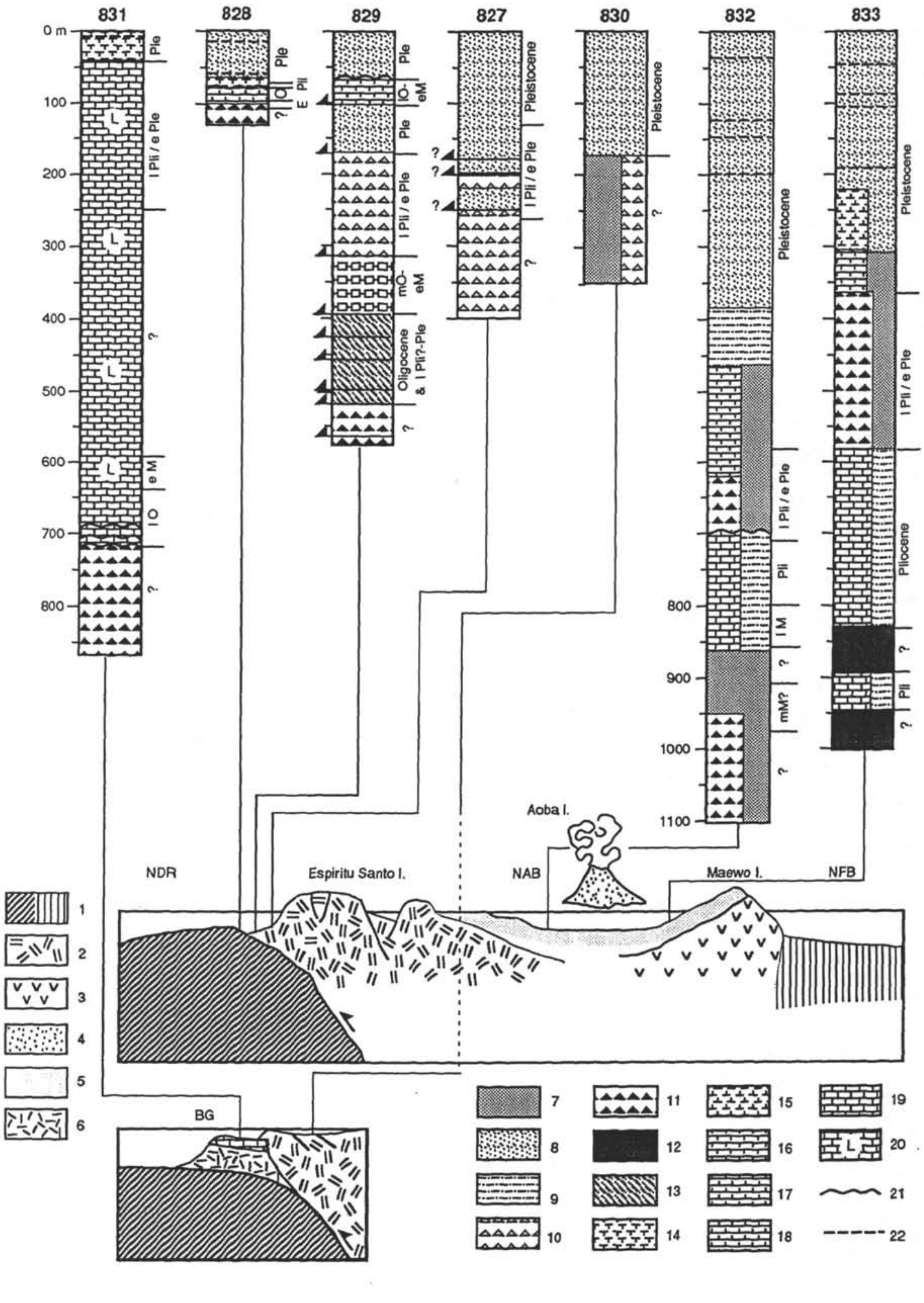

14°S
15°
16°
166°E
167°
168°
Vanua Lava Island
BANKS ISLANDS
Santa Maria Island
Mere Lava Island
WTM
832
833
Queiros Pennensula
NAB
NFB
Maewo Island
828
827
829
Espiritu Santo Island
Aoba Island
EB
NDR
d' Entrecasteaux Zone
SAB
Pentecost Island
WB
831
830
SDC
Sabine Bank
Malakula Island
Ambrym Island
Bougainville Guyot
NLB
Epi Island

Figure 2


831
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Ple
l Pli / e Ple
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lO-eM
mO-eM
Oligocene & l Pli?-Ple
Pleistocene
Pli
l M
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Pliocene
Aoba I.
NDR
Espiritu Santo I.
NAB
Maewo I.
NFB
BG
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Figure 3

OPERATIONS SYNOPSIS

The ODP Operations and Engineering personnel aboard JOIDES Resolution for Leg 134 were:

Operations Superintendent:	Glen Foss
Development Engineer:	David Huey

OPERATIONS SYNOPSIS
OCEAN DRILLING PROGRAM
LEG 134

Leg 134 began with the first mooring line at Berth 8, Port of Townsville, Queensland, Australia, at 2000UTC 10 October 1990. Scientific, TAMU, and UDI crew changes were made. Freight shipments on and off the vessel (including cores) were handled and foodstuffs, water, lube oil, etc., were received. The working drill string was inspected, and a new coaxial cable for the reentry system was installed. Fuel for the vessel was not available in Townsville as had been promised, so it was necessary to shorten the Townsville port call and move the ship to Gladstone, where additional fuel had been located. Departure from Townsville Harbor was at 0200UTC 14 October.

The port of Gladstone is located about 430 nmi down the coast to the southeast of Townsville. After an uneventful transit inside the Great Barrier Reef, the first line at Auckland Point Pier 1 was put over at 1715UTC 15 October. Because of the small diameter of the fuel-supply line, bunkering took nearly twice the normally required time. By the next morning, 449,000 U.S. gallons of marine gasoil had been received and the vessel sailed at 2030UTC 16 October.

After the Great Barrier Reef had been transited, course was set for the operating area in the Vanuatu (New Hebrides) island group. Opposing trade winds increased somewhat during the crossing of the Coral Sea, but an average transit speed of 12 kts was achieved in otherwise fine weather.

A fairly extensive preliminary survey was carried out in the initial operating area and positioning beacons were dropped on Prospectus sites DEZ-1 and DEZ-2 before the vessel took station on the latter.

SITE 827, NORTH D'ENTRECASTEAUX RIDGE

Hole 827A

Seafloor depth was established at 2814.2 meters below rig floor (mbrf) on the basis of an advanced piston core (APC) taken at 0410UTC 21 October. After two additional APC cores, the volcanic silt sediment became too stiff for full penetration of the APC. Coring then proceeded by the advance-by-recovery method. Ten additional cores were taken with good results before core length became insufficient and the switch was made to the extended core barrel (XCB) system. After two XCB cores, low penetration rate (ROP) and a temporary electrical breakdown of the coring winch prompted the decision to trip the drill string for the rotary core barrel (RCB) bottom-hole assembly (BHA).

The total depth of the hole was 2924.8 m (110.6 mbsf). Overall core recovery was 91.1%. Three successful bottom-hole temperature measurements were made with the instrumented probe (WSTP).

Hole 827B

The second hole was drilled to the total depth of Hole 827A before continuous RCB coring began. Core recovery was very good in volcanic silt to about 252 mbsf. Recovery and ROP then dropped drastically in an unconsolidated conglomerate with volcanic clasts up to boulder size. Hole conditions deteriorated progressively with depth and it was necessary to abandon operations short of basement for the safety of the drill string.

The total depth was 3214.6 m (400.4 mbsf). Average recovery was 41.4%, nearly all of which was from the upper lithologic unit. Two additional WSTP temperature measurements were made.

SITE 828, NORTH D'ENTRECASTEAUX RIDGE

The second site was located across the subduction thrust zone from the island arc and was selected as a reference site to study the rocks of the ridge away from the area of tectonism.

Hole 828A

The drillship moved in dynamic positioning (DP) mode from Site 827 to the beacon dropped earlier on site DEZ-1. The precision depth recorder (PDR) reading upon arrival indicated a drilling depth of about 3125 m, but again the reading proved too deep. Seafloor depth finally was established at 3097.6 mbrf after a full-barrel misrun with the APC.

APC cores were then taken with excellent results through volcanic silt, calcareous ooze, and foraminiferal sand to 95 mbsf, where the APC was stopped abruptly by hard rocks. Core orientation was only partially successful because of instrument problems.

Two XCB cores then were attempted but produced less than 1 meter of brecciated volcanic rock. No further XCB attempts were made because the hard rock was beyond the capabilities of the XCB system and the PDC drag-type bit in use. The situation was favorable for the planned testing of the motor-driven core barrel (MDCB) system, however. Two MDCB cores were attempted with mixed success, but over 2 m of extremely rubbly material was recovered.

Hole problems began as the final core was being retrieved. The drill string became stuck for several minutes as the pipe trip began. It eventually was worked free and recovered without incident.

The total penetration was 111.4 m, and core recovery averaged 91%.

Hole 828B

The BHA was exchanged for an RCB BHA, complete with drilling jars, and the drill string was run back for a second attempt to reach basement. The ship was offset 214 m to the northwest in an effort to avoid the unstable and rubbly unit that apparently was a transition zone above solid basement rocks.

The hole was drilled to 90 mbsf before the "wash barrel" was recovered and continuous RCB coring commenced. The bit contacted hard material at the end of the first core interval, which produced an excellent core with basal sediments. The next two core intervals produced only pebbles of volcanic rock and a return to unstable hole conditions.After measures were taken to stabilize the hole, a fourth RCB core was attempted. The pipe became stuck as the bit was lifted off the bottom of the hole. About 45 min of working and jarring was required to free the pipe. The hole was judged to be undrillable, and the final core barrel was recovered with the drill string.

The total penetration was 129 m; average core recovery was 20.3%.

SITE 829, NORTH D'ENTRECASTEAUX RIDGE

Site 829 represented a second attempt to penetrate the décollement near Prospectus site DEZ-2. The new location was situated away from sediment ponding as indicated on the seismic profiles and in an area where the section overlying the décollement was considerably thinner that at Site 827.

Hole 829A

During the round trip of the drill string, the vessel was moved in DP mode to a location about 4.1 nmi southeast of Site 828 and 2.3 nmi south of Site 827.

Because the PDR displayed multiple reflections, the top drive was deployed well before the bit reached the shallowest echo (2863 m). After several joints of "feeling for bottom" and one "water core," a seafloor core finally determined the depth to be 2916.2 m below driller's datum (mbrf).

Continuous RCB cores then were taken through an alternating series of Pleistocene clayey silt and older fractured carbonates separated by thrust faults. Below about 465 mbsf, volcanic and intrusive igneous rocks also were components of the melange, with more thrust faults. The sheared and overcompacted fault gouge tended to be well recovered, but the other lithologies were not. The ROP was generally low.

The hole remained remarkably stable through the highly fractured and apparently unstable tectonized section. The first signs of torque, fill, and sticking began at about 525 mbsf and became progressively worse with depth despite mud flushes and short trips. At 3506.6 m (590.3 mbsf), the risk of continued penetration to the drill string was deemed unacceptable. Coring operations were terminated short of the décollement and basement targets and preparations were made for logging.

The logging program was unusually smooth operationally. The Schlumberger "quad combo," formation microscanner (FMS), and geochemical combination logs were recorded successfully from about 460 mbsf. The LDGO digital borehole televiewer and the Schlumberger magnetic susceptibility logs then were run from about 430 mbsf with good results.

Core recovery for the hole was 33.4%.

Hole 829B

With the intention of recovering oriented APC cores through the uppermost tectonized slab of carbonates at 60-100 mbsf, Hole 829B was to have been cored at a minimal offset of 10 m south of Hole 829A. Three attempts to spud with the APC on the sloping seabed resulted in a total recovery of 15.59 m of soft surficial sediment and a badly bent core barrel.

Hole 829C

The rig was repositioned to a point 10 m east of Hole 829A for another try. The spud was successful, but the sediment proved to be exceptionally firm, and incomplete stroke indications began with the second core. Short cores were taken, with broken liners and some core disturbance, to 52 mbsf, where chalky ooze was encountered. The chalk was even harder, and little APC progress could be made. In an attempt to make a second WSTP temperature measurement at 58 mbsf, the thermistor probe tip was broken off and left in the hole.

The hole was then terminated, due both to the ineffectiveness of the APC in the hard formation and junk in the hole. Core recoverey was 90.2%.

SITE 830, SOUTH D'ENTRECASTEAUX RIDGE

The move from Site 829 to Prospectus site DEZ-4 was made in 14 hr. During that time, preliminary surveys were conducted at sites DEZ-5 and DEZ-4, and a beacon was dropped on DEZ-5 for later occupancy. At 0230UTC 6 November, a second beacon was launched on DEZ-4 to begin Site 830.

Hole 830A

The initial APC core found the seafloor at 1029.5 m, only 2.5 mbrf short of the PDR depth. Oriented cores began with Core 134-830A-2H, but incomplete stroke began with Core 3H. At 48.5 mbsf, after Core 6H, it was necessary to switch to the XCB coring mode. XCB coring continued, with low rates of core recovery and penetration, to 96.9 mbsf. The last of a series of three WSTP temperature measurements was then taken and the pipe was tripped for the RCB BHA.

Overall core recovery was 55.5%.

Hole 830B

The vessel was offset 10 m northwest of Hole 830A for the spud, and Hole 830B was drilled without coring to 48.5 mbsf, where continuous RCB coring commenced. Coring then continued through clayey volcanic silt to about 175 mbsf, where a "cataclasite" of sheared volcanic rocks and sediments was encountered. The material, which included sand and gravel-sized particles, was quite hard to drill, but the poorly recovered cores were relatively soft.

Hole conditions remained excellent to about 260 mbsf, where problems due to inadequate hole-cleaning began. Three cores later, the drill string became plugged during a pipe connection, and circulation could not be reestablished. The string also was stuck, but it eventually was freed by "drilling up" with the top drive. All efforts to unplug the string met with failure, however, and it was necessary to abandon the hole and make a "wet trip" to correct the problem.

Upon recovery of the lower BHA, the outer core barrel was found to be clogged with 3 to 4 meters of drill cuttings. The float-valve spring had weakened, allowing the flapper to hang partially open. The bit was balled, with all cones locked by packed-in sediment, and all jet nozzles were plugged.

Core recovery for the hole was only 20.9%.

Hole 830C

The bit and the mechanical bit release (MBR) were replaced and the drill string was run back to the seafloor. During the trip, the rig was offset 143 m to the west in the hope of finding better drilling conditions and a thinner sediment section.

The hole was drilled without coring from the seafloor at 1020 m to 244.4 mbsf before continuous RCB coring began. Coring operations took up where they left off in the previous hole. Despite increased RPM and circulation rate, penetration rate and core recovery were low. Packing-off tendencies began upon retrieval of the first core and indicated poor annular cleaning even when mud flushes were used.

Hole-cleaning problems continued and increased with depth as more of the volcanic breccia and sandstone were cored. Core recovery was essentially the same as in Hole 830B, but ROP did improve with increased RPM and circulating rate. Inability to keep the annulus clean and the resultant bit plugging and annular packing forced cessation of coring operations at 350.6 mbsf. Recovery averaged 16.8% in the cored interval.

After hole preparation and release of the bit, two Schlumberger logs, the "quad combo" and the geochemical combination, were recorded from a bridge at 272 mbsf. The caliper curve showed nearly the entire logged hole interval to be in excess of 19 in diameter (the maximum caliper reading). Because of the excessive hole diameter, no other logs were attempted.

SITE 831, BOUGAINVILLE GUYOT

The next site, DEZ-5, was to be drilled to basement through the top (platform) of Bougainville Guyot, which is being subducted under the island arc. The drill site was located only 7.3 nmi east-southeast of Site 830. Because the beacon had been pre-placed, the vessel could be moved in DP mode during the drill-string trip and change of BHA. No operating time was lost during the transit, the DEZ-5 beacon signal was acquired without difficulty and the rig was stable on position by spud time.

Hole 831A

A "mud-line" APC core found the seafloor at 1077.6 m from driller's datum (mbrf) with the recovery of 4.4 m of mud, sand, and coral rubble. Because of the hard coral fragments in the otherwise soft sediment, the APC reached penetration refusal at only 17 mbsf. The quality of the APC cores was degraded by incomplete stroke and flow-in recovery.

XCB coring then continued with poor core recovery in unconsolidated calcareous matrix with coral fragments. The ROP was rapid. An MDCB core was tried at 88 mbsf. Only 27 cm was recovered, primarily due to the soft nature of the sediment, which allowed the large XCB bit to advance too fast during the coring operation. Two unsuccessful WSTP temperature measurements were attempted. Hole problems existed from the beginning and were attributed to large coral fragments in the large hole annulus. Coring was terminated at 116.5 mbsf, after two zero-recovery cores. Average recovery for the hole was 22.4%.

Hole 831B

After the round trip, Hole 831B was spudded at 0815UTC 13 November. The hole was drilled to 102.4 m where continuous RCB coring began. Hole-cleaning problems started before the first core barrel was in place and worsened to about 140 mbsf. Conditions then gradually improved, with progressively less time required to clean the hole between cores. Frequent mud flushes and moderately high circulation rates were needed. Core recovery was no improvement over Hole 831A and typically consisted of a handful of coral fragments.

The ROP remained exceptionally high to about 670 mbsf and the limestone fragments recovered corresponded to hard streaks as indicated by drilling parameters. At 731 mbsf, the long-awaited breakthrough to underlying volcanic rocks occurred. There was an immediate and dramatic increase in core recovery. Coring continued in rocks composed mostly of andesitic breccia to 852 mbsf, where the drilling objectives were considered fulfilled, albeit with only 11.6% average core recovery.

The ensuing wiper trip in preparation for logging found the hole to be in apparently very good condition and preparations for logging were made. In addition to the "standard" suite of three Schlumberger logs, the Schlumberger magnetic susceptibility and magnetometer logs and the LDGO/German digital borehole televiewer were run successfully. The hole remained open, but fill increased from 30 m to 106 m during logging operations.

Upon completion of logging, the drill string was recovered, and the vessel departed for Santo Harbor at 1630UTC 20 November.

SITE 832, NORTHERN AOBA BASIN

A brief stop in Santo had been planned for the purpose of receiving some important spare parts. The port stop was canceled almost literally at the last minute when it was learned that the parts had not arrived in Santo as scheduled. The ship then proceeded to Prospectus site IAB-1 after only a slight diversion from the most direct track.

The new site lay in the basin between Espiritu Santo, Maewo, Aoba, and Santa Maria islands. The closest land was Santa Maria, 25 nmi to the north. The vessel approached the site from the southwest along a reference profile, then conducted a 6-hr preliminary survey and dropped a positioning beacon on the third site crossing at 0645UTC 21 November.

Hole 832A

The first APC core found the seafloor at 3100.6 m from driller's datum (mbrf), only 4.4 m shallower than PDR depth. Oriented APC cores were attempted to 116 mbsf, though incomplete stroke began after the second core. The volcanic sand and silt in the sediments resulted in fluidized "slurp" cores with much flow-in disturbance. Unoriented short-stroke APC cores then were taken to 151 mbsf where overpull refusal was reached. Seven XCB cores were tried to 216 mbsf, but core recovery averaged only 9%, so the hole was terminated to trip for the RCB BHA. Five WSTP temperature measurements were attempted, but only two produced usable data. Again the problem was the properties of the volcanic sand, silt, and ash.

Hole 832B

The second hole was located on a 25 m north offset from Hole 832A. It was drilled to core point at 144 mbsf before continuous RCB coring began. Core recovery was no improvement initially and averaged only 12% to about 330 mbsf. WSTP temperature runs were made at 174 and 319 mbsf, confirming a relatively high geothermal gradient.

As the volcaniclastic sediments became indurated, clay and carbonate content increased and core recovery improved with depth. Hole conditions and ROP remained good as the target depth of 700 mbsf was approached. The sediments were younger than expected and no hydrocarbons were present, so clearance was requested and received to continue coring to 1000 mbsf. With continued coring success and good scientific results, a further extension to a maximum of 1200 mbsf was secured.Though hole conditions and ROP remained favorable, the lithology gave way to unfossiliferous and less promising volcanic breccia and sandstone. Coring was discontinued at the request of the scientists at 1106.7 mbsf. Overall core recovery had been 46.9%.

A wiper trip made in preparation for logging encountered considerable drag between about 250 and 154 mbsf and a substantial bridge at about 890 mbsf. These were "cleaned up," and, following a mud sweep, two wireline runs were made to actuate the MBR and to reshift the MBR sleeve.

Because of the bridging tendencies deep in the hole, the logging plan had been modified to include two stages. The end of the pipe was pulled to 902 mbsf for the first suite, and the "quad combo" tool string was assembled. A good log was recorded from about 25 m off total depth to the end of the pipe, and the tools were recovered. While logging tools were being assembled for the second run, strong backflow unloaded the weighted mud "slug" from the drill string, and the pipe began to stick. The logging plan was revised to place the end of the pipe at 250 mbsf, the bottom of the upper "trouble zone," and run the remainder of the logs from as deep as possible to that depth. The hole then was cleaned out to total depth and pulled to 277 mbsf, where the pipe suddenly became stuck.

When the pipe could not be freed after 2-1/2 hours, the logging program resumed, using the stuck pipe as surface casing. The seismic stratigraphy tool string ("quad combo" less density) went down the hole unobstructed. A tie-in was made with the first logging run and the log was extended up to the pipe. The FMS tool string then reached to within 23 m of total depth, and a good log was recorded. The tool became stuck at about 520 mbsf. It was freed and recovered without further attempt at logging. A third logging run was then made with the magnetic susceptibility tool string but was aborted when the tool would not pass completely out of the drill string into open hole. Because of increasingly adverse logging conditions, the remaining scheduled logs were canceled.

The drill string was worked free, and a "back-off job," with loss of drill-string components, was avoided. The drill string and the positioning beacon then were recovered, and JOIDES Resolution departed for the final scheduled drill site.

SITE 833, FLANK OF NORTH AOBA BASIN

The drilling location was about 19 nmi east-southeast of Site 832 and only about 9 nmi west of the northern tip of Maewo Island. The vessel profiled the entire distance and conducted a brief preliminary survey before the beacon was launched at 0500UTC 2 December.

Hole 833A

A PDR depth reading of 2618 mbrf from driller's datum was obtained, but the seafloor was found at 2640.5 m by the APC. Oriented APC cores started with core 134-833A-2H. Only the first three attempts achieved full 9.5-m stroke, but the APC was taken to 81 mbsf with fairly good results by means of the advance-by-recovery method. A few cores consisted mainly of fluidized ash and volcanic sand. There apparently was less of that material than at Site 832, however.

When sufficient APC stroke was no longer possible, coring continued with the XCB system. Again the volcanic silt and ash were difficult to recover, and core recovery averaged 13% for the interval of 81-200 mbsf. The WSTP temperature measurement program was more successful than at Site 832, with five usable data points obtained including one at total depth.

At 199.5 mbsf, XCB coring was terminated in favor of the RCB system for the anticipated deep penetration, and the pipe was tripped. Core recovery was 49% for the hole.

Hole 833B

Continuous RCB coring began after the hole had been drilled to 77 mbsf. Core recovery gradually increased with depth and degree of induration of the sediment to about 320 mbsf. With a few exceptions, good core recovery and hole conditions then continued to total depth. Progress was slowed drastically when basaltic sills were encountered at 831 mbsf. With the exception of about 40 m of intercalated sediments, the basalt persisted to total depth. Hole conditions continued to be good, but increased torque was noted for the final three or four cores. At 1001.1 mbsf, coring operations were terminated due to the expiration of leg operating time and diminished prospects of penetrating into Miocene sediments.

Recovery was 56.2% through the cored interval.

The upper part of the hole was found to be somewhat unstable on the wiper trip made to prepare it for logging. Fine volcanic silt flowing into the hole hampered the logging program, sticking the drill string and causing bridges to form in the hole after the first log.

The initial log, the "quad combo," was recorded over most of the open-hole interval. After considerable difficulty, the lower half of the hole was logged with the FMS tool. The geochemistry combination surveyed the same open-hole interval plus the remainder of the hole through pipe.

With operating time expired, the drill string and beacon were recovered and JOIDES Resolution departed for the port call in Fiji at 2330UTC 13 December.

Leg 134 came to its official end when the anchor was dropped in the port of Suva at 1900UTC 16 December 1990.

OCEAN DRILLING PROGRAM
SITE SUMMARY REPORT
LEG 134

HOLE	LATITUDE	LONGITUDE	SEA FLOOR DEPTH M*	NUMBER OF CORES	INTERVAL CORED (M)	RECOVERED CORE (M)	PERCENT RECOVERED	INTERVAL DRILLED (M)	TOTAL PENETRATION (M)	TIME (HRS)
827A	15-17.74S	166-21.12E	2814.2	15	110.6	100.8	91.1	.0	110.6	32.25
827B	15-17.75S	166-21.11E	2814.2	31	289.8	119.0	41.1	110.6	400.4	78.00
	SITE TOTALS:			46	400.4	219.8	54.9	110.6	511.0	110.25
828A	15-17.34S	166-17.04E	3097.6	15	111.4	101.3	90.9	.0	111.4	34.50
828B	15-17.26S	166-16.96E	3093.0	4	39.0	7.9	20.3	90.0	129.0	22.00
	SITE TOTALS:			19	150.4	109.2	72.6	90.0	240.4	56.50
829A	15-18.96S	166-20.70E	2916.2	64	590.4	197.2	33.4	.0	590.4	180.75
829B	15-18.97S	166-20.70E	2920.0	3	19.5	15.6	80.0	.0	19.5	9.25
829C	15-18.96S	166-20.70E	2921.7	11	58.4	52.7	90.2	.0	58.4	19.00
	SITE TOTALS:			78	668.3	265.5	39.7	.0	668.3	209.00
830A	15-57.00S	166-46.79E	1029.5	11	96.9	53.8	55.5	.0	96.9	19.50
830B	15-57.00S	166-46.78E	1029.5	24	233.2	48.7	20.9	48.5	281.7	51.50
830C	15-57.00S	166-46.71E	1020.0	12	115.6	19.4	16.8	235.0	350.6	75.50
	SITE TOTALS:			47	445.7	121.9	27.4	283.5	729.2	146.50

* Note: Water depths are in meters below dual elevator; dual elevator datum is ~11 meters above sealevel.

OCEAN DRILLING PROGRAM
SITE SUMMARY REPORT
LEG 134

HOLE	LATITUDE	LONGITUDE	SEA FLOOR DEPTH M*	NUMBER OF CORES	INTERVAL CORED (M)	RECOVERED CORE (M)	PERCENT RECOVERED	INTERVAL DRILLED (M)	TOTAL PENETRATION (M)	TIME (HRS)
831A	16-00.56S	166-40.34E	1077.6	15	115.5	25.9	22.4	1.0	116.5	24.00
831B	16-00.56S	166-40.36E	1077.6	84	749.6	87.3	11.6	102.4	852.0	179.50
	SITE TOTALS:			99	865.1	113.2	13.1	103.4	968.5	203.50
832A	14-47.78S	167-34.35E	3100.6	27	215.9	146.3	67.8	.0	215.9	44.75
832B	14-47.77S	167-34.35E	3100.6	100	962.3	451.0	46.9	144.4	1106.7	210.75
	SITE TOTALS:			127	1178.2	597.3	50.7	144.4	1322.6	255.50
833A	14-52.57S	167-52.78E	2640.5	26	199.5	97.8	49.0	.0	199.5	41.50
833B	14-52.56S	167-52.78E	2640.0	99	923.7	519.5	56.2	77.4	1001.1	242.00
	SITE TOTALS:			125	1123.2	617.3	55.0	77.4	1200.6	283.50
	LEG TOTALS:			541	4831.3	2044.2	42.3	809.3	5640.6	1264.75

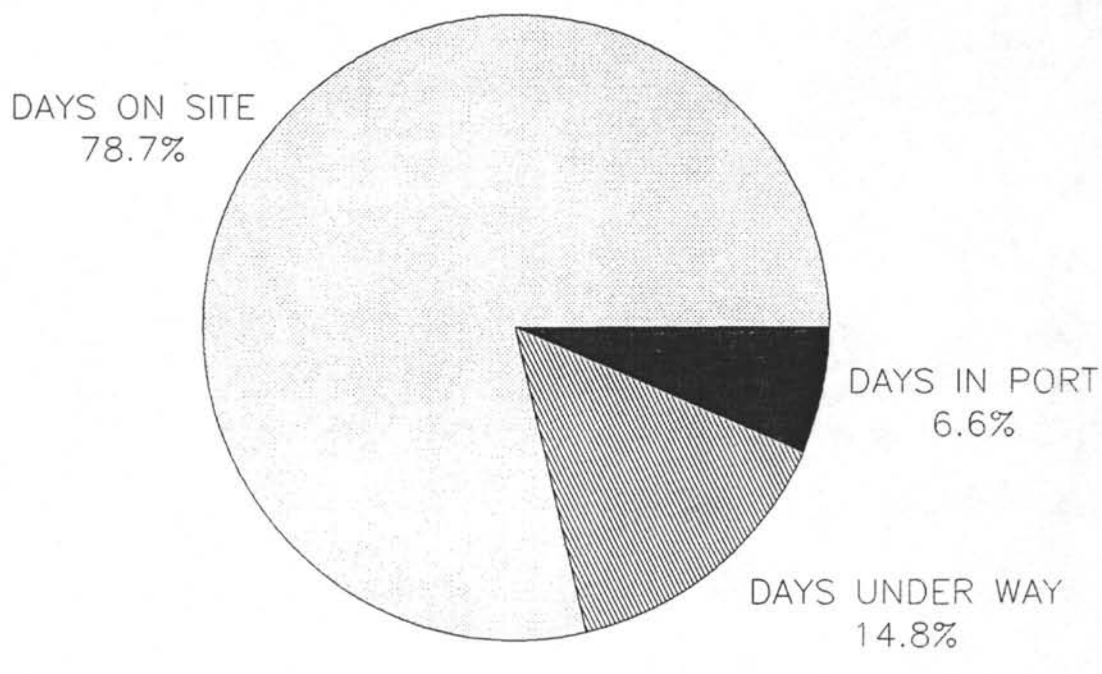
OCEAN DRILLING PROGRAM
OPERATIONS RESUME
LEG 134

Total Days (11 Oct - 17 Dec 90)	67.0
Total Days in Port	4.4
Total Days Under Way	9.9
Total Days on Site	52.7

Trip Time	6.02
Coring Time	31.89
Drilling Time	1.55
Logging/Downhole Science Time	8.92
Repair Time (Contractor)	0.06
Stuck Pipe/Hole Trouble	3.38
Other	0.89

Total Distance Traveled (nautical miles)	2133
Average Speed (knots)	10.8
Number of Sites	7
Number of Holes	16
Number of Reentries	0
Total Interval Cored (m)	4831.3
Total Core Recovery (m)	2044.2
Percent Core Recovered	42.3
Total Interval Drilled (m)	809.3
Total Penetration (m)	5640.6
Maximum Penetration (m)	1106.7
Maximum Water Depth (m from drilling datum)	3100.6
Minimum Water Depth (m from drilling datum)	1020.0

LEG 134
TOTAL TIME DISTRIBUTION



TOTAL DAYS OF LEG = 67

TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard JOIDES Resolution for Leg 134 of the Ocean Drilling Program were:

Laboratory Officer:	Bill Mills
Asst. Laboratory Officer/ Storekeeper:	Matt Mefferd
Yeoperson:	Michiko Hitchcox
Curatorial Representative:	Robert Kemp
Curatorial Representative:	Dan Quoidbach
Computer Systems Manager:	Bill Meyer
Electronics Technician:	Barry Weber
Electronics Technician:	William Stevens
Electronics Technician:	Mark Watson
Photographer:	Stacey Cervantes-DuVall
Chemistry Technician:	MaryAnn Cusimano
Chemistry Technician:	Mark Simpson
Paleomagnetics Lab/ Physical Properties Technician	Wendy Autio
X-ray Technician:	Donald Sims
Thin Section/ Underway Geophysics Lab:	Gus Gustafson
Marine Technician	Valerie Clark
Marine Technician:	Laura Heintschel

TECHNICAL REPORT

Scientific Objectives of Leg 134

Leg 134 was undertaken to study the unusual tectonic history (arc-ridge collision, subduction-polarity reversal, and the formation of intra-arc basins) of the central New Hebrides Island Arc system. The New Hebrides Arc marks the subduction of the Australia-India Plate under the North Fiji Basin and Pacific Plate. The unusual and complex tectonics of this area are the result of the aseismic ridge, the d'Entrecasteaux Zone (DEZ), colliding with the arc and clogging the trench. To investigate this collision and the resulting tectonics, we occupied 7 sites and cored 16 holes.

On 14 October, 1990 D/V *JOIDES Resolution* departed from Townsville, Australia, with a crew of 113 (48 scientists and technical staff). A fuel shortage in Townsville required that we make an overnight stop in Gladstone for fuel before proceeding to our first site in the New Hebrides. Leg 134 ended in Suva, Republic of Fiji on 17 December 1990 after 64 days at sea.

Port call: Townsville, Australia

On 11 October 1990 the *Resolution* docked in Townsville, Australia, ending Leg 133. During a 4 day port call we discharged all of Leg 133's cores and freight and loaded new supplies. In addition to normal portcall duties, technicians conducted various tours for members of the Shipboard Measurements Panel (SMP) and the Downhole Measurements Panel (DMP) and for the LDGO Borehole Research Groups's (BRG) logging-school. Panel members met individually with technicians to discuss specific lab problems and lab improvements. Both scientists and technicians found these discussions helpful. Similar exchanges with SMP and DMP should be encouraged and scheduled on a regular basis.

Lab Operations

Underway operations

We collected geophysical data on five transit lines. Technicians routinely collected bathymetrics on all lines, while magnetic data were collected only on the long transits to and from the New Hebrides drilling area. We used two 80 $in.^3$ water guns for site surveys.

Continued deployment of the global positioning system (GPS) constellation has greatly improved coverage time and data quality. GPS coverage was nearly 100% and was used to navigate all geophysical lines.

On-site lab operations

There were no special core lab experiments conducted on this leg other than Integrated Data Analysis (see discussion in the **What's New** section). Lab operations were routine, and all technicians worked hard to provide full lab support to the scientific party.

The following table summarizes the amount of lab analysis for this leg.

LABORATORY MEASUREMENT SUMMARY

General:	Sites:	7
	Holes:	16
	Meters cored:	4831
	Meters of cores recovered:	2044
	Total number of samples:	7768
Analysis:		
Physical properties:	Density:	839
	Velocity:	743
	Thermal conductivity:	443
	Vane shear:	198
	P-wave (MST):	21,101
	G.R.A.P.E. (MST):	25,152
Paleomagnetics:	Susceptibility (MST):	62,421
	Cryogenic Magnetometer:	2,000 meters approximately
	Spin Magnetometer:	600 samples for 3500 analyses
Chemistry:	inorganic carbon:	776
	Organic carbon:	334
	Total carbon:	335
	Gas/GC:	366
	Alkalinity:	59
	pH:	62
	Salinity:	72
	Sulfate:	74
	Chlorinity:	76
	Magnesium:	68
	Calcium:	71
	Phosphate:	62
	Potassium:	75
	Ammonia:	71
	Silica:	71
	Manganese:	68
	Sodium:	28
X-ray:	XRF major & trace:	54
	XRD:	104
Petrographic:	T.S.:	104

Underway Geophysics: (approximate)

Total transit nautical miles:	2,470
Bathymetry:	1,748
Magnetics:	1,528
Seismics:	93

Downhole Tools:

Heat flow (WSTP):	25

What's New

Navlog

Barry Weber made two important enhancements to the navigation software. First, Navlog will now poll the Micrologic Loran C receiver (at the same time interval as GPS) for ship's positions. The user also has the option to exclude fixes based on poor data quality. Second, when GPS is in static mode, Navlog will now store the ship's heading instead of course-over-ground. This new enhancement has greatly simplified the procedure for site-position determination.

New Masscomp hardware

Hardware enhancements included the addition of 50-mb drives to each Masscomp and an A/B switch box to switch the Loran C input between the Masscomps.

MST

Steve Bearman (MST software author) attended the Townsville port call to install a new software version. This new version allows us to complete the upgrade hardware from PRO 350's to IBM PC's. During the cruise, minor problems occured with the software. All problems were resolved.

Thermocon

The physical properties technicians installed the new half-space bath used to measure thermal conductivity on hard rocks. New Thermcon needles for both the full-space and half-space methods were tested. These needles are more durable than the old needles; however, there are still problems that will be addressed.

Integrated data analysis (IDA)

The SMP recommended that we pursue development of IDA. The concept behind IDA is to combine all shipboard data into a common database, make these data available to each member of the scientific party, and provide the software tools for correlation and analysis.

As an experiment, Bill Meyer worked with various members of the technical and scientific staff to produce this central database. The scientific party considered the experiment a success and the ability to correlate data from various disciplines initiated many lively debates among the scientific party. The experiment also provided us with an opportunity to evaluate the amount of technical and software support that will be needed for IDA. Present levels of shipboard technical support would be unable to support IDA on a routine basis without eleminating some existing science requirements. To implement IDA fully, we would need a full-time programer on shore (to develop analytical tools) and an additional systems manager.

FMS processing

Starting with this leg, ODP provided technical support to assist BRG with formation micro scanner data processing. Matt Mefferd was assigned to this task. He also assisted with the installation of their 3200 VAXstation.

Magnetometer orientation

On Leg 132, the paleomagnetist observed that the magnetic orientation measured by the cryogenic magnetometer did not agree with the same measurement from the spinner magnetometer. At the Townsville port call, Laura Stokking, Wendy Autio, and Dan Bontempo met to discuss this problem. They believe that this problem did not exist prior to the installation of new squid electronics at the Leg 132 port call. Squids have a particular orientation when built (right or left handed), and the supporting electronics must take this into account. Our magnetometer is "left handed," and it is possible that 2G installed "right-handed" squid electronics. Laura will check with 2G. An orientation correction was added to the current version of the PC software.

VAX hardware

As part of our desire to insure computing resources meet demand, the following hardware was installed on this leg:

A DELNI box was added connecting BRG's Masscomp, VAXstation, and Macintosh to lab network.

Two 1.2-gigabyte SCSI hard disks were added to the VAX cluster to relieve data congestion.

CNS

A new "low-carbon" standard was evaluated (NBS estuarine sediment 1646). Calibration curves obtained using this standard gave accurate and reproducible results for low-carbon samples. Problems exist with "high-carbon" samples indicating this standard is unacceptable.

A method to extend combustion-tube life was evaluated utilizing nickel foil. The nickel foil prevents the tin sample cups from fusing to the wall of the tube and should help prevent costly meltdowns inside the combustion ovens.