JOIDES Journal

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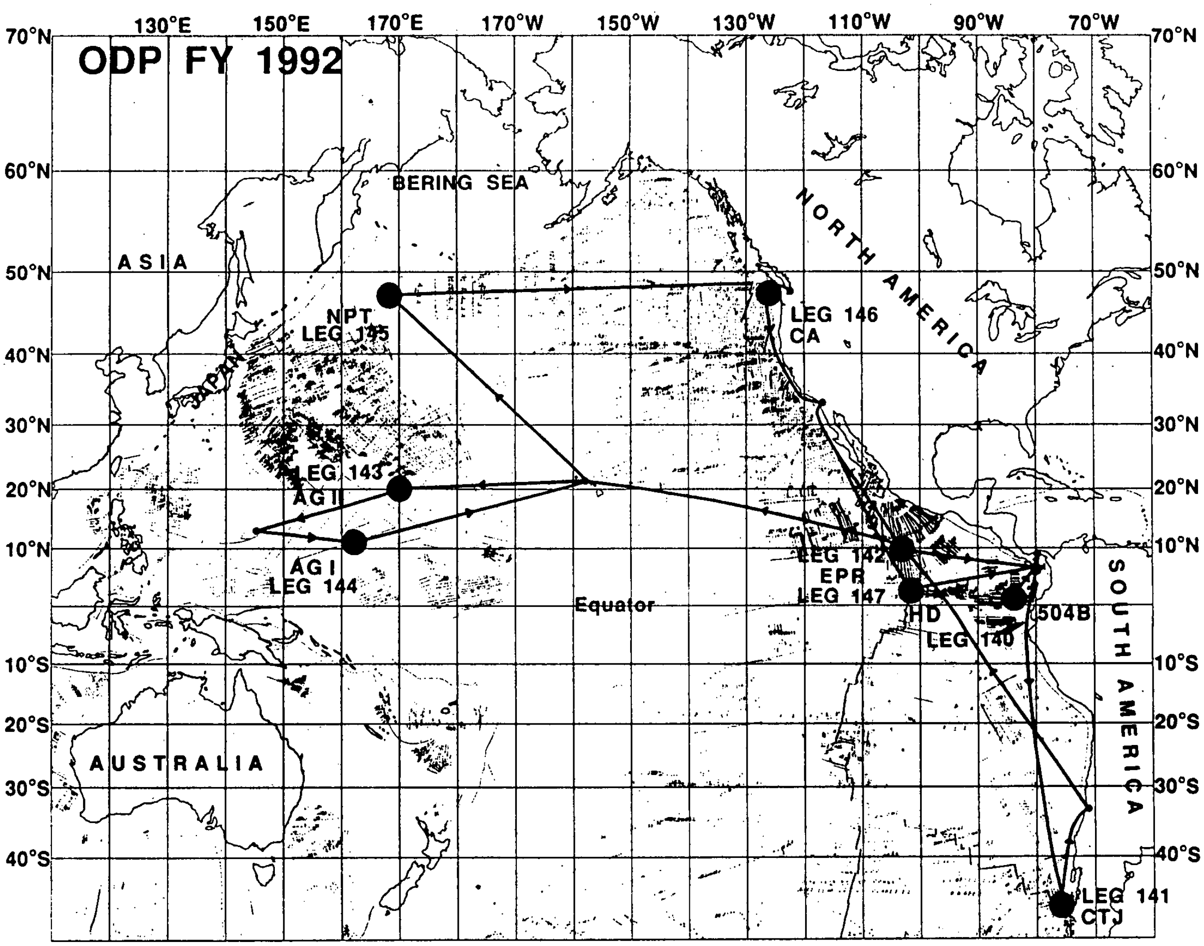

AG I	Atolls & Guyots, Leg 1	EPR	East Pacific Rise
AG II	Atolls & Guyots, Leg 2	HD	Hess Deep
CA	Cascadia Margin	NPT	North Pacific Transect
CTJ	Chile Triple Junction	504B	Deepening Hole 504B

Front Cover

The "Fiscal Year 1992" drilling schedule. Leg 140 will begin in September 1991 and Leg 147 will conclude the first phase of ODP Pacific operations in January 1993, when the *JOIDES Resolution* will transit to the Atlantic for an as yet unspecified period of drilling activity there. Leg 140 will either deepen Hole 504B (if Leg 137 cleaning/milling operations are successful) or attempt to sample lower oceanic crust and upper mantle at Hess Deep. One or two engineering tests of the DCS will occur on the East Pacific Rise at 9° 30'N. Leg 142 will set a guidebase and attempt to start a deep hole at Site EPR-1 with DCS Phase II. Leg 147 may be an inaugural test of DCS Phase III at the same site, if it is ready. Hess Deep could also become Leg 147 if operations continue at Hole 504B during Leg 140. Additional details concerning the FY92 schedule are available in *GSA Today* and *Eos*.

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Focus

Howdy, ya'll! Greetings from the (almost) new JOIDES Office, now situated at the Institute for Geophysics of The University of Texas at Austin. We have grabbed the reins from the University of Hawaii, and the horse has not run away (so far). I am proud to introduce an exceptional staff to the scientific ocean drilling community: Craig Fulthorpe, my "right hand man" with responsibilities to EXCOM, PCOM and the *JOIDES Journal*; Peter Blum, who has already proven himself to be a database genius in the seemingly never-ending task of attempting to improve communications and proposal handling; and last but not least, Kathy Moser, the "voice on the telephone" who covers for all of us. We are a phone call, fax, telemail, or e-mail away, and we are here to serve everyone either involved with or interested in ODP. Please let us help you in any way we can.

So much for pleasantries. We live, it is said, in interesting times. Against a backdrop of possible war in the Middle East, PCOM set its Fiscal Year 1992 (November 1991-January 1993) schedule in December. The *JOIDES Resolution* will address scientific objectives spanning the Pacific Basin: from Atolls and Guyots to the Chile Triple Junction to both sedimented and unsedimented ridge crests. Never has the drillship tackled such enticing and challenging targets, but never has scientific ocean drilling needed advanced drilling technology more than it will in the early 1990s. In recent years, the crowning jewel in our engineering tiara has been the Diamond Coring System (DCS). To date, ODP has spent millions to develop a marine version of the DCS. In December, we learned that a truly viable DCS will require millions more to become a reality, at a time when fuel costs have increased around the world. Without the DCS, ODP will have to retreat from long-held and cherished goals, like improved sampling of chert-chalk sequences and deep-penetration at ridge crests and on continental margins. We must continue the DCS engineering effort, while at the same time providing the funds necessary to operate the *Resolution* through her upcoming Pacific activities without interruption.

As renewal approaches, I urge all JOIDES partners to recommit to one of the most exciting international scientific programs the world has ever seen. Investment in ODP is not and will not be cheap, but the return on investment will be exceptional. Thank you all for giving me the opportunity to participate.

Jamie

James A. Austin, Jr.
Planning Committee Chairman

Science Operator Report

LEG 133 PRELIMINARY REPORT (SUMMARY): NORTHEAST AUSTRALIAN MARGIN

The complete Leg 133 Preliminary Report, available from Ocean Drilling Program, Texas A&M University Research Park, College Station, Texas 77845-9547, contains further details.

INTRODUCTION

Leg 133 began on 4 August, 1990, with a port call in Guam, U.S.A., and ended on 11 October in Townsville, Australia. The following site summaries were prepared by Co-Chiefs Drs. Peter Davies and Judith McKenzie. Dr. Amanda Palmer-Julson was the Staff Scientist. Objectives were to define the evolution of platforms, including their relations to adjoining basins, and to understand effects of climate and sea level on their development in space and time. In achieving these objectives, over 5.5 km of core was recovered from 36 holes.

Sites and physiographic-structural elements are located in Figure 1. Figure 2 contains a lithostratigraphic summary of the Queensland Trough transect (Sites 821, 820, 819, 822, 823, 824, 825 and 811). Figure 3 contains a lithostratigraphic summary of the Townsville Trough transect (Sites 812, 814, 813, 817, 815, 816 and 826).

SITE 811

Site 811 (proposed site NEA-8) is located on the western margin of the Queensland Plateau, 3.5 nmi east of Holmes Reef. The site was intended to sample a periplatform sequence and to determine sea level and climatic signals for comparison with proposed sites NEA-1 through -3 (Sites 819-821).

Results

Drilling penetrated a 392.5-m-thick sequence of early-middle Eocene to Pleistocene calcareous (‹99% $CaCO3$) platform-top sediments. Based on benthic foraminifers, the site has remained at middle bathyal depths (600-1000 m) for at least the last 10 m.y. Below 200 mbsf, reworking and redeposition of shallower water deposits are indicated by larger benthic foraminifers. Below 270 mbsf, redeposited skeletal grains document the transition to a neritic environment, possibly fore- or back-reef. Sedimentation rates for the upper 270 mbsf were relatively low for a carbonate platform environment, ranging between 1.5 and 3 cm/k.y. Variations can be attributed to varying amounts of bank-derived carbonate detritus and removal of finer fractions by winnowing.

Six major lithostratigraphic units were recovered:

Unit I (0-33.15 mbsf; upper Pleistocene to upper Pliocene, 1.8-2.5 Ma): foraminifer oozes with nannofossils and nannofossil oozes with foraminifers, intercalated with redeposited shallow-water carbonates composed of unlithified bioclastic packstones with nannofossils and lithoclastic rudstones.

Unit II (33.15-147.5 mbsf; upper Pliocene to upper Miocene, 2.4-8.75 Ma): homogeneous nannofossil oozes with foraminifers to foraminifer oozes with nannofossils.

Unit III (147.5-269.5; upper to middle Miocene, 8.75-12.5 Ma): periplatform oozes and chalks, which alternate with 10- to 70-cm-thick bioclastic foraminifer wackestone, packstone, lithoclast floatstone, and rudstone layers; these commonly fine upward and are considered to be turbidites.

Unit IV (269.5-356.3 mbsf; middle to lower Miocene, 12.5-? Ma): redeposited sand and rubble containing skeletal grains such as coral debris, alcyonarian spicules, mollusc fragments, small and larger benthic foraminifers (amphisteginids, miliolids, textularians), echinoids, crustaceans, bryozoans, and red algae. This unit

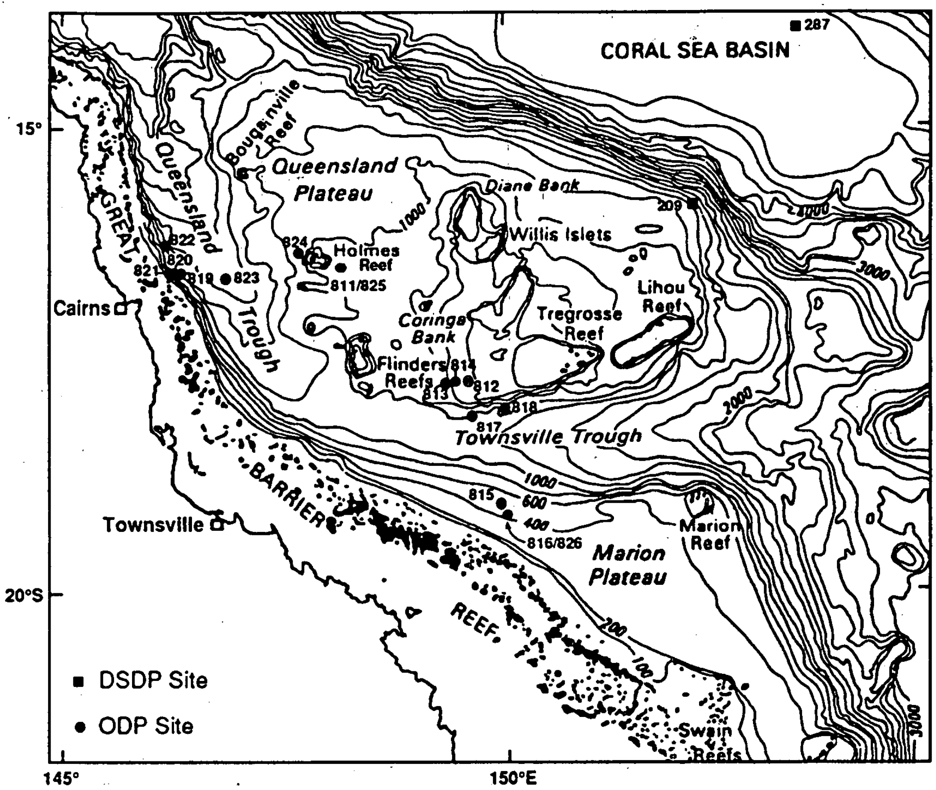

Figure 1. Main physiographic-structural elements and Leg 133 sites.

documents passage from a neritic environment, possibly representing a fore- or back-reef, into the middle bathyal environment of overlying units. Very poor recovery of neritic sediments and lack of biostratigraphic markers limit this interpretation.

Unit V (356.3-365.9 mbsf; upper Oligocene, ? Ma): a poorly recovered, unlithified to well-cemented, fine-grained skeletal packstone, containing abundant planktonic foraminifers in a micritic matrix composed of silt-sized bioclasts. This unit documents sedimentation in a comparatively cold, open-water environment.

Unit VI (365.9-392.5 mbsf; lower to middle Eocene): A pebble of shallow-water limestone recovered from this interval may represent the sedimentary cover overlying basement.

Site 812

Site 812 (proposed site NEA-10A/1) is located on the southern margin of Queensland Plateau between Flinders and Tregrosse reefs. It represents the lagoonal-bank end-member of a three-site transect (with Sites 813 and 814) intended to study facies distribution in response to sea-level changes across a platform-slope transition in a pure carbonate system.

Results

Drilling penetrated a 300-m-thick sequence of middle Miocene to Pleistocene platform-top sediments (av. 97% CaCO3). Benthic foraminifers indicate deepening from a neritic setting (0-200 m) in late Miocene to early Pliocene to upper bathyal depths (200-600 m) during late Pliocene and Pleistocene. Middle Miocene sedimentation occurred in a shallow-water, lagoonal, or back-reef environment.

Latest Pliocene to Pleistocene sedimentation rate is slightly more than 1 cm/k.y., whereas it was ~0.5 cm/k.y. in the early Pliocene. A hardground separating lower Pliocene (Hole 812A) or uppermost upper Miocene (Hole 812C) from overlying upper Pliocene sediments is consistent with

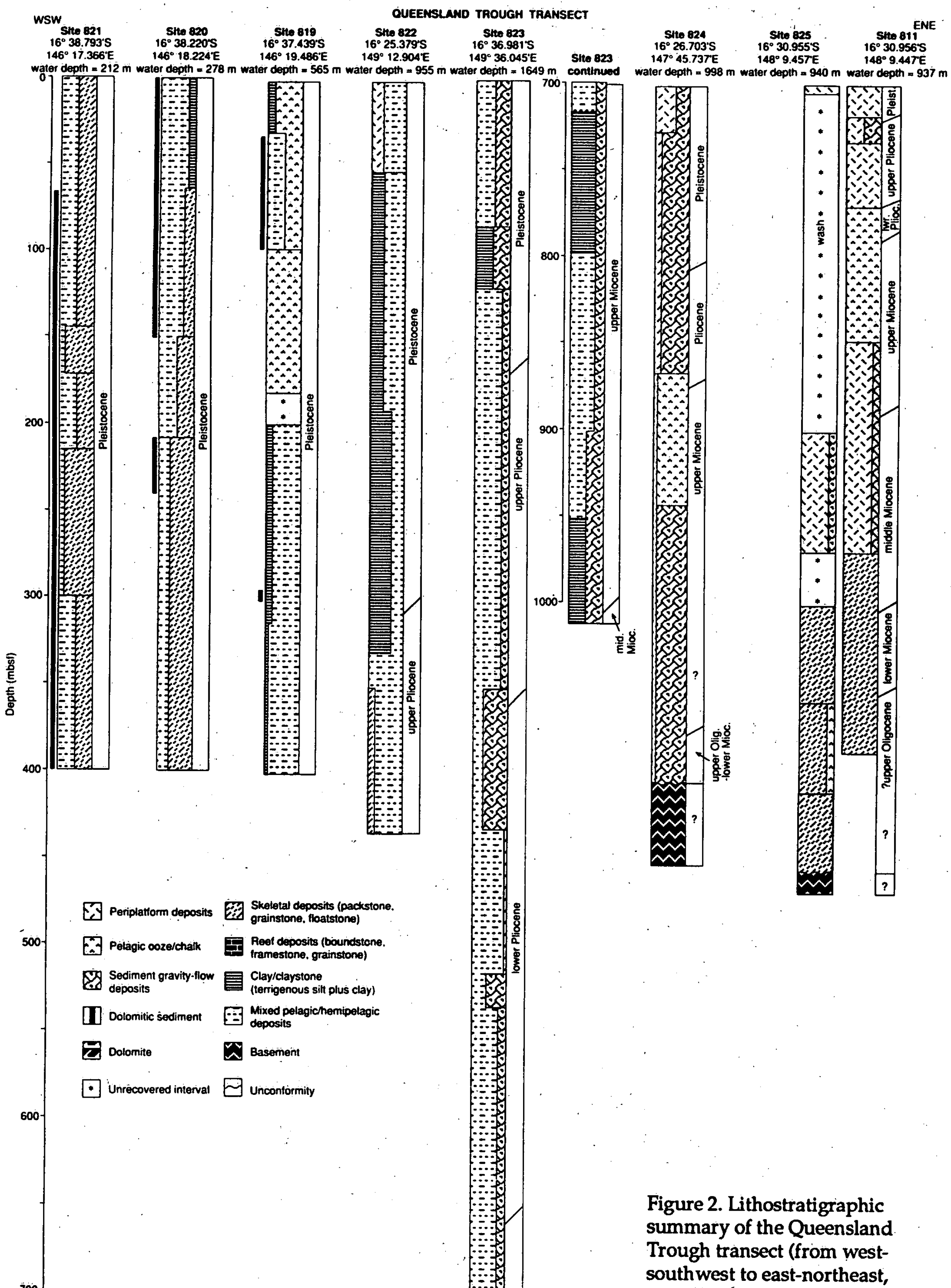

Figure 2. Lithostratigraphic summary of the Queensland Trough transect (from west-southwest to east-northeast, Sites 821, 820, 819, 822, 823, 824, 825, and 811).

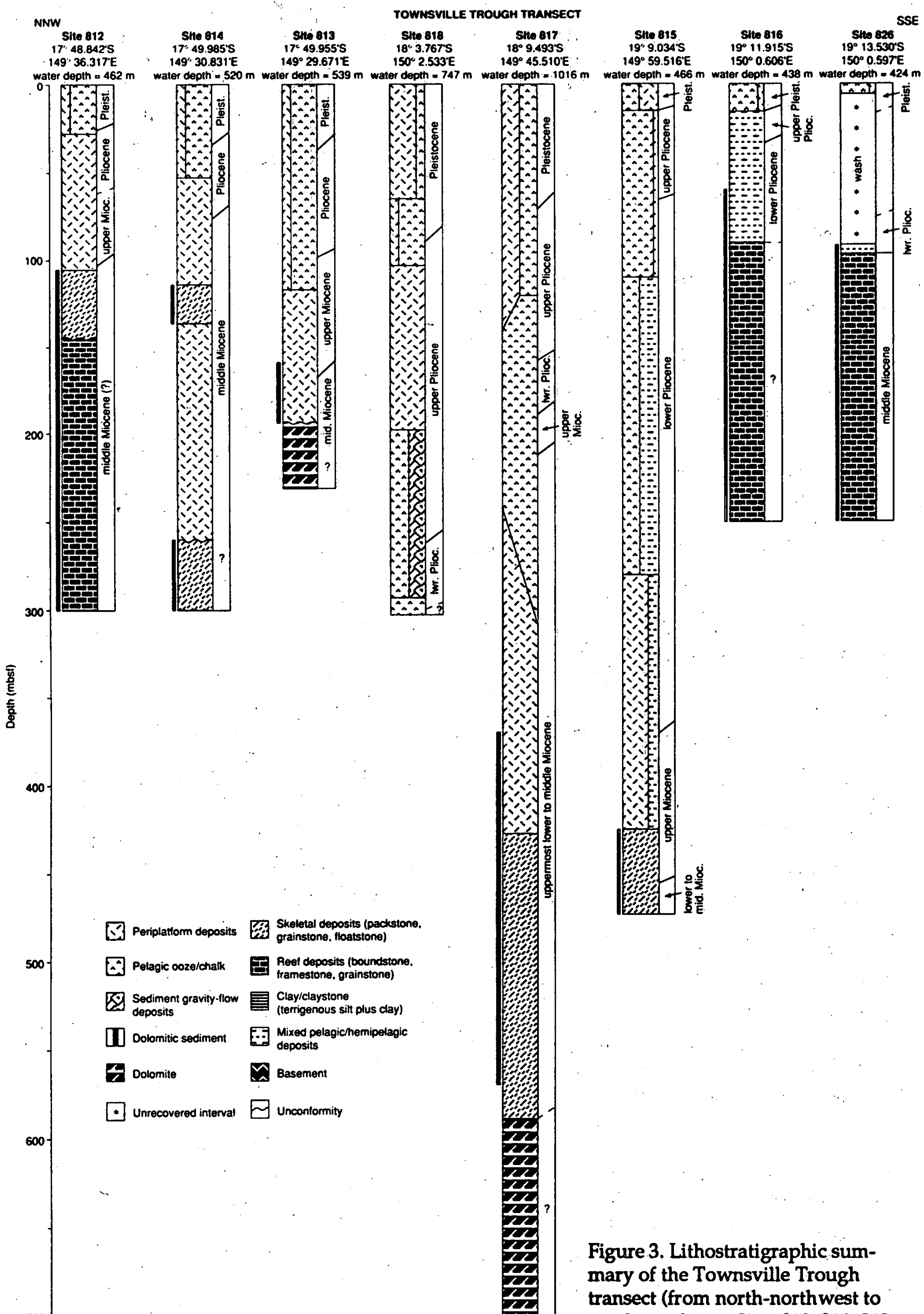

Figure 3. Lithostratigraphic summary of the Townsville Trough transect (from north-northwest to south-southeast, Sites 812, 814, 813, 818, 817, 815, 816, and 826).

that interpretation. Shipboard paleomagnetic studies revealed the top of the Olduvai event (1.88 Ma) above the hardground.

Three major lithostratigraphic units were recovered:

Unit I (0-27.9 mbsf; upper Pliocene to Pleistocene): white foraminiferal oozes with pteropods and bioclasts consisting of fine-grained planktonic foraminiferal debris and bryozoan particles.

Unit II (27.9-141.6 mbsf; upper Pliocene to middle or lower upper Miocene): 1.5-m-thick white to light gray dolomitized limestone hardground separates Unit I and Unit II. The capping surface is composed of light reddish-brown to brownish fine laminations, presumably iron oxides and phosphate coatings. The degree of induration decreases downward from lithified grainstone to unlithified packstone.

Unit III (141.6-300.0 mbsf; middle Miocene?): based on downhole logs, the contact between Unit II and Unit III is sharp, with marked increases in resistivity, velocity, and U content between 141 and 145 mbsf.

SITE 813

Site 813 (proposed site NEA-10A/3) is located on the southwestern edge of the extensive Tregrosse/Lihou/Coringa Bank complex. Site 813 represents the most distal part of an aggradational/progradational sequence.

Results

Double-APC coring penetrated a 231.5-m-thick sequence of middle Miocene to Pleistocene drowned platform sediments (av. >95% CaCO3). Benthic foraminifers indicate water depth increasing from shallow neritic (0-100 m) in the middle Miocene to upper bathyal (200-600 m) during the late Pliocene and Pleistocene.

Upper Pliocene to Pleistocene sedimentation rate was 2.2 cm/k.y., succeeding an early Pliocene rate of ~1.2 cm/k.y. Latest late Miocene sedimentation rate was 3 cm/k.y. Nannofossil foraminiferal oozes of Unit II were deposited during earliest late Pliocene to late Miocene and are distinguished from overlying and underlying oozes by inclusion of iron-stained and/or phosphatized particles. In addition, changes in physical properties (e.g., lower velocity and increased porosity and water content) occur between 64.2 and 102.4 mbsf, encompassing most of Unit II. These properties suggest that fines may have been winnowed away, leaving behind coarser grained, more porous sediment. Concentration of iron-stained and phosphatized reworked particles requires a source area wherein these chemical alterations occurred, possibly associated with the contemporaneous condensed sequence recovered at nearby Site 814.

Five major lithostratigraphic units were recovered:

Unit I (0-76.8 mbsf; Pleistocene to upper Pliocene): homogeneous, micritic, foraminiferal to foraminiferal nannofossil ooze with bioclasts. High nannofossil content (50%-80%) is consistent with predominantly pelagic origin, but variable degrees of induration suggest that flux of metastable bank-derived carbonates - having a greater diagenetic potential - was not constant.

Unit II (76.8-117 mbsf; lowermost upper Pliocene-upper Miocene): nannofossil foraminiferal ooze with micrite. Upper boundary is marked by salmon-colored foraminiferal ooze containing reddish brown to reddish yellow, presumably iron-stained particles mixed with *in-situ* foraminifers, bioclasts, and grains of unknown origin. In the lower part, ooze is characterized by dark grains that are phosphatized benthic foraminifers.

Unit III (117-160 mbsf; upper Miocene): bioclastic foraminiferal ooze with micrite and nannofossils ("periplatform ooze"); this unit differs from overlying units in having reduced nannofossil content (~20%-30%) in the fine fraction, which suggests a larger input of bank-derived metastable carbonate.

Unit IV (160--~195 mbsf; lowermost

upper Miocene-middle Miocene): dolo mitized semi-lithified to lithified foraminiferal micritic chalks containing bioclasts interbedded with dolomitized unlithified to semi-lithified micritic foraminiferal ooze containing bioclasts and nannofossils. Basal 3 m contains dolomitized bioclastic nannofossil chalk interbedded with dolomitic foraminiferal rudstone and packstone.

Unit V (~195-231.5 mbsf; middle Miocene or older?): poor recovery in this interval yielded fragments of dolomitized skeletal grainstones and microcrystalline dolomite, including calcareous algae and foraminifers which suggest a shallow neritic environment (10-50 m) adjacent to or on a carbonate bank.

Site 814

Site 814 (proposed site NEA-10A/2) is located on the southwestern edge of the Tregrosse/Lihou/Coringa Bank complex. The site is in front of the carbonate bank and represents the proximal transition between lagoonal-bank (Site 812) and distal parts (Site 813) of an aggradational/ progradational sequence.

Results

Drilling penetrated a 300-m-thick sequence of middle Miocene (or older) to Pleistocene platform-slope sediments (av. 96% CaCO3). Benthic foraminifers indicate deepening from shallow neritic (0-100 m) in middle Miocene to upper bathyal (200-600 m) during late Pliocene-Pleistocene. Late Pleistocene sedimentation rate was 2.4 cm/k.y. and ~1.2 cm/k.y. in the late Pliocene-early Pleistocene. Late Miocene-early Pliocene is either missing or corresponds to a time of reduced sedimentation. Middle Miocene sedimentation rate is estimated to be ~1.4 cm/k.y.

Five major lithostratigraphic units were recovered:

Unit I (0-56.8 mbsf; Pleistocene to upper lower Pliocene): nannofossil foraminifer ooze intercalated with foraminiferal packstone.

Unit II (56.8-66.5 mbsf; lower Pliocene?-upper Miocene?): well-lithified yellow to white foraminiferal micritic limestone containing fish teeth and phosphate grains capped by a hardground surface coated with iron- rich crust. Surface has been bored and filled by several generations of cement. Moldic and vuggy porosity occurs, in addition to scattered silt-sized dolomite crystals and grains. Coring recovered 0.6 m of limestone, but downhole logging suggests that Unit II is ~8 m thick, with degree of induration decreasing downward.

Unit III (66.5-136.0 mbsf; middle Miocene): micritic ooze to bioclastic packstone.

Unit IV (136.0-263.9 mbsf; middle Miocene): dolomitized bioclastic packstone, calcareous ooze, partially lithified mudstone and partially lithified lithoclastic floatstone.

Unit V (263.9-300.0 mbsf; age unknown): yellowish brown to pale brown dolomitized lithified packstone of sucrosic dolomite with high intergranular porosity. Dolomitization obliterates original fabric and texture.

Site 815

Site 815 (proposed site NEA-14), located along the southern margin of Townsville Trough ~3 km north of the northwestern edge of Marion Plateau, was intended to: establish composition and age of the forereef and over-lying sediments, and to establish cause and timing of platform demise. Other objectives were to investigate paleoclimatic history and facies response to climatic variation and initiation of boundary-current activity.

Results

Drilling penetrated a 473.5-m-thick sequence; 416 m of uppermost Miocene-Pleistocene hemipelagites overlying lower/middle-upper Miocene shelf carbonates. Uppermost Miocene benthic foraminifers indicate outer neritic water depths (100-200 m), but redeposited reefal taxa occur. Site 815 deepened to upper bathyal (200-600 m) during hemipelagite deposition. Late Pliocene-Pleistocene sedimentation rates were 1.7 to 3.2 cm/k.y., but increased tenfold during the early Pliocene, with rates up to 32.4 cm/k.y. between 3.51 and 4.24 Ma. Lower Pliocene sediments ~275 m thick should provide high-resolution biostratigraphy.

Six major lithostratigraphic units were recovered:

Unit I (0-73.3 mbsf; Pleistocene to lower upper Pliocene): foraminifer nannofossil to nannofossil foraminifer ooze; nannofossil content 20%-30%.

Unit II (73.3-280.5 mbsf; lower Pliocene): greenish gray to gray, slightly bioturbated nannofossil oozes to unlithified nannofossil mixed sediment.

Unit III (280.5-348.4 mbsf; lower Pliocene): greenish gray to gray foraminifer nannofossil and nannofossil foraminifer chalks distinguished by increases in degree of induration and contorted and folded bedding. Nannofossil content is up to 80%.

Unit IV (348.4-425.3 mbsf; upper upper Miocene): greenish gray foraminifer nannofossil and nannofossil foraminifer chalks with increases in number of burrows preserved as sedimentary structures. Larger burrows become more numerous with depth; recognized trace fossils include *Chondrites, Zoophycos, Planolites,* and possibly *Scoyenia.* Nannofossil content is 35%-50%.

Unit V (425.3-444.5 mbsf; upper middle to upper Miocene): pale brown dolomitized lithified foraminifer packstones with bioclasts and minor chalk. Trace fossils become less common with depth. Between Units V and VI (444.5-454.2 mbsf) there was no recovery, and downhole logging did not reach this level.

Unit VI (454.2-473.2 mbsf; uppermost lower Miocene to lower middle Miocene): poorly recovered dolomitized white large benthic foraminifer rudstones to floatstones within a planktonic foraminifer packstone.

Site 816

Site 816 (proposed site NEA-13) is located on the northwestern corner of Marion Plateau. This site was intended to determine nature, age and cause(s) for demise of known buildups and minimum position and timing of middle Miocene sea-level fall.

Results

Drilling penetrated a 250-m-thick sequence of sediments composed of 90 m of lower Pliocene-Pleistocene hemipelagites overlying very shallow-water (< 5 m)\earliest Pliocene or older lithified carbonates. Shallow-water bio-assemblages are chlorozoan, indicative of warm surface waters. Within hemipelagites, benthic foraminifers indicate upper bathyal depths (200-600 m). Late Pleistocene sedimentation rate was low (0.5 cm/k.y.), whereas late Pliocene rates (2 cm/k.y.) were normal for a pelagic setting. Sediments from the top 31 m of Hole 816A are magnetically reversed, indicating that most of the Brunhes and perhaps part of the Matuyama magnetic zones are missing. This could account for low Pleistocene sedimentation rate. As at Site 815, early Pliocene sedimentation rate increased dramatically.

Three major lithostratigraphic units were recovered:

Unit I (0-90.0 mbsf; Pleistocene to lower Pliocene): light gray foraminifer nannofossil ooze grading downward into olive green nannofossil clayey ooze with dolomite and foraminifers.

Unit II (90.0-163.7 mbsf; age unknown, but probably older than CN 10-11 and N18- 19): partially dolomitized rhodolith-bearing bioclastic floatstone and rudstone. Spheroidal to discoidal rhodoliths are cemented within a matrix consisting of coarse angular fragments of molluscs, coralline algae, coral, *Halimeda*, bryozoans, echinoid spines, and lithoclasts. Moldic and intraparticle porosity is well developed and geopetal fabrics partially fill some cavities. Deposition probably occurred in shallow-water (< 5 m) back-reef environment.

Unit III (163.7-250.0 mbsf; older than lower Pliocene): dolomitized coralline algal and coral (including *Porites* and *Acropora*) boundstone and framestone with white rhodoliths up to 5 cm in diameter. Minor bioclasts include fragments of coralline algae, molluscs, rare *Halimeda*, and coral. Moldic and intraparticle porosity are well developed. Deposition probably occurred on a reef flat, possibly in an intertidal regime.

Site 817

Site 817 (proposed site NEA-11), located on the lower slope of the Queensland Plateau southwest of the Tregrosse/Lihou/Coringa bank complex, was intended to obtain stratigraphic and age data to interpret event stratigraphy on the northern side of the Townsville Trough.

Results

Drilling penetrated 700 m of late early Miocene to Pleistocene carbonate platform slope sediments. The sequence contains a record of varying flux of platform-derived vs. pelagic-derived carbonate sediment to the slope. Latest early Miocene to middle Miocene and early late Pliocene to Pleistocene were periods when platform-derived material dominated. During late middle Miocene to early late Pliocene, Queensland Plateau was apparently drowned and pelagic flux dominated.

Nature of bank-derived sediment varied with time; during middle Miocene, bioclastic debris accumulated, whereas only periplatform ooze reached the site during Pliocene to Pleistocene. Apparently, the slope was adjacent to a producing carbonate platform margin during the middle Miocene. During the Pliocene to Pleistocene, carbonate production had stepped back to the present position of the Tregrosse/Lihou/Coringa bank complex, enabling only fine-grained material to reach the preexisting slope.

Three major lithostratigraphic units were recovered:

Unit I (0-200.8 mbsf; Pleistocene to uppermost Miocene): strongly bioturbated white micritic ooze with foraminifers and nannofossils (0-120 mbsf) that grades into nannofossil ooze with foraminifers and micrite (120-200.8 mbsf). Soft-sediment deformation (i.e., slump folds) occurs at several points.

Unit II (200.8-426.7 mbsf; upper Miocene to uppermost lower Miocene): possible unconformity, distinguished by transition from ooze to chalk, separates Units I and II. Unit II contains micritic chalk, nannofossil chalk with foraminifers, micrite, sponge spicules, and radiolarians, and micritic chalk with foraminifers and bioclasts.

Unit III (426.7-700.0 mbsf; uppermost lower to middle Miocene, not > 18 Ma): contact between Units II and III is gradational and conformable; it is arbitrarily placed where coarse-grained bioclasts first appear. Unit III is characterized by relatively coarse-grained bioclastic limestone and dolomite.

Site 818

Site 818 (proposed site NEA-9A), located on a gently inclined upper slope terrace of the Queensland Plateau southwest of the Tregrosse/Lihou/Coringa bank complex, was selected to penetrate a thick pile of upper Neogene sediments. in order to determine their composition and origin.

Results

APC drilling recovered 303 m of early Pliocene to Pleistocene periplatform sediments. Benthic foraminifers indicate middle bathyal paleodepths (600-1000 m). Occurrence of platform-derived carbonate throughout implies transport from the Queensland Plateau since the early Pliocene, but varying flux may be associated with changes in bank productivity and/or amount of redeposition at the site. Compared with the sedimentation rate for the past 1.5 m.y. (5.7 cm/k.y.), two previous periods exhibit significantly different carbonate accumulation rates: 2.4 cm/k.y. between 1.5 and 2.42 Ma, and 42 cm/k.y. between 2.42 and 2.6 Ma.

Two major lithostratigraphic units were recovered:

Unit I (0-293.4 mbsf; Pleistocene to lower Pliocene): white to light gray homogeneous periplatform oozes composed of varying proportions of micrite and nannofossils with minor amounts of bioclasts, foraminifers and pteropods.

Unit II (293.4-302.9 mbsf; possibly upper Miocene): light gray well-indurated calcareous chalk with bioclasts and foraminifers.

Site 819

Site 819 (proposed site NEA-3) occurs in Grafton Passage on the continental slope east of Cairns, defining the deeper water end of a shelf-edge transect (with Sites 820 and 821) aimed at defining relations between sea-level change, sedimentary sequences, seismic geometries, and in particular the response of a developing slope sequence to rapid global sea-level changes. Objectives were to determine nature of progradational and aggradational units beneath the upper slope terrace and age and origin of eight seismic sequences.

Results

APC/XCB coring to 400 mbsf recovered 84.9% of an expanded Pleistocene section spanning <1.48 m.y. Preservation of nannofossils was excellent, although preservation of planktonic foraminifers is facies specific, with light-colored intervals containing abundant foraminifers. Benthic foraminifers indicate upper bathyal water depths throughout, but sediment studies suggest variations controlled by sea-level change and fluvial contributions. A hiatus occurs between 275 and 465 k.y. Sedimentation rates vary in relation to lithologic changes: 10-11 cm/k.y. in the late Pleistocene, 6 cm/k.y. from 0.93 to 0.465 k.y., and 42.4 cm/k.y. during the middle Pleistocene (1.27-0.93 Ma). Between 1.27 Ma and the base of Hole 819A (<1.48 Ma), sedimentation rate is ~87 cm/k.y. Calculation of sedimentation rates and definition of sedimentary units are complicated by slumping at 32.5 and 75 mbsf and a slump detachment surface at ~190 m observed in seismic data.

Five major lithostratigraphic units were recovered:

Unit I (0-32.5 mbsf; <275 k.y. in age, upper Pleistocene): rhythmically interbedded couplets of dark green clay-rich and green gray carbonate-rich clayey pteropod ooze.

Unit II (32.5-97.0 mbsf; Pleistocene): five rhythmic couplets of silty stringers toward the base grading upward into dolomitized clayey nannofossil oozes.

Unit III (97.0-179.7 mbsf; Pleistocene): rhythmically interbedded bioclastic and micritic oozes. An unrecovered interval between Units III and IV occurs at 179.7-198.1 mbsf.

Unit IV (198.1-313.2 mbsf; >1.27 Ma and <1.48 Ma in age; Pleistocene): bioclastic wackestones and nannofossil clayey oozes with quartz and silt stringers. Carbonate contents are generally low; a mixed terrigenous/neritic to upper bathyal origin is indicated. Although higher percentages of quartz silt and sand characterize the unit as a whole, they are best seen near the base, where three upward-coarsening packages occur.

Unit V (313.2-400 mbsf; 1.27 to 1.48 Ma in age; Pleistocene): relatively homogeneous sequence of dark green gray bioclastic clayey chalk at the base, micritic clayey chalks in the middle, and clayey bioclastic nannofossil chalks in the uppermost part. Carbonate contents are uniform. Quartz is most dominant in the middle micritic part of the section.

Site 820

Site 820 (proposed site NEA-2) occurs in Grafton Passage, the central site in the shelf-edge transect described above. Objectives included determining composition and origin of prograding and aggrading units beneath the outer upper slope. In conjunction with Site 821, Site 820 allows calibration of abrupt seismic facies changes.

Results

Hole 820A was APC/VPC cored to 144.2 mbsf with 100% recovery. Hole 820B was APC cored to 160.2 mbsf and XCB cored to 400 mbsf; recovery overall was 81.2%. The section to 400 mbsf is an expanded Pleistocene interval; nannofossil and planktonic data suggest that the section is fairly complete and has an age range at the bottom of the hole from 1.27 to 1.48 Ma. Nannofossil preservation is related to subtle lithologic changes and is good in the upper 100 mbsf, moderate to poor between 100 and 300 mbsf, and improves again below 300 mbsf. Preservation of planktonic foraminifers is related to lithologic variability. Benthic foraminifers suggest that sediments above 150 mbsf were deposited in an upper bathyal environment and that sediments below 150 mbsf were deposited in upper bathyal and outer neritic water depths. Sedimentation rates at Site 820 compare to those at Site 819: 41.1 cm/k.y. typifies middle Pleistocene; 8.2 cm/k.y. in latest middle Pleistocene; 35 cm/k.y. in earliest late Pleistocene; and 10-11 cm/k.y. in latest Pleistocene.

Three major lithostratigraphic units were recovered:

Unit I (0-150.7 mbsf; age, 0 to 1.27 Ma; Pleistocene): very fine-grained wackestones and mudstones interbedded with bioclastic packstones; generally finer grained than underlying sediments. Bioturbation is pervasive. Dolomite increases gradually with depth.

Unit II (150.7-208.1 mbsf; Pleistocene): mixture of bioclastic packstones, bioclastic clayey mixed sediments, and silty claystones; transition from coarser Unit III to finer grained Unit I.

Unit III (208.1-400 mbsf; Pleistocene): bioclastic packstones with interbedded finer grained calcareous mudstones (some laminated) and mixed sediments. Five cycles are recognized, each representing upward-coarsening from dark greenish gray calcareous mudstone with bioclasts and nannofossils to medium to fine calcareous chalky packstone containing quartz, feldspar, nannofossils, and clay. Dolomite (max. = 17.4%, at 224.4 mbsf) is present within top three cycles.

Site 821

Site 821 (proposed site NEA-1) occurs in Grafton Passage, defining the shallow end member of the shelf-edge transect described above. Objectives were to determine composition and origin and sea-level signal of prograding and aggrading units beneath the uppermost slope terrace.

Results

Hole 821A was APC cored to 145.9 mbsf and XCB cored to 400 mbsf, with average recovery of 95%; Hole 821B was APC cored to 165.9 mbsf with 100% recovery. As at Sites 819 and 820, the section to 400 mbsf at Site 821 is an expanded Pleistocene section. Nannofossils indicate an age of 1.27 to 1.48 Ma for its base. Preservation of planktonic foraminifers and nannofossils varies from near pristine in clayey intervals to overgrown in sandy intervals. Benthic foraminifers indicate a depth range of neritic to upper bathyal. Variation in sedimentation rates at Site 821 is similar to that at Site 820: middle Pleistocene rates of 28.2 cm/k.y. are succeeded by 12.2 cm/k.y. between 0.930 and 0.465 Ma, 49.2 cm/k.y. in the succeeding 190 k.y., and 10.2 cm/k.y. from 0.275 k.y. to the Present. The locus of increased sedimentation had shifted from Site 820 to Site 821 by late Pleistocene, coincident with an aggradation phase of sedimentation.

Five major lithostratigraphic units were recovered:

Unit I (0-145.5 mbsf; age, <0.456 Ma; Holocene to upper Pleistocene): mixed sediments of siliceous and bioclastic components, calcareous silts and clays, bioclastic and nannofossil oozes and chalks, bioclastic packstones, and *Halimeda* rudstones. With the exception of its uppermost part, this unit is thought to represent a series of rapidly deposited aggradational packages.

Unit II (145.5-172.0 mbsf; age, > 0.465 to <0.93 Ma; upper Pleistocene): at the base is an upward-fining siliciclastic-dominated packstone; at the top is a glauconitic and siliciclastic lithified mudstone, perhaps representing a hardground.

Unit III (172.0-215.8 mbsf; age, >0.93 to 1.27 Ma; lower Pleistocene): dolomitized bioclastic wackestone/chalk and bioclastic packstone.

Unit IV (215.8-298.8 mbsf; age, >0.93 Ma to ~1.27 Ma; lower Pleistocene): thickly bedded dolomitized chalk and bioclastic packstones and wackestones.

Unit V (298.8-400.0 mbsf; lower Pleistocene): dolomitized bioclastic packstones and chalky mixed sediments interbedded with less calcareous sandy, silty, and clayey mudstones.

Site 822

Site 822 (proposed site NEA-4) occurs at the foot of the slope east of the Great Barrier Reef offshore Cairns, northeast of the transect in Grafton Passage. Drilling was aimed at determining age and facies of a lower slope fan; an additional objective was to define lower slope fan processes and to understand sea-level signatures preserved in the lower slope facies.

Results

Hole 822A was APC cored to 95.9 mbsf and XCB cored to 433.9 mbsf; recovery was 98.3%. The hole samples Holocene to upper Pliocene (>2.6 Ma) hemipelagites with a hiatus between 2.75 and 4.65 k.y. Benthic foraminifers indicate deposition within middle bathyal depths. Sedimentation rates are highly variable: 36-42 cm/k.y. between 0.93 and 1.48 Ma and 16 cm/k.y. between 1.88 and 2.6 Ma. Lowest rates (4.0 cm/k.y.) occur at the base of the section, with relatively low rates (8-12 cm/k.y.) occurring above 9.3 k.y. High sedimentation rates may be coincident with global highstands.

Sediments are mainly muds containing varying amounts of carbonate ooze and terrigenous clays, with lesser bioclastic and terrigenous (mostly quartz) sand and silt. The sequence is distinctly cyclical, as seen in color and compositional variations related to proportions of carbonate and terrigenous sediments.

Two major lithostratigraphic units were recovered:

Unit I (0-52.9 mbsf; age, 0 to <0.93 Ma; upper Pleistocene): bioclastic ooze with nannofossils and micrite.

Unit II (52.9-433.9 mbsf; age, 0.465 to >2.6 Ma; middle Pleistocene to Pliocene): dark greenish gray clayey calcareous mixed sediment containing terrigenous clay interbedded with clayey nannofossil ooze. Claystones dominate the middle part, whereas bioclastic sediments become more important downward.

Site 823

Site 823 (proposed site NEA-5) is located in the central-western Queensland Trough, toward its deepest part. The location was selected to recover a basinal material for paleoceanographic studies and for correlation with other drill sites on a transect from the Australian continental margin to the Queensland Plateau.

Results

APC/XCB/RCB drilling penetrated a 1011.0-m-thick sequence of uppermost middle Miocene to Pleistocene hemipelagic to pelagic sediments interbedded with gravity-flow deposits interpreted as turbidites, debris flows, and slumps; recovery was 92%. Benthic foraminifers indicate lower bathyal paleodepths (1000-2000 m). Over 1800 gravity-flow deposits were recognized; chronological integrity of microfossil biostratigraphy was maintained, indicating nearly contemporaneous deposition of redeposited material.

Seven major lithostratigraphic units were recovered:

Unit I (0-120.7 mbsf; Pleistocene): pelagic to hemipelagic sediments interbedded with redeposited layers, interpreted as turbidites and debris flows.

Unit II (120.7-352.75 mbsf; Pleistocene to upper Pliocene): gray to greenish gray nannofossil ooze with clay and bioclasts interbedded with gray to dark gray lithoclastic rudstone, interpreted as debris flows; gray to greenish gray bioclastic and skeletal packstones showing normal grading and abrupt basal contacts, indicative of turbidites.

Unit III (352.75-535.7 mbsf; lower Pliocene): dark gray to gray nannofossil chalk with bioclasts and foraminifers or quartz, clayey nannofossil mixed sediment, and dolomitic nannofossil chalk with clay intermixed with dark greenish gray lithoclastic rudstone, conglomerate, and mixed sediment interpreted as debris flows and slumps; nannofossil siltstone with bioclasts, calcite and pyrite, light greenish gray to greenish gray nannofossil chalk, nannofossil chalk with micrite, and mixed sediments; mud clasts in a matrix of greenish gray to dark greenish gray mixed sediment with micrite separated by an interval of relatively undeformed light greenish gray nannofossil chalk.

Unit IV (535.7-715.0 mbsf; lower Pliocene to uppermost upper Miocene): foraminifer nannofossil chalk, nannofossil mixed sediment to chalk with foraminifers and bioclasts becoming clayey nannofossil chalk with foraminifers, bioclasts and/or quartz, nannofossil chalk with clay or foraminifer nannofossil clayey chalk with depth; characterized by large-scale slump features. Dark greenish gray bioclastic foraminifer packstone layers, showing graded bedding indicative of turbidites, are sometimes found inverted within slumps. Microfaults are associated with some slumps. Clasts and matrix in greenish gray lithoclast rudstones, interpreted as debris flows, are cut by *Chondrites* and *Zoophycos*, indicating post-depositional bioturbation. The base of Unit IV is a debris flow.

Unit V (715.0-795.7 mbsf; upper Miocene): dark gray nannofossil mixed sediment to nannofossil claystone. Greenish gray nannofossil chalk is present, although less abundant than in Unit IV.

Unit VI (795.7-899.1 mbsf; upper Miocene): alternations of white to light gray, strongly bioturbated nannofossil chalk to mixed sediment, limestone, and clayey nannofossil chalk with dark greenish gray nannofossil mixed sediment and claystone. Interbedded layers of partially graded lithified calcareous grainstone with siliciclastics and traces of glauconite and skeletal packstone, both interpreted as turbidites, are dark greenish gray. Multiple generations of microfaults and large-scale slump folds are present. Lithoclastic rudstone and floatstone, interpreted as debris flows, are common. Unit VI and Unit VII together contain ~50% of the debris flows observed at Site 823.

Unit VII (899.1-1011.0 mbsf; upper Miocene to uppermost middle Miocene): shallow-water platform-derived pebbles and clasts within lithoclastic rudstones, interpreted as debris flows. Pebbles and clasts contain coralline algae, large benthic foraminifers, coral fragments and dolostone fragments. Sediments include nannofossil chalk with clay, foraminifers, and bioclasts, clayey nannofossil mixed sediments, and nannofossil claystone. Increases in the amount of clay, siliciclastics, and traces of glauconite give the sediments a dark gray color.

Site 824

Site 824 (proposed site NEA-6) lies on the western slope of the Queensland Plateau west of Holmes Reef. Objectives were to understand processes along the eastern margin of the Queensland Trough by obtaining as complete a section as possible of Paleogene sediments and basement onto which they have transgressed.

Results

Four holes were drilled to a total depth of 431 mbsf: Hole 824A with APC/XCB tools after washing down to 50 mbsf; Hole 824B used APC coring to recover the top 50 mbsf; Holes 824C and 824D used RCB coring to recover sections below 300 mbsf, including basement. The sequence of drilling was necessitated by a shortage of core liners. Recovery averaged 28.4%.

Sediments range in age from late Pleistocene to late Oligocene-early Miocene. Basement is Paleozoic(?). Benthic foraminifers indicate middle bathyal deposition. Sedimentation rates were apparently highest in the late Pleistocene. Thereafter, rates decreased to 12.9 cm/k.y. by 2.4 Ma before increasing again to 22-30 cm/k.y. for the section down to 11 Ma.

Sediments are pure carbonates deposited as nannofossil oozes and allochthonous packstones and rudstones composed of molluscs, bryozoans, corals, and coralline algae.

Seven major lithostratigraphic units were recovered:

Unit I (0-105 mbsf; Holocene-Pleistocene): two cycles of upward-fining bioclastic packstones and rudstones; alternating pelagic oozes and chalks occur in the upper part.

Unit II (105-135.5 mbsf; uppermost Pliocene): pelagic calcareous mudstones with varying amounts of nannofossils, micrite, and shallow-water-derived bioclasts and upward-fining packstones, which are thickest in the middle of the unit.

Unit III (135.5-166 mbsf; lower Pliocene): white to dark gray densely cemented bioclastic rudstones and packstones. Large fragments of corals, coralline algae, and whole rhodoliths occur in a sand-sized bioclastic matrix.

Unit IV (166-242.3 mbsf; upper Miocene): white to light gray nannofossil ooze and chalks with varying amounts of bioclasts, micrite, and calcite. Layers of fine to medium bioclastic packstones with nannofossils and micrite occur throughout and contain abundant shallow-water components.

Unit V (242.3-338.7 mbsf; upper to middle Miocene or older): upper half is composed of interbedded white foraminifer chalk and allochthonous shallow-water-derived molluscs, corals, coralline algae, rhodoliths, *Halimeda*, and benthic reef foraminifers. Shallow-water sediments exhibit upward fining, grading, and moldic porosity; lower half is composed of dense skeletal packstone and rudstones composed of branching corals, molluscs, echinoids, and benthic foraminifers.

Unit VI (338.7-401.9 mbsf; Miocene to upper Oligocene): white bryozoan-dominated bioclastic rudstone with poorly preserved coralline and large foraminifer fragments and ahermatypic(?) corals, recrystallized and cemented. Base is a dark yellowish brown to gray poorly sorted quartz bioclastic sandstone in a mud matrix. Identifiable carbonate grains are bryozoans and larger foraminifers (*Operculina* and *Assilina*). Milky to clear rounded and angular quartz grains are common, along with reworked black phyllite clasts.

Unit VII (401.9-431 mbsf; age unknown): deeply weathered orange to brown regolith overlying black to dark gray phyllite and schists with quartzitic lenses and a light gray to green finely crystalline metavolcanic rock.

Site 825

Site 825 (proposed site NEA-8) is located on the windward western margin of the Queensland Plateau immediately east of Holmes Reef. It was a reoccupation of Site 811 in an attempt to reach basement and recover additional sediment from poorly recovered intervals.

Results

Hole 825A was washed to 200 mbsf after retrieval of a 4.5-m APC mud-line core. APC/XCB drilling penetrated to 381.5 mbsf, followed by RCB drilling of Hole 825B between 379.5 and 466.3 mbsf, with basement contact at ~453 mbsf.

Continental basement is a possible quartz-feldspar-mafic(?) metasediment or metavolcanic rock. Accurate identification requires shore-based thin-section analysis. Age of bioclastic grainstone and rudstone representing inner-shelf facies that transgressed over basement cannot be determined precisely; sparse coccoliths indicate a range from middle Eocene to early Miocene. An age interpretation based on abundant larger benthic foraminifers will be forthcoming.

Five lithostratigraphic units (possibly six based on recovery of a single pebble dated as early to middle Eocene) were defined at Site 811 sedimentary. Hole 825B extended below the level of the lowest Unit VI section defined at Site 811. Therefore, Site 811 unit designations are used for Site 825 sediments except for redefinition of Unit VI based on better recovery and an additional Unit VII, basement rock. (Note that Units II and V recognized at Site 811 were not recovered at Site 825.)

Unit I (0-4.5 mbsf; upper Pleistocene): nannofossil foraminifer micritic ooze with interbeds of thin foraminifer pteropod packstone layers, interpreted as calciturbidites. These sediments correlate with Pleistocene periplatform ooze of Unit I at Site 811.

Unit III (200.0-276.4 mbsf; middle Miocene): white micritic ooze and chalk with nannofossils and foraminifers alternating with white unlithified to partially lithified bioclastic packstone and floatstone; similar to deep-water periplatform ooze and chalk alternating with gravity-flow deposits recovered at Site 811 in the same depth interval.

Unit IV (305.4-315.0 mbsf; upper lower Miocene): white lithified bioclastic packstone with foraminifers, and yellow indurated bioclastic rudstone with larger benthic foraminifers, coralline algae, and coral molds, also observed at Site 811. Deposition in a tropical fore- or back-reef environment at water depth < 50 m.

Unit VI (408.4-453 mbsf; middle Eocene to lower Miocene): white and pale yellow to yellow, alternating with more pinkish levels, indurated well-sorted bioclastic grainstone and rudstone. Dominant bioclasts are coralline algae, echinoids, molluscs, and small branching corals. Primary intergranular porosity is well preserved, with only minimum moldic porosity. Interpreted depositional environment is temperate to subtropical waters on inner neritic shelf. These sediments probably represent the transgressive facies overlying continental basement.

Unit VII (453-466.3 mbsf; age unknown): dark gray, poorly foliated, well-lithified fine-grained quartz-feldspar-mafic(?) metasediment(?) or metavolcanic(?) rock containing more coarsely crystalline zones of quartz and feldspar.

Site 826

Site 826 (proposed site NEA-13) occurs on the northwestern margin of Marion Plateau, ~1.5 nmi south of Site 816. The location defines a lagoonal site immediately behind the Miocene(?) barrier reef drilled at Site 816. Objective was not to establish stratigraphy, but to penetrate postulated lagoonal sequences so as to obtain faunas with which to date Sites 816 and 826. After establishing the mud line, Hole 826A was washed to 98.5 mbsf and RCB cored to 250 mbsf.

Results

Sediments included muds immediately above the lagoonal sequence at 98.5 mbsf and dolomitized skeletal packstones, rudstones, and minor boundstones between 98.5 mbsf and total depth.

One lithostratigraphic unit was recovered:

Unit I (98-250 mbsf; middle Miocene?): partially to completely dolomitized bioclastic rudstone and minor coralgal boundstone. Benthic foraminifers are occasionally common; accurate dates will be forthcoming, and should impact the interpretation at Site 816 and middle Miocene sea-level history of Marion Plateau.

Discussion

Leg 133 drilling has provided valuable and sometimes surprising new information about evolution of carbonate-platform environments. Combining litho-, chemo-, magneto-, and biostratigraphic analyses to estimate timing of events, we interpret a record of Cenozoic environmental change and carbonate-platform development on the northeast Australian margin that can tentatively be used to differentiate among influences of sea-level fluctuation, tectonic subsidence, terrigenous flux, paleoclimate, and paleoceanography. However, attempts to relate causes and consequences of interpreted environmental changes await results from future shore-based studies.

LEG 134 SITE SUMMARIES: VANUATU

October 16 to December 17, 1990

The complete Leg 134 Preliminary Report, available from Ocean Drilling Program, Texas A&M University Research Park, College Station, Texas 77845-9547, contains further details.

Site Summary, Site 827

Latitude: 15°17.69'S
Longitude: 166°21.12'E
Water Depth: 2803.4 m

Site 827 (proposed Site DEZ-2) lies within the collision zone of the d'Entrecasteaux zone (DEZ), along the forearc slope of the New Hebrides Arc, on a flat plateau 3 km east of the subduction zone trace. Collision of the North d'Entrecasteaux Ridge (NDR) with the arc slope has formed a lobate tectonic front, producing an unstable slope prone to mass wasting from arcward-dipping thrust faults. The site was chosen to penetrate the lower forearc slope where rocks of the overriding plate are thin, in anticipation of drilling through the decollement and rock units of the underlying NDR. Objectives were to define lithology, composition, age and mechanical properties to determine degree and rate of material transfer from one plate to another, timing of collision, present-day stress field, and composition and role of fluid circulation in collision.

At Hole 827A, 110.6 m of section was cored; 100.76 m was recovered. At Hole 827B, 400.4 m was cored and 119.04 m was recovered.

Four lithostratigraphic units have been described:

Unit I (0-86 mbsf): Pleistocene volcanic silt interbedded with normally graded, sandy volcanic silt beds (turbidites).

Unit II (86-141 mbsf): upper Pliocene to Pleistocene volcanic silt and siltstones.

Unit III (141-252 mbsf): upper Pliocene calcareous volcanic siltstone with intervals of sed-lithic conglomerate.

Unit IV (252-400.4 mbsf): clasts of volcanic siltstone and sandstone.

Chlorinity and salinity increase with depth to values 10-15% higher than seawater concentrations at 250 mbsf. Both potassium and sodium decrease to 40-50% of seawater values at 250 mbsf. Calcium concentrations increase strongly with depth to 250 mbsf. Nutrients concentrations are low and silica concentrations are variable. Sulfate reduction is complete by 50 mbsf, but sulfate concentrations increase with depth to values equal to ~30% of seawater. Methane concentrations are near zero except for a strong, sharp maximum at ~75 mbsf, which is probably not a result of organic matter diagenesis because it appears too large relative to increases in nutrients and is located below the maxima in nutrient concentrations. This peak suggests that there may be "exotic" fluids at this depth. Calcium concentrations in this zone are controlled more by 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, high methane, and the presence of sulfate below the zone of complete sulfate reduction are all attributes of fluids in the Barbados and Nankai decollement zones.

Site Summary, Site 828

Latitude: 15°17.35'S
Longitude: 166°17.04'E
Water Depth: 3086.7 m

Site 828 (proposed Site DEZ-1) is located on the NDR of the DEZ of ridges, ~2

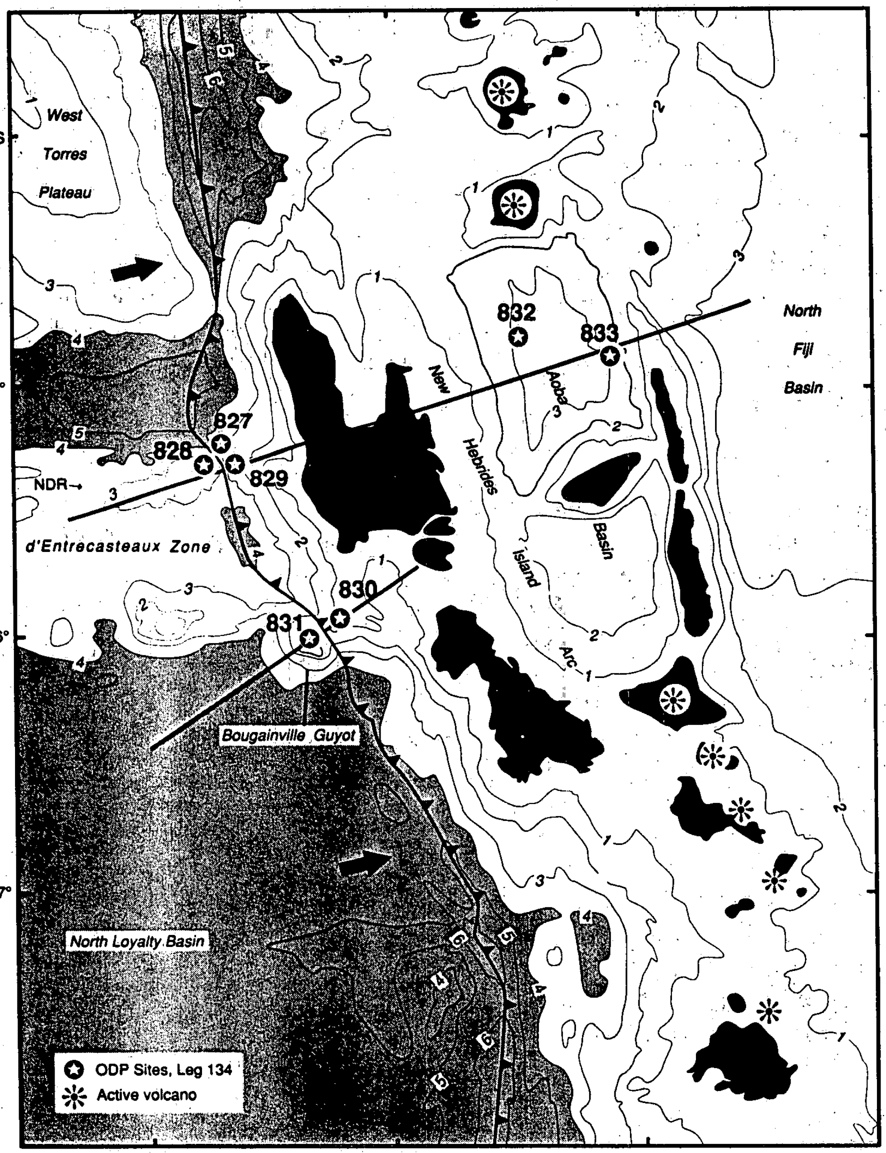

Figure 1. Site location map.

km west of the trace of the New Hebrides subduction zone where the NDR is colliding with the New Hebides Arc. This site was chosen to document nature and age of the NDR and to provide a critical reference section of DEZ north-ridge rocks to enable recognition of these rocks in other drill holes. Objectives were to determine reaction of the accretionary wedge to collision, and whether incorporated rocks form large blocks in the collision zone.

We cored 111.4 m and recovered 101.34 m of sediment and brecciated volcanic rock in Hole 828A; in Hole 828B penetration reached 129.0 mbsf, but only 39.0 m was cored to recover 7.92 m of brecciated basement-like rock.

Five lithostratigraphic units have been described:

Unit I (0-58.73 mbsf, Hole 828A): Pleistocene volcanic silt.

Unit II (58.73-69.32 mbsf, Hole 828A): early (?) Pliocene to late Miocene nannofossil ooze in sharp contact with

Unit III.

Unit III (69.32-90.83, Hole 828A; 90.0-100.0 mbsf, Hole 828B): early to late Oligocene nannofossil chalk; most, if not all, of the Miocene and latest Oligocene appears to be absent. Detailed sampling revealed an unconformity at ~69 mbsf.

Unit IV (90.83-106.8 mbsf, Hole 828A; 100.0- 119.4 mbsf, Hole 828B): volcanic breccia. On the basis of planktonic foraminifers in the core catcher, these flows may be middle Eocene.

Unit V (106.8-111.4 mbsf; Hole 828A): brecciated aphyric basalt/dolerite.

Calcium and magnesium concentrations are similar to values measured at Site 827. Chloride concentrations exhibit a broad maximum, reaching values of 580 mM (~4% higher than seawater). Samples from Site 827 were characterised by high chloride concentrations, so the chloride maximum at Site 828 may represent water flowing out of the wedge. Solute concentrations can also be explained, however, by diffusion upward from reaction zones basement rocks, and thus are not proof that water has flowed from the wedge. Nutrient data (alkalinity, ammonia, and phosphate) show only minor amounts of organic matter oxidation, which suggests that there is little (perhaps 0.5%) organic carbon in the sediment.

Site Summary, Site 829

Latitude: 15°18.92'S
Longitude: 166°20.70'E
Water Depth: 2905.2 m

Site 829 is located within the collision zone of the DEZ along the forearc slope of the New Hebrides Arc, where the NDR impinges upon the arc-slope, ~3 km south of Site 827 and about 35 km west of the island of Espiritu Santo, Vanuatu.

Hole 829A drilled and cored to 590.3 mbsf, recovering 197.44 m (33.4%). Hole 829B drilled and cored to 19.5 mbsf, recovering 9.85 m (80%). Hole 829C drilled and cored to 58.4 mbsf, recovering 52.67 m (90.2%). Hole collapse prevented penetration of the decollement, but overlying thrust sheets and the accretionary prism were sampled.

The 582.8 m of sedimentary and igneous rocks recovered can be divided into 21 lithostratigraphic units (Units I-XXI) that are repeated throughout. Because of these repetitions, the lithostratigraphic units can be divided into four composite units on the basis of age and lithology (designated Bigwan Wan, Bigwan Tu, Bigwan Tri, and Bigwan Fo, named in Bislama, official language of Vanuatu).

Bigwan Wan: Pleistocene volcanic silt, sandstone or gray silty chalk.

Bigwan Tu: upper Oligocene to lower Miocene, foraminiferal or calcareous chalk.

Bigwan Tri: upper Pliocene or Pleistocene chalk breccia with upper Oligocene to lower Miocene clasts.

Bigwan Fo: volcanic breccia of unknown age with clasts of volcanic rock fragments, microgabbros, gabbros, and basalts. At least five major thrust faults and seven minor thrust faults separate the lithologic units, which become more intensively deformed downhole.

Magnesium content decreases sharply within the upper 10 m, suggesting high fluid flux upward. Chloride is constant from 0 to 250 mbsf. Solutes related to organic carbon appear low in the upper 100 m of core, but increase in concentration beneath the thrust fault at 99.4 mbsf. Beneath this fault to a depth of ~500 mbsf, the core is extremely dry and devoid of water. Minor amounts of methane were measured, and chloride concentrations were low. Initial interpretations indicate that Hole 829A terminated close to the decollement, because the increase in methane accompanying low chloride concentrations is similar to that found along other subduction zones (i.e., Barbados and Nankai).

The digital borehole televiewer (BHTV) and magnetic susceptibility tool were run for the first time in ODP history and resulted in collection of data that appear to correlate well with FMS and other logging tools.

Site Summary, Site 830

Hole 830A:
Latitude: 15°56.95'S
Longitude: 166°46.78'E
Water Depth: 1018.4 m
Hole 830B:
Latitude: 15°57.01'S
Longitude: 166°46.78'E
Water depth: 1018.4 m
Hole 830C:
Latitude: 15°57.04'S
Longitude: 166°46.70'E
Water depth: 1008.9 m

Site 830 is located on the forearc slope in the collision zone between Bougainville Guyot and the central New Hebrides Island Arc, ~6.5 km east of the plate boundary and ~30 km from the southern coast of Espiritu Santo Island. Site 830 is close to proposed site DEZ-4, on a small flat area protruding from a slope dipping 10° south where Bougainville Guyot impinges upon the arc slope. Considerable uplift and deformation are indicated by a 750 m-high bulge of accreted rocks and well-developed, arcward-dipping thrust faults east of the impact zone. The site was chosen to penetrate a thrust slice in the forearc, where thin surficial sedimentary rocks appear to overlie a strongly reflective acoustic basement. Objectives were to determine if guyot fragments are being accreted to the forearc, to study the physical properties of deformed forearc rocks, and to determine geochemistry of interstitial fluids.

Hole 830A was drilled with APC and XCB to 96.9 mbsf, with 55.5% recovery. Hole 830B was washed to 48.5 mbsf, then cored to 281.7 mbsf with 20.9% recovery. Hole 830C was washed to 235. 0 mbsf, then cored to 350.6 mbsf with 16.8% recovery.

Two lithostratigraphic units were described:

Unit I (0-174.9 mbsf): dark gray volcanic silt and siltstone with various amounts of sand and clay.

Unit II (174.9-350.6 mbsf): altered, poorly sorted, coarse volcaniclastic, partially lithified sandstone with a matrix of sandy silt. These rocks are considered cataclastites, with increasing abundance of scaly fabric downhole. Clasts and isolated pebbles of igneous rocks can be divided into two groups on the basis of their mineralogy and structure. The first group comprises volcanic breccia; the second group consists of fragments of altered basalt as well as vesicular andesite.

Chloride concentration in pore fluids strongly increases with depth to values about 11% higher than seawater. Alteration of ash and coarse volcanic siltstone and breccia is reflected in extreme calcium, magnesium, potassium and sodium concentrations. Calcium increases to 229 mM in a pore-fluid sample taken from 341 mbsf, the base of Hole 830C, in an interval of highly altered igneous breccia. The sample contains no magnesium or potassium, and only 172 mM of sodium. Similar, although not as extreme, abnormal variations in concentrations occur between 50 and 100 mbsf in overlying Pleistocene sediments. These variations could reflect local diagenetic alteration of ash layers or lateral flow of deep fluids along a slightly sandier layer.

Hole 830C was logged using standard Schlumberger combinations only to 260 mbsf; below that depth hole conditions had deteriorated. Logging confirmed the presence of a major boundary between Unit I and Unit II near 160 mbsf.

Site Summary, Site 831

Latitude: 16°00.52'S
Longitude: 166°40.36'E
Water Depth: 1066.4 m

Site 831 is located on the summit platform of Bougainville Guyot, ~42 km southwest of the southern tip of Espiritu Santo Island, ~5 km west of the DEZ-New Hebrides Island Arc subduction zone, and 15 km due west of Site 830.

Objectives at Site 831 were to determine if the Bougainville Guyot's carbonate cover was suitable as a sea-level indicator, ascertain age and nature of basement, and relate basement deformation to the guyot's collision history.

Bougainville Guyot impinges upon the forearc slope of the central New Hebrides Island Arc (Vanuatu) and is either being subducted beneath or accreted to the arc. The guyot clogs the New Hebrides Trench and indents the forearc slope by 10 km. Bougainville Guyot represents the eastern terminus of the South d'Entrecasteaux Chain (SDC) of the DEZ, the two-ridge system that also includes the NDR. The SDC is a chain of conical volcanic seamounts and guyots located on the Australia-India Plate that presently is converging with the New Hebrides Island Arc (Pacific Plate) at ~10 cm/yr. Anomalous bathymetric features, such as a sub-circular topographic reentrant in forearc-slope rocks east and south of Bougainville Guyot, suggest that other seamounts or guyots have been subducted previously. The number of seamounts subducted along the DEZ collision zone is indirectly related to duration of convergence, which is important to understanding collision deformation. In addition, style of deformation along the forearc slope of Vanuatu appears to differ considerably from where the NDR is colliding and where the SDC/ Bougainville Guyot is impinging upon the forearc slope.

We drilled to 116.5 mbsf in Hole 831A, retrieving only 25.85 m (22.4%). After washing to 102.4 mbsf in Hole 831B, we penetrated 852 mbsf, recovering only 87.25 m of core (11.6%). Nevertheless, we were able to drill 120 m into volcanic rocks beneath the guyot's carbonate cap.

Four lithostratigraphic units have been described:

Unit I (0-20.0 mbsf, Hole 831A): Pleistocene pelagic bioclastic foraminiferal ooze.

Unit II (20.0 mbsf in Hole 831A to 429.6 mbsf in Hole 831B): Pleistocene to Pliocene neritic coral rudstone and mollusc floatstone with some marine-water carbonate cements as well as neritic rudstone and floatstone of unknown age.

Unit III (429.6-727.0 mbsf, Hole 831B): lower Miocene neritic bioclastic floatstone to upper Oligocene foraminiferal grainstone and bioclastic packstone. The base of Unit III unconformably overlies Unit IV, the volcanic rock complex.

Unit IV (727.0-852.0 mbsf):volcanic basement, a series of andesitic hyaloclastites. The contact with overlying coral limestone is a reddish-orange weathered zone (or bole). Calc-alkaline affinities of the andesitic clasts point unequivocally to an island-arc origin for Bougainville Guyot and the eastern end of the SDC.

Initial interpretations indicate that Bougainville Guyot was an andesitic volcano and island that accumulated a 728-m carbonate cap. The guyot has gone through several episodes of emergence and submergence, as indicated by various soil horizons and oxidized rocks. Carbonate lithologies suggest lagoonal deposits consisting of two major sedimentary facies. Facies 1 (16.8-429.5 mbsf) is Pleistocene to Pliocene coral-rich grainstone that contains fragments of mollusc, coral rubble, algae, echinoid spines and giant clam (*Tridacnid*). Facies 2 (429.5-727.5 mbsf) is foraminiferal grainstone that contains coralline algae, algal fragments and large benthic foraminifers. The lower part (563.6-727.5 mbsf) is early Miocene to late Oligocene (21.8-28.2 Ma) in age.

Logging data were obtained using standard Schlumberger geophysical and geochemical tool strings. In addition, FMS, BHTV, and magnetometer/ susceptibility tools were run twice. All tools produced good data and initial interpretations indicate positive correlation between logs and lithology.

Site Summary, Site 832

Latitude: 14°47.77'S
Longitude: 167°34.35 'E
Water Depth: 3089.3 m

Site 832 (proposed Site IAB-1) is located on the flat intra-arc basin floor in the central part of the North Aoba Basin (NAB). 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. The primary objective at this site and at Site 833 was to investigate how arc-ridge collision affects development of intra-arc basins and evolution of the magmatic arc.

In Hole 832A, we cored 215.9 mbsf and recovered 146.26 m (67.7%). Hole 832B was drilled to 1106.7 mbsf, coring 962.3 m and recovering 450.95 m (46.9%).

Seven lithostratigraphic units were identified:

Unit I (0-206.2 mbsf, Hole 832A; 144.4-385.6 mbsf, Hole 832B): Pleistocene volcanic clays, silts and sands.

Unit II (385.6-461.5 mbsf): Pleistocene sandstone, siltstone and claystone, largely volcanic in the upper part and more calcareous in the lower part.

Unit III (461.5-625.7 mbsf): upper Pliocene or lower Pleistocene chalk, limestone, and calcareous mixed sedimentary rocks interbedded with volcanic siltstone, sandstone and sed-lithic breccia containing volcanic clasts.

Unit IV (625.7-702.0 mbsf): upper Pliocene or Pleistocene basaltic breccias with subordinate volcanic siltstone and sandstone.

Unit V (702.0-865.7 mbsf): upper Miocene to upper Pliocene 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.

Unit VI (865.7-952.6 mbsf): middle to upper(?) Miocene lithified volcanic sandstone that grades downward to coarser material.

Unit VII (952.6-1106.7 mbsf): lithified basaltic breccia with subordinate lithified volcanic sandstone, siltstone and vitric ash; the top of Unit VII is latest early Miocene in age.

More than 10 volcanic ash layers >3 cm thick and several tens of reworked volcanic ash layers were recovered. Altered volcanic breccia of Unit VII was probably derived from submarine volcanism, as suggested by abundant alteration products in the matrix.

Structural studies indicate that deformation observed appears to result from small- to large-scale slumping, normal microfaulting and compaction processes.

Concentrations of all measured solutes 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 maxima in concentrations of other solutes. 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 sodium, potassium, magnesium, and chloride maxima. Accompanying a decrease in sulfate at ~75 mbsf, resulting from sulfate reduction, are maxima of phosphate, ammonia, methane, and alkalinity which probably reflect organic matter diagenesis. The solutes may provide a source of phosphate and bicarbonate for authigenic minerals. Organic carbon contents are low, mostly less than 0.5%, but rapid sediment-accumulation rates cause high concentrations of various solutes.

Because of deteriorating hole conditions, including bridging and rapid infilling from above, the complete complement of logging tools could not be used. The Schlumberger geophysical string and FMS were run and produced good data.

Site Summary, Site 833

Hole 833A:
Latitude: 14°52.57'S
Longitude: 167°52.78 'E
Water Depth: 2628.5 m
Hole 833B:
Latitude: 14°52.56'S
Longitude: 167°52.78 'E
Water Depth: 2629.0 m

Site 833 (proposed site IAB-2) is located on the lower east-central flank of the NAB, ~24 km northwest of the northern tip of Maewo Island and ~72 km southeast of the active volcanic island of Santa Maria.

In Hole 833A, we cored 199.5 mbsf and recovered 97.75 m (49.0%). Hole 833B was drilled to 1001.1 mbsf, coring 923.7 m and recovering 519.54 m (56.2%).

Five lithostratigraphic units were identified:

Unit I (0-84.0 mbsf, Hole 833A): numerous interbedded unlithified volcanic ashes and volcanic silt; ash layers are thinner and more numerous in the upper part and carbonate content increases to ~15% near the seafloor.

Unit II (84.0-199.5 mbsf, Hole 833A, and 77.4-375.8 mbsf, Hole 833B): calcareous siltstones and claystones that are highly bioturbated; this 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.

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

Unit IV (577.8-830.0 mbsf): 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.

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

Volcanic ash layers are abundant in the upper 150 m, 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. In Hole 833B, occasional basaltic tuffs were recovered between 308 and 317 mbsf. These are of a different type, having low-potassium, island-arc tholeiite affinity. 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 deeper succession and are interstratified with calcareous volcanic siltstones and bioturbated mixed sedimentary rocks.

Pore fluid geochemistry 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. 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 locations of well-cemented volcanic sandstone and sed-lithic rocks. Diagenesis and cementation of the volcanogenic sediment presumably causes variations in solute concentrations similar to that observed at Site 832. However, the most altered calcium, chloride and sodium concentrations are nearly two times more extreme at Site 833. Maximum concentrations of alkalinity (19.9 mM), phosphate (55.2 mM) and ammonia (1794) occur between 20 and 40 mbsf. Concentrations are not extremely high, probably reflecting low (generally <0.5%) organic carbon content of the sediments and slightly lower sediment-accumulation rate at this site.

Poor hole conditions and time constraints prevented the use of the complete complement of logging tools. However, good results were obtained from geophysical and geochemical tool strings between 250 and 900 mbsf, with distinct increases in resistivity and velocities taking place between 380 and 430 mbsf, which correlates with the presence of volcanic sandstones and breccia at those depths. The contact between the basaltic sill and overlying sedimentary rocks is easily distinguished in the logs by sharp increases in resistivity, velocities, thorium and potassium at 830 mbsf.

LEG 135 SCIENTIFIC PROSPECTUS (SUMMARY): LAU BASIN

The Leg 135 Scientific Prospectus, available from Ocean Drilling Program, Texas A&M University Research Park, College Station, Texas 77845-9547, contains further details and full references.

Abstract

The objective for ODP Leg 135 is to understand the geologic history of the Lau Basin. A drilling transect with five sites is planned. One site will sample old backarc crust in the western Lau Basin, two sites will sample young crust in the central basin, one site will be drilled on the Tonga platform, and a fifth site will sample the outer edge of the Tonga forearc.

The transect will address one of the thematic problems posed in the COSOD I science plan. This question, concerning the temporal relationships between arc volcanism, subduction processes (e.g., accretion vs. non-accretion), and backarc extension and compression, will be explored within the Lau Basin-Tonga arc system.

Introduction

The objective for Leg 135 is to deduce the geologic history of the Lau Basin. The results will be important, not only for understanding the evolution of the Lau Basin, but for gaining a better understanding of the geologic processes that form new oceanic crust at convergent plate margins. In addition to adding to our knowledge of Lau Basin-Tonga arc and forearc geology, a major goal is to assess the links between backarc spreading, island- arc volcanism, and subduction. We will address the temporal relationships between arc volcanism, subduction processes (e.g. accretion vs. non-accretion), and backarc extension and compression. This problem was identified as a major thematic objective in the COSOD I science plan. It was reiterated in the COSOD II plan, which perceived a need for "clearer documentation of the interaction between such (arc and backarc) magma types both spatially and with time in the development of an arc-backarc system". The Lau Basin was selected because (1) it has been the target of numerous marine geologic and geophysical studies including a deep drill hole (DSDP Site 203), (2) the geology of the nearby Lau and Tonga arcs is well known, and (3) we have some testable models for its evolution. A drilling transect of five sites (Fig. 1) is planned that will sample the backarc-basin crust and the arc-forearc area of the Tonga Ridge. The Lau Basin studies will complement parallel studies of the Mariana Arc-Trough and Bonin Arc areas; collectively the results should help to improve our models for backarc-basin evolution.

The Lau Basin (Fig. 1) has formed by the emplacement and eruption of basaltic magmas within rifts and as seamounts in a region of lithospheric extension between the Lau Ridge and the Tonga Trench. The age of inception of this extension is poorly constrained by magnetic anomaly data but has been variously interpreted as about 2.5 to 3 Ma. The rate of opening probably varies with latitude; near 18°S, where the magnetic data are better constrained, the spreading rate may be 5-6 cm/yr in an east-west direction. It is clear that crustal generation by seafloor spreading has operated in the basin since late Pliocene time. It is also well established that the modern volcanic arc (Tofua Arc) has been active

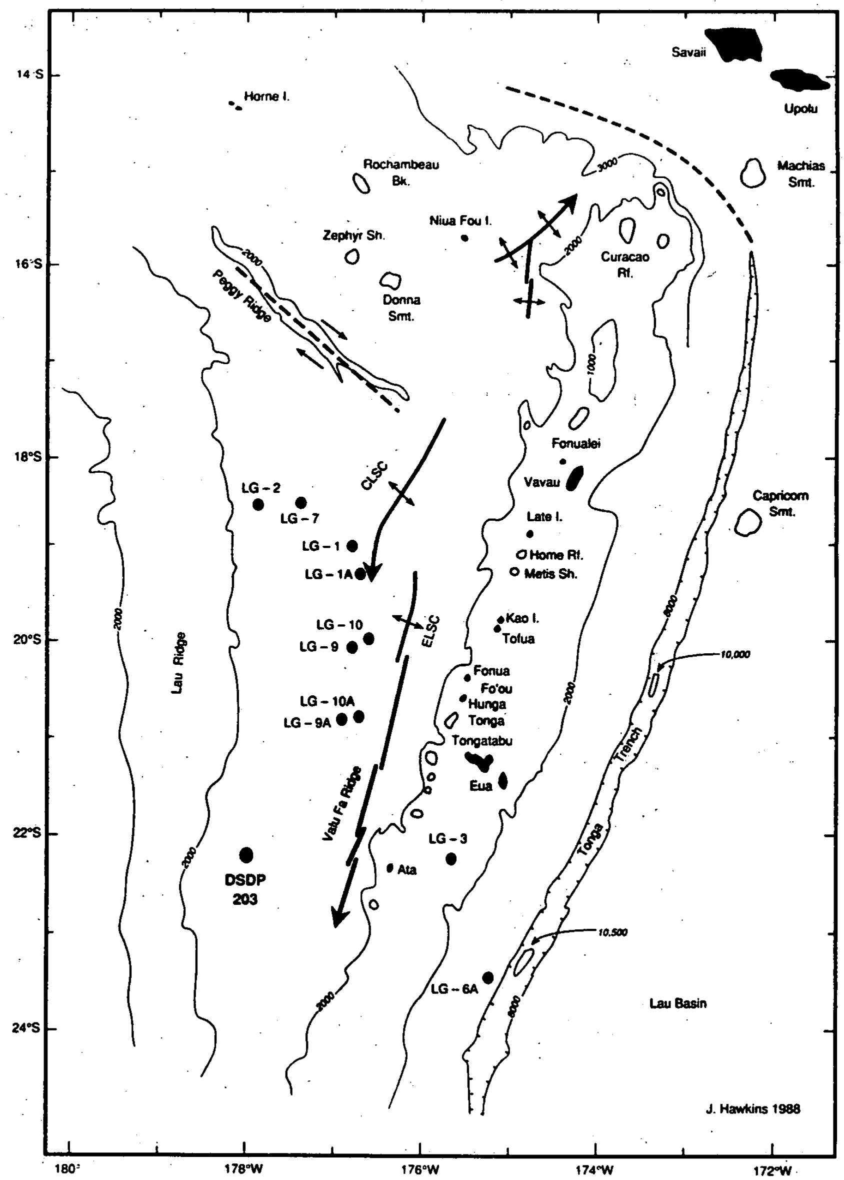

Figure 1. Generalized map of the Lau Basin showing the major petrologic, tectonic, and morphologic features, and the sites planned as primary (priority 1) or alternate (priority 2) drilling targets (see text). The location of DSDP Site 203 (Burns, Andrews, et al., 1973) is also shown.

since at least early to mid-Pleistocene time (~1 Ma), and that parts of the forearc basement include pre-late Eocene gabbro and basaltic rocks as well as younger arc-volcanic rocks. The age of initial volcanism of the Tofua Arc has not been determined, although some have proposed that it represents a direct continuation of Lau Ridge volcanism which lasted until about 3 Ma. Alternatively, the data may be interpreted as indicating a hiatus in arc volcanism that resulted in the modern (Tofua Arc) volcanoes being new volcanic-plutonic systems imprinted on what was formerly the forearc region of the Lau Ridge. This major question of Tofua Arc genesis will be addressed by the drilling plan.

The Lau Basin appears to be spreading actively and has a well-defined axial ridge system near 176°30′W between latitudes 17°S and 22°S (Fig. 1). The axial ridge is formed of relatively unfractionated olivine tholeiite basalt, but more fractionated and Fe-Ti-enriched lavas are found near a propagating rift tip at 19°30′S. The extreme southern end of this axial ridge (Valu Fa Ridge) differs markedly from the rest of the basin in being dominated by rocks of andesitic to dacitic composition. This part of the axial ridge has abundant hydrothermal vents, and seismic data have been interpreted as indicating the presence of a magma chamber. The basin is much more complex north of 17°S and east of 178°W: here there are abundant seamounts, including the volcanically active island Niua Fo'ou; a nascent triple junction having one limb that intersects the Tofua Arc and a western limb that projects toward Niua Fo'ou; and a well-defined ridge which presently marks the trend of a zone of right-lateral strike-slip as defined by first-motion studies of shallow seismic activity (Peggy Ridge).

The Lau Basin presents a number of important problems concerning the tectonic/petrologic evolution of the lithosphere above the plate-convergence system of the Tonga Trench subduction zone. In addition to giving insights into how backarc basins evolve, it also offers an opportunity to understand broader problems of crustal evolution that pertain to other intra-oceanic trench-forearc-backarc systems. The proposed drilling transect of 5 sites will include studies of both the earliest crust formed as the basin opened and the crust rifted away from the remnant arc (Lau Ridge) and now exposed on the forearc, which pre-date backarc opening.

Regional Setting - Lau Basin

The Lau Basin (Fig. 1) separates the Lau Ridge (remnant arc) from the Tonga Ridge. The Tonga Ridge comprises two parallel chains of islands and shoals that cap the older seafloor on the inboard side of the Tonga Trench. The western chain includes active volcanic islands of the Tofua Arc which have erupted basaltic andesite to low-K rhyolitic magmas. The eastern chain consists of tilted blocks formed of upper Eocene to Pleistocene limestone with interbedded tuffs and volcaniclastic beds which overlie an igneous basement comprising mafic plutonic rocks, basaltic to andesitic pillow lavas, dikes and aa flows. It has been proposed that the rocks of 'Eua constitute the upper part of an ophiolite assemblage. The oldest rocks of the region are the Eocene (46 Ma) "crystalline basement" of 'Eua, known from boulders of gabbro, norite, basalt, andesite, dacite, and rhyolite. The chemistry of these rocks is typical of an island arc volcanic-plutonic series. The lowest outcrops exposed in the 'Eua section are basaltic to andesitic flow and dikes. These are overlain by upper Eocene to lower Oligocene limestone and in turn, these are overlain by a series of Miocene to Pliocene volcaniclastic rocks that are interbedded with foraminiferal limestone. Three distinct episodes of Tertiary volcanic activity are recognized on 'Eua. The oldest, 40-46 Ma, is measured on the gabbro and basalt beach boulders; basaltic and andesitic flows give ages of 31-33 Ma, and andesitic dikes give 17-19 Ma ages. Paleontologic ages of tuffaceous sediments range from middle Miocene to early Pliocene, i.e., until 3-5 Ma.

The islands of the Lau Ridge display a more complete record of early Tertiary volcanism than is exposed on the uplifted blocks of the Tonga Ridge. The oldest rocks known are the middle to upper Miocene Lau Volcanic Group (6-14 Ma), mainly basalt and basaltic andesite but also include andesite, dacite, and rhyolite. This group consists mainly of low- to medium-K arc tholeiitic and calc-alkaline series lavas and is interpreted as representing the early and mature stages of arc evolution. Some of the Oligocene and Miocene rocks of the Tonga Ridge probably are correlative with the Lau Ridge volcanism even though no Oligocene rocks are known from the Lau Ridge. It is likely that the Lau Ridge first became active in Eocene time, based on other occurrences of Eocene volcanic series in the broader Fiji-Tonga area.

Lau Ridge volcanism ended in the late Miocene and was followed by erosion, subsidence, and the growth of coral reefs. Renewed volcanism, forming the Korobasage Volcanic Group (4-3 Ma), may have been in response to the initial phase of rifting that led to the opening of the Lau Basin. The Korobasage Group is formed mainly of submarine tholeiitic basalt but also includes some hornblende andesite. The youngest Lau Ridge volcanism is represented by the Mago Volcanic Group

(<2.5 Ma), which includes alkalic olivine basalt and hawaiite. The eruption of these lavas may have been coeval with, or slightly older than, the earliest phases of Lau Basin opening.

The geologic record seen on the Tonga and Lau ridges demonstrates the transition from plate convergence accompanied by arc volcanism (Eocene? to late Miocene) to cessation of arc volcanism and submergence of the arc (late Miocene). This was followed by rifting of the arc and renewed arc and submarine volcanic activity (early Pliocene). Backarc basin rifting probably began in the late Pliocene (2.5 Ma), e.g., at the time of magnetic anomaly 2a, which has been recognized in the western Lau Basin. The fabric of the Lau Basin has proved difficult to determine and, although the major elements of the geometry were recognized some time ago, the use of GLORIA imagery coupled with SeaBeam and magnetics data from PAPATUA and ROUNDABOUT expeditions has greatly improved our understanding of the Lau Basin tectonic fabric. The time of beginning of volcanism on the Tofua Arc remains a major question that may be resolved in the ODP Leg 135 drilling transect in the Lau Basin. One proposal is that the Tofua Arc did not become active until mid- to late-Pleistocene time, and this accounts for the lack of volcanic detritus in the Pleistocene and younger limestones of the Tonga Ridge. An alternate view, long favored, is that the active volcanic arc was rifted away from the Lau Ridge and implies that the modern Tofua

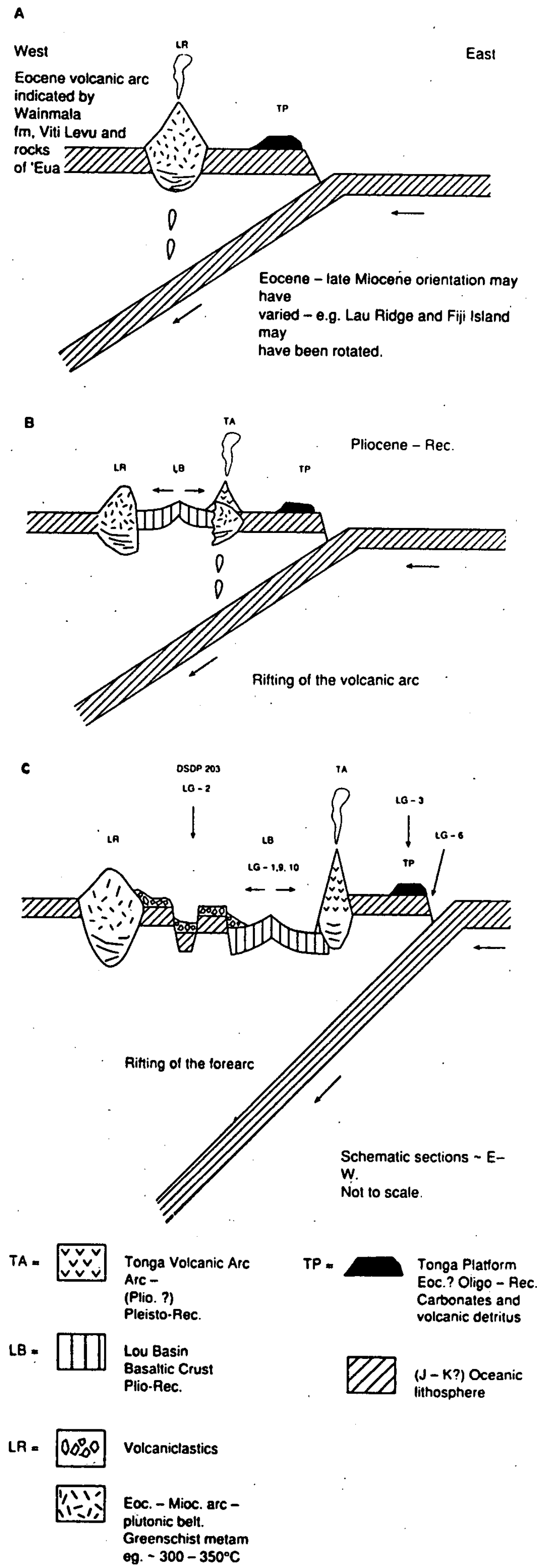

Figure 2. Schematic representation of the two possible models for evolution of the Lau Basin discussed in the text. Figure 2A represents the pre-Lau Basin volcanic arc. Figure 2B represents the model considering the Tofua Arc to be a continuation of the earlier Lau Ridge arc. Figure 2C shows the newer model of Hawkins and Melchior (1985) proposing that Lau Basin spreading and Tofua Arc volcanism have occurred in the forearc region of the earlier Lau Ridge arc. The proposed schematic locations of ODP Leg 135 drill sites and the DSDP Leg 21 sites in the Lau Basin are also shown.

Arc is a direct petrogenetic descendant of the Lau Ridge.

These two possible models for post-late Miocene Lau Basin evolution are shown in Figure 2. The pre-late Miocene history (Fig. 2A) is complex, and we show an island-arc system related to west-dipping subduction. In fact, the Lau Ridge-Fiji Islands may represent more than one arc complex; there may have been subduction reversals or amalgamation of arc terranes, but this history is not important for this discussion.

The original model proposed that the Lau Ridge arc system split (Fig. 2B), with the Lau Basin subsequently forming in the rifted area. A consequence of this style of evolution would be that arc volcanism in the Tofua Arc is a direct continuation of Lau Ridge volcanism. The area encompassing the former forearc to the Lau Ridge (except what has been removed by tectonic erosion) has moved eastward relative to the Lau Ridge. The more recent model (Fig. 2C) proposes that the rifting to form the Lau Basin was initiated in the forearc instead of within the Lau Ridge volcanic arc. In this case, the modern Tofua Arc is a new volcanic system built either on the Lau Ridge forearc or on an older part of the current backarc basin. This model suggests that some fragments of forearc crust may have been left under the western Lau Basin. The presence or extent of this forearc material would depend on how close the rifts formed to the Lau Ridge.

The crust of the Lau Basin is floored mainly by basalt, which has most of the mineralogic, chemical and isotopic characteristics of mid-ocean ridge basalt (MORB) and includes varieties termed "normal" (N-MORB) and "enriched" (E-MORB). The least altered, least fractionated, basalt glasses of the neo-volcanic zones of the axial ridges generally have this N-MORB signature, with the notable exception that $^{87}Sr/86Sr$ is more radiogenic than N-MORB (e.g., 0.7035 or higher), but otherwise element ratios and abundances are clearly MORB-like, rather than like arc lavas. Rocks and glasses collected from the outer (older) edges of the Lau Basin are variable in composition, and many show "arc-like" characteristics. This suggests that there is an age-dependent magmatic variation from initial arc-like or transitional to arc composition to more MORB-like compositions.

The data are interpreted as indicating that the Lau Basin, as well as other backarc basins, have undergone a petrologic evolution from basaltic melts having a strong imprint, or memory, of an arc source (or arc-like melt component) to basalts that have a strong N-MORB signature. In the evolutionary process there are many petrological diversions that may be unique to certain basins, e.g., the formation of extensive eruptions of "high silica" (56-62% SiO_2) lavas such as those of the Valu Fa Ridge in the Lau Basin. A further complexity in the Lau Basin is the development of the northern seamount province, which has an E-MORB or "plume" signature. Our interpretation of Lau Basin history, from the Leg 135 cores, will be guided by these observations.

The Lau Basin data show that the mantle sources are quite heterogeneous in a three- dimensional view and that these heterogeneities may have persisted or have been reinstated on the short time span (<5 m.y.) associated with its opening. One of the objectives of the drilling transect will be to sample backarc crust at 3 (or 4 if time permits) sites of different age to look for compositional variability and to compare the older crust with samples from the neo-volcanic zone. The Lau Basin and other backarc basins are important geologic features in their own right, but an understanding of their geology has two important implications for understanding crustal evolution. They may offer insight to the earliest stages of the tectonic/petrologic processes that form mid-ocean ridges; the evidence for these stages is usually long since buried by seafloor sediments. A second implication

Table 1
Proposed Drill Sites, Leg 135

Site	Latitude	Longitude	Water Depth	Prop. Penetr.
LG-1	19°03.0'S	176°36.0'W	2475	175[1]
LG-1A	19°14.8'S	176°31.9'W	2405	175[1]
LG-2	18°34.4'S	177°51.0'W	2704	500
LG-3	22°13.0'S	175°40.5'W	675	800[2]
LG-6A	23°20.0'S	175°10.0'W	5665	550
LG-7	18°29.9'S	177°17.0'W	2913	150[3]
LG-9	20°07.6'S	176°42.8'W	2576	350
LG-9A	20°50.0'S	176°51.5'W	2285	350
LG-10	20°05.1'S	176°34.3'W	1910	300
LG-10A	20°48.7'S	176°38.0'W	2385	300[4]

[1] Sites LG-1 and LG-1A approved by PPSP for penetration to 200 mbsf.

[2] PPSP has approved penetration to 800 mbsf pending their inspection of crosslines collected aboard *JOIDES Resolution* prior to drilling this site.

[3] Site LG-7 approved by PPSP for penetration to 300 mbsf.

[4] Site LG-10A approved by PPSP for penetration to 350 mbsf.

is related to the origin of ophiolites and the ophiolite model for the nature of oceanic lithosphere. There is a growing consensus that many, if not most, ophiolite suites originally formed in arc/backarc settings. A proper understanding of the range in chemistry and petrology of backarc-basin lavas is necessary for evaluating the origin of ophiolite series and their relevance to models for ocean crust formed at mid-ocean-ridge settings.

Drilling Objectives

Leg 135 will depart Suva on 22 December 1990 and end in Honolulu on 28 February 1991. The Co-chief Scientists will be Dr. James Hawkins (Scripps Institution of Oceanography) and Dr. Lindsay Parsons (Institut of Oceanographic Sciences, UK). The ODP Staff Scientist will be Dr. James Allan.

The drilling plan for the Lau Basin (Fig. 1) will collect data on a transect across the basin from the presumed oldest crust on the west to younger crust near the presently active axial ridge. It also will sample the crust of the Tonga platform and forearc. No sites are planned for the axial rift zone or the Valu Fa Ridge because of the difficulties with drilling at a bare-rock setting and because of potential problems with high-temperature environments. Three sites (LG-2, LG-7, and LG-10) are planned for the backarc basin; five sites (LG-1, LG-1A, LG-9, LG-9A, and LG-10A) are planned as contingency sites in the event that any of the primary sites in the backarc basin have to be abandoned. The forearc/upper-trench slope will be the target of site LG-6A and the Tonga platform will be drilled at site LG-3.

Detailed site surveys have been undertaken in the vicinity of all of the proposed sites to ensure that (a) sampling objectives will be achieved with suitable drilling conditions and (b) the requirements of the JOIDES Safety Panel (PPSP) were fully met. Site survey information gathered at each of the proposed sites is discussed in the following text. Site locations are shown in Figure 1. A summary of the primary and alternate sites is given in Table 1.

Backarc Basin Transect

Primary sites proposed for the backarc basin transect include LG-2, LG-7, and LG-10. Collectively the backarc transect sites, plus the work already done at the neovolcanic zone, will give us an understanding of the physical and chemical/petrologic properties of backarc crust formed over the last ~3 m.y., from several different mantle sources, and from the initial stages of rifting to the present. Major objectives for drilling in the backarc basin include the following:

1. Determining the age and composition of the basement.
2. Recording the stratigraphy, sedimentary petrology, geochemistry, and paleontologic record of the sedimentary column.
3. Understanding the diagenetic history of the sediments.

4. Documenting the fluid geochemistry and physical properties of the sediments and basement.
5. Investigating the nature and origin of metalliferous deposits in the crystalline basement, basal sediments, and sediment column.
6. Assembling a chronology of rifting, arc volcanism, and variations in backarc basin crustal composition.

At the backarc basin sites we expect to drill calcareous oozes interbedded with volcanic ash and clastic volcanic material. Basement is likely to be basalt.

Tonga Platform and Forearc

The overall objectives for the forearc sites are these:

1. Determining the temporal and compositional variation of arc volcanism as reflected in distal ash layers in the sediments.
2. Documenting the uplift and subsidence history of the forearc.
3. Identifying the age, composition, physical properties and fluid geochemistry of the outer forearc basement.
4. Conducting paleomagnetic studies of the forearc basement in an area away from thermal effects of later arc volcanism.

At the forearc sites we expect to drill volcaniclastic rocks, serpentinite, brecciated gabbro/diorite, and arc volcanic rocks.

LEG 136 SCIENTIFIC PROSPECTUS: OCEAN SEISMOGRAPHIC NETWORK PILOT HOLE - HAWAIIAN ARCH

Abstract

The primary objective of ODP Leg 136 is to drill a hole for future experiments needed to develop the Ocean Seismographic Network (OSN). The long-term (5-10 year) goal is to establish a global network of 15-20 permanent seismic observatories in the deep ocean. Such a network would revolutionize studies of global earth structure, upper mantle dynamics and lithosphere evolution, earthquake source mechanisms, oceanic crustal structure, tsunami warning and monitoring, and deep ocean noise sources and propagation mechanisms. This hole will provide a site for pilot experiments that include noise measurements, data recording from teleseismic events for comparison with existing nearby island stations, and testing new broad-band sensors and other long term deployment instrumentation.

Coring the sedimentary and basaltic sequences at the OSN site will provide useful geologic data. The sediments and basalts at the site are analogs of the material through which the Hawaiian lavas first erupted. Analysis of the chemistry and physical properties of this material will determine the extent of contamination of Hawaiian magmas and will shed light on the role that these sediments play in the mechanical behavior of Hawaiian volcanoes. The frequency of explosive volcanism of Hawaiian volcanoes will be determined by coring volcanic ash blown downwind from the islands of Hawaii and Maui. Age constraints on these deposits will be determined by paleomagnetic studies. The hole will also be used to test a reentry cone plug designed to seal boreholes for long term temperature monitoring and fluid sampling.

Introduction and Scientific Objectives

Ocean Seismographic Network

The need for global distribution of seismograph stations in studies of earthquakes and Earth's structure was recognized as early as the beginning of this century. Major initiatives in deployment of broadband digital networks are currently under way. These initiatives include, among others, the United States' Global Seismographic Network project sponsored by IRIS, GEOSCOPE in France, and MedNet in Italy. The Federation of Digital Seismographic Networks (FDSN) promotes common instrumentation standards and facilitates data exchange. All member countries of the Ocean Drilling Program are also members of FDSN.

With all this effort, however, distribution of land-based stations would be inadequate to study the Earth with uniform resolution. The potential contribution of ODP in establishing a network of permanent geophysical observatories on the deep-ocean floor was recognized in the COSOD II report (1987). The long-term goal is to establish during the next 5 to 10 years a permanent global network of 15 to 20 seismic observatories in the deep ocean. The objectives of such an effort encompass the most fundamental questions concerning Earth structure and dynamics. Examples of these goals were summarized at a JOI/USSAC-sponsored workshop (Purdy and Dziewonski, 1988) and can be best considered in several broad subject areas:

- Global Earth structure: Some examples of key questions are: Is the inner core heterogeneous or anisotropic? What is the geometry of the core/mantle boundary? Are hot spots correlated with slow regions at the base of the mantle? What is the geometry of the 400-km and 670-km discontinuities?
- Oceanic upper mantle dynamics and lithosphere evolution: Can seismic anisotropy be used to map flow in the upper mantle? What are the degree and spatial variations of lithospheric thinning beneath hot spot swells? What are the spatial variations in the depth extent of anomalous structures beneath ridges? Do oceanic plateaus have roots like continents? What is the form of small-scale convection beneath plates?
- Earthquake source studies: Ocean floor stations are needed to improve source location (particularly depth), focal mechanism, and rupture process determinations. These measurements are critical to studies of the depth of the seismic decoupling zone, the depth extent of outer rise events, and the rheology of the oceanic lithosphere. Near field data, in particular ocean floor recordings, are needed to improve the resolution of the source mechanisms of events not caused by faulting but by slumping or magmatic injection. Such studies have important implications for estimation of long-term seismic hazards.
- In addition, opportunities for study exist in the following areas: oceanic crustal structure, tsunami warning and monitoring, and sources and propagation of seismic noise.

Broadband, long term ocean floor observatories are needed for these studies. Generally, only seafloor stations can provide uniform global coverage in areas without islands. Seafloor installations are needed for regional studies of individual tectonic features and for sampling wave propagation in "normal" oceanic lithosphere.

At present, island seismic stations are the only places where permanent observatories exist in the oceans. Oceanic islands are, however, located on anomalous structures with thick crust and, in many cases, unusual upper mantle velocities. In addition to the objectives listed above, the following questions may be addressed with ocean floor observatories: How adequate are island based stations? What role should they play in the global seismograph network? Would ocean bottom observatories provide substantial improvements in broad-band signal-to-noise? How does local structure influence seismic signals received on islands compared with an ocean floor site?

Before progress can be made toward the construction of a permanent global ocean floor network, thorough solutions to a number of experimental and technical issues must be found. Current under-

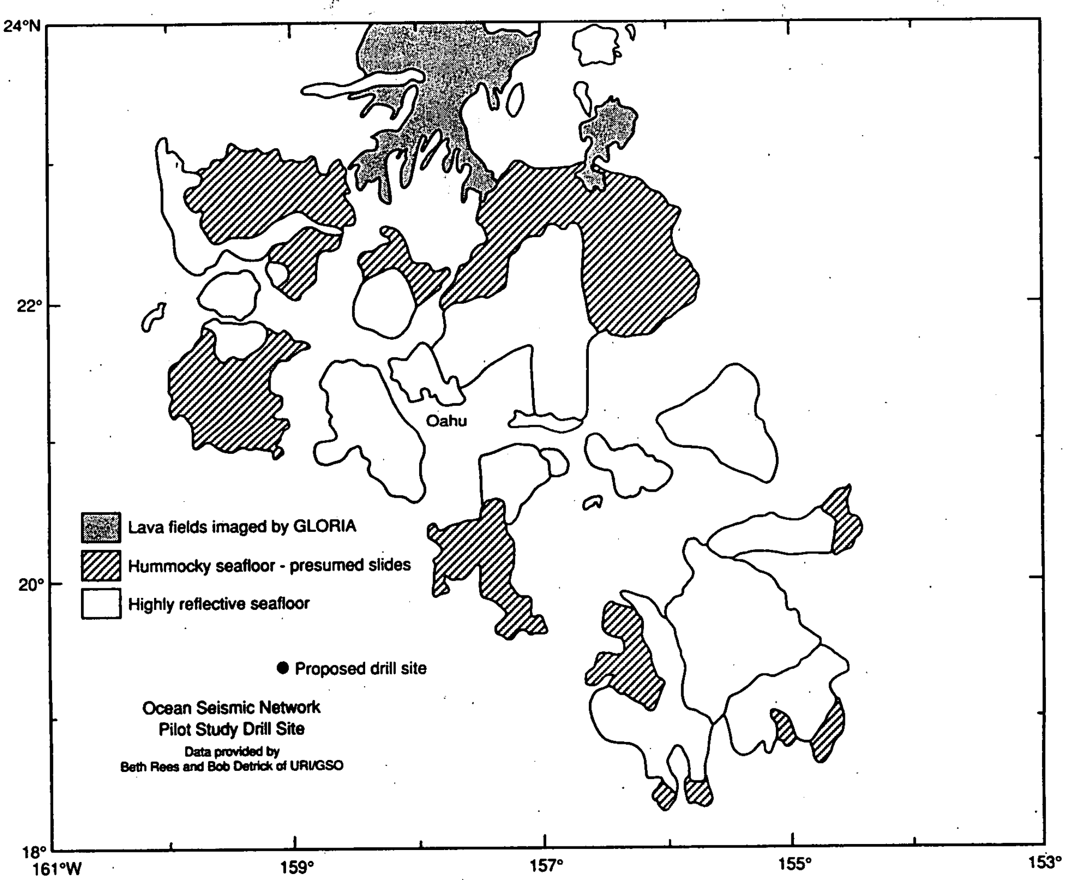

Figure 1. Location of the proposed drill site 250 km south of Oahu. Lava fields and slumps are as mapped by Moore et al. (1989) and Clague et al. (1989). Note that the site is well clear of any of these disturbances.

standing of long period noise sources and noise propagation mechanisms is insufficient to guide emplacement of permanent observatories. Measurements of inertial noise at intermediate frequencies (10-100 mHz) are very limited and at low frequencies (3-10 mHz) do not exist. A key parameter that remains unknown is the depth of sensor burial required (in various tectonic settings) to optimize the signal-to-noise ratio while minimizing required drilling penetration.

In addition, a large number of purely technical problems must be solved. One-Hz geophones are the lowest frequency sensors routinely used on the ocean floor. These geophones have little sensitivity to earth noise below 50 mHz. An urgent priority is to adapt a presently available broadband sensor for operation on the ocean floor. How would a permanent global ocean floor network be operated in practice? With a data rate between 5 and 50 MBytes per day, the problems of both internal recording (with periodic data retrieval) or real-time telemetry are extremely challenging. Costs associated with use of fiber optic or existing telecommunication cables can be huge, but completely remote packages produce the problem of power source. Completely new (micropower) sensors and data loggers may need to be developed.

Satisfactory solutions to all these questions can be established only by carrying out a series of pilot experiments. These experiments must be carried out at several locations in a variety of tectonic settings.

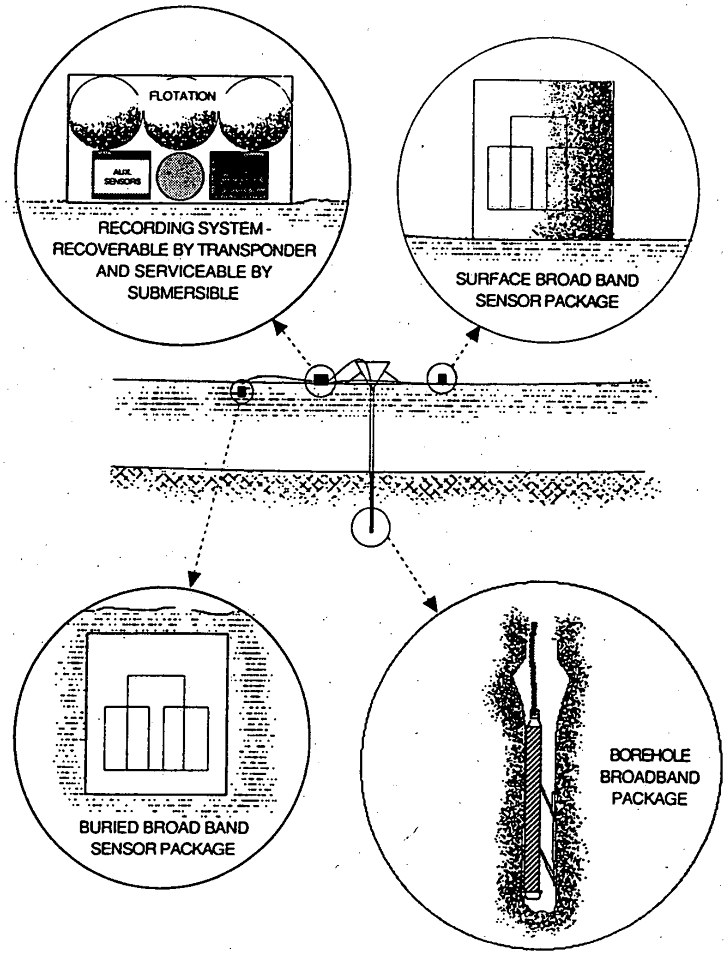

Fig 2. Possible configuration of experiment in which data from borehole, surface, and buried broadband sensor packages are simultaneously recorded by a common data-acquisition system.

The objective of this leg is to establish the first site at which these experiments, using wireline reentry from a conventional research vessel, can be performed over the next 2-3 years.

The site we have chosen is ~250 km south-southwest of Honolulu (Fig. 1). The experiments will be carried out by a variety of investigators and coordinated by a steering committee, jointly sponsored by JOI and IRIS, as proposed at a workshop held at Woods Hole Oceanographic Institution. Examples of specific objectives of such experiments are:

- To prove the satisfactory and reliable operation of a low-power (and eventually micropower) broadband ocean floor seismometer.
- To measure and compare noise levels (in the band 3 mHz to 50 Hz) downhole at various burial depths, with adjacent seafloor sensors, and with the island site on Oahu; and to understand the dependencies of the variations in these noise levels upon environmental parameters.
- To establish the satisfactory and reliable operation of the required recording, telemetry and timing systems.
- To develop routine sensor emplacement and data package recovery schemes.
- To obtain a sufficient number of high quality broadband recordings of teleseismic events to allow quantitative comparisons to be made with the data recorded on Oahu. These data could provide interesting new information on the upper mantle structure beneath the Hawaiian swell.

The benefits of the OSN-1 site for the development of the network will not be realized until the seismic package is deployed at some time in the future. Pilot experiments are needed to address three key issues:

- How "good" will ocean bottom observatories be in comparison with existing island stations? Noise and signals recorded by a broadband downhole sensor must be compared with those recorded on a nearby high quality island station.
- How deep do the drill holes need to be for sensor emplacement? We must measure variations in broadband noise levels on a downhole sensor with depth below the ocean floor.
- Do we need drill holes at all? Compari-

sons must be made between broadband noise levels on a downhole sensor with identical seafloor and surficially buried broadband sensors.

An example of the components of such a pilot experiment is shown in Figure 2. All of the above questions may be answered by experiments at the OSN-1 site.

Hawaiian Volcanoes

The drilling of the OSN hole presents an excellent opportunity to characterize a poorly known part of the Pacific basin. The Hawaii area is important because it is the type locality for oceanic, intraplate hot spots, and it is centrally located well away from other tectonic and sedimentary influences. The only previous attempt to drill in this region (Deep Sea Drilling Project Site 67, ~150 km north-northwest of Oahu; Winterer et al., 1971) recovered only 3 cores over 60 m of section before drilling stopped due to the presence of porcellanites. The objectives for coring in the Hawaii area are:

- To evaluate the seismic stratigraphy around the drill site and to better understand the relationship of crustal seismic structure to basaltic structure.
- To determine the physical properties of the sediment and basalt for use in modeling the mechanical behavior of Hawaiian volcanoes.
- To determine the chemistry of the sediment and basaltic basement for Hawaiian volcanoes (which could be a contaminant in Hawaiian magmas).
- To determine the amount of ash produced during Hawaiian eruptions.

Reentry Cone Seal

The reentry cone seal or "cork" consists of a mechanism that seals the throat of an ODP reentry cone and the 11-3/4-in. casing suspended below the reentry cone. The cork latches into the 11-3/4-in. casing hanger and thus will prevent fluid flow into or out of the borehole. The cork will house a removable data logger. Attached to the data logger and suspended in the borehole will be a thermistor string with integral pressure transducers. A hydraulic feed-through will be incorporated into the thermistor string to allow for borehole fluid sampling. The cork has been designed to allow the borehole fluid samples to be retrieved and the data logger to be downloaded and/or removed, without the drillship, utilizing a remote observation vehicle or manned submarine.

The first deployment of the cork prototype will occur during Leg 136. The cork will be run in the hole, latched into a reentry cone, pressure tested and retrieved as an operational and engineering test. The first deployment of the cork for scientific reasons will occur during Leg 139, Sedimented Ridges (July-August 1991).

Regional Setting

OSN-1 will be the focus of numerous experiments, carried out using the new U.S. wireline or French submersible reentry capability. Developments at OSN-1 will provide the groundwork for the construction of a global network. We have chosen the site 250 km south-southwest of Honolulu for three simple reasons:

- Clear comparisons can be made between our new data (both signal and noise) and those recorded by a well-established island site (Kipapa tunnel on Oahu);
- The opportunity exists to determine the upper mantle structure beneath the Hawaiian swell.
- Logistics for instrument placement, recovery, and maintenance are excellent.

The seismic experiments require at least a 100-m penetration into basaltic basement, beneath a few hundred meters of sediment cover in ~4000-m water depths at a location sufficiently far from the islands that the noise field is not dominated by island interactions but close enough so that logistics are simple and meaningful comparisons can be made with signals recorded at the joint GEOSCOPE - Global Seismic Network (GSN) site in the Kipapa tunnel on Oahu.

The OSN site is situated ~250 km southwest of the island of Oahu in ~4,500 m of water (Fig. 1). The sites are well clear of the extensive debris slides (Moore et al., 1989) and lava flows (Clague et al., 1989) mapped within the Hawaiian Exclusive Economic Zone by means of the GLORIA sonar imaging system. High-quality multichannel reflection and refraction data tightly define the impedance and velocity structure of the sediments and igneous crust (Watts et al., 1985). Expanding Spread Profile data indicate two primary sedimentary layers: a 200-m-thick layer of sediment increasing in velocity from 1.5 to 1.6 km/s overlying a thin (40 m), fast layer (4.2-4.3 km/s). The upper layer exhibits a normal gradient for compacting, uncemented seafloor sediments, while the lower layer may well be the same porcellanite encountered at DSDP Site 67 (Winterer et al., 1971).

Drilling Objectives and Strategy

Leg 136 will begin with a port call in Honolulu, 28 February - 2 March 1990. JOIDES Resolution will sail from Honolulu on 3 March, occupying one site—OSN-1—during the leg. On 20 March the ship will return to Honolulu, ending Leg 136. The Co-Chief Scientists will be Dr. Adam Dziewonski (Harvard) and Dr. Roy Wilkins (Hawaii). Dr. John Firth will be ODP Staff Scientist.

The primary objective of Leg 136 is to drill a hole 100 m into basement. Secondary geological and engineering goals will be accomplished through the following scenario:

1. A brief (3-hr) site survey.
2. Hole A: APC and XCB to basement, continuously coring sediments, with ~2 cores in basement.
3. Shift to Hole B. Set reentry cone (cased into basement ~20 m.)
4. Perform 2 days of reentry cone seal testing.
5. RCB at least 100 m into basement. Full coring if time allows.
6. Well logging. Quad-combo string (velocity, density, resistivity, and gamma-ray), digital borehole televiewer. Geochemistry string run through casing depending on time and need to correlate log and core.
7. VSP/Check Shots for traveltime in sedimentary section (run through casing) and in basement if time allows.

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Detailed Planning Group Report

RECOMMENDATIONS FOR AN EAST PACIFIC RISE DRILLING PROGRAM

Preface

In 1989 a working group was created by the Planning Committee (PCOM) of the Ocean Drilling Program to establish and prioritize scientific objectives for a drilling program on the East Pacific Rise (EPR). At that time, neither the Lithosphere Panel (LITHP) nor PCOM felt that the maturity of existing EPR drilling proposals was sufficient to provide a basis for planning the multiple legs of drilling required to reach a reasonable set of objectives. Furthermore, it was anticipated that the technical difficulties of establishing holes in zero-age fractured or rubbly basalts and continued drilling in the presence of high formation temperatures would be too great for existing drilling equipment. Attempting to drill into the zero- age crust of a fast spreading-rate ridge had been set previously as a high priority by a number of more general planning groups including LITHP, COSOD I and COSOD II, however, and the East Pacific Rise Working Group (EPRWG) was established to make recommendations about how to overcome the difficulties, and to create a general drilling strategy that could be accomplished with augmented drilling technology. The results of the deliberations of that group can be found in the report "A Drilling Strategy for the East Pacific Rise: ODP East Pacific Rise Working Group Report" which was reviewed by LITHP and PCOM. In that report, the group outlined the major scientific objectives that should be addressed with an EPR drilling program, created a "generic" drilling strategy that focused on the hydrothermal and magmatic processes active in the creation of oceanic crust at a ridge segment scale, defined the criteria for choosing a segment best suited to such a program, suggested possible segments, and made recommendations for the acquisition of new survey data to enable final site selection and for new engineering developments necessary for the successful completion of the program.

Major technical advances have been made since that report was written. In particular, a number of substantial improvements have been made to the hard-rock guide base, and ODP now has the proven capability to utilize a narrow-kerf, high-speed diamond coring system (DCS) from the *JOIDES Resolution*. With these improvements, and with the additional experience that was to be gained during the Engineering Leg 132 and other scientific legs, it was anticipated that the general objectives outlined in the EPR Working Group report could be met, and that the next level of planning could proceed.

Also subsequent to the activity of the EPR Working Group, two proposals of greater maturity were submitted to ODP for drilling on two different segments of the northern East Pacific Rise, one centred at roughly 12°50'N, the other at 9°30'N. With a preliminary drilling leg potentially less than two years away, PCOM established an East Pacific Rise Detailed Planning Group (EPRDPG) to review these proposals and to help finalize a drilling program. The charge of the group was to choose which of the two active proposals was better in light of the criteria set by the EPRWG, to establish actual drilling sites, and to prepare a drilling plan.

The EPRDPG met at the Pacific Geoscience Centre in April, 1990, to carry out this assignment. The meeting commenced with a review of the goals established by the EPRWG. It was concluded that these were still sound and valid, and that the segment selection criteria and the general configuration of the array of holes to be drilled could provide a framework for the work of EPRDPG. New site survey data were then reviewed and evaluated as they pertained to specific segment and site selection criteria for the drilling program. After much discussion, it was concluded that the segment centred at roughly 9°30'N was somewhat better suited for the program because of the breadth and the particularly good geophysical characterization of the axial magma chamber. Final sites at this segment, and alternate sites at the 12°50'N segment were selected on the basis of the survey data, and recommendations for additional survey work were made.

Scientific Objectives and Drilling Strategy

Scientific objectives and priorities are discussed in detail in the EPRWG report; only a brief summary is provided here. Central to the drilling strategy suggested was the recommendation to select a single ridge segment, taken to be the "unit element" of sea floor spreading, and direct all drilling efforts there. *Within this segment-focused program, the highest priority for drilling on the East Pacific Rise rests with establishing a single deep hole near the ridge axis that penetrates as closely as possible to the top of the geophysically defined axial low velocity zone, which is interpreted to be the top of an axial magma chamber.* In hopes of avoiding the difficulties anticipated in the axial rift zone, *this hole (EPR-1) has been sited just outside the axial rift where there are no manifestations of faulting at the seafloor. A second hole (EPR-2), intended to penetrate only that section of the crust where convective heat transport dominates, is proposed within the axial rift zone and near a hydrothermal discharge area.* This second axial hole may serve as an alternate site for deep penetration, depending on the thermal and physical conditions found and the drilling difficulties encountered during the initial penetration at these sites. Objectives at these sites include:

1) determining the compositional and physical structure of "zero-age" oceanic crust,
2) characterizing the physical and chemical nature of the fluid/rock interaction immediately above a crustal magma chamber,
3) characterizing the physical and chemical nature of fluid flow and fluid/rock interaction in the permeable portion of the crust where large quantities of heat are transported advectively,
4) determining the temporal variability of lava compositions to help constrain models of the physics of partial melt supply to, and strorage in, crustal level magma chambers, and
5) providing calibrations for geophysical observations that can be made remotely, such as with seismic reflection and refraction and electrical resistivity methods.

Other objectives discussed in the EPRWG report include the investigation of the larger scale spatial and temporal variability in the composition of magma supplied to the ridge and of the physical and chemical alteration of the crust as it begins to age. Approaching these objectives requires an array of holes distributed across and along the strike of the ridge segment. These holes are intended to penetrate through the extrusive layer of the upper crust and will each require several hundred metres of drilling. Because of the time required to complete such an array, this clearly must form part of a long-term effort of intensive ridge segment characterization. A specific position for only the first of these additional holes is suggested in this report.

Geological Setting

Detailed descriptions of the morphology, structure, and composition of the two ridge segments discussed by the EPRDPG are given in the proposals 321/E (Fornari et al.) and 357/E (Hekinian et al.), and in publications referred to therein; only a summary is provided here. Survey data at both sites are extensive and include conventional underway geophysical surveys, Seabeam bathymetry, detailed dredging, camera tows, surface (SeaMARC II) and deep-towed (SAR, SeaMARC I, and ARGO) side scan surveys, multichannel seismic reflection, and seismic refraction and tomography. Extensive submersible sampling and observational programs have been carried out on the northern segment, and an extensive ARGO side-scan and photo survey has been completed on the southern segment.

Both segments are similar in terms of first-order structure, and both fully meet the criteria for segment simplicity outlined in the previous report (see Figures 1-3): their current configurations as well as their spreading histories appear to be relatively simple; a bright reflector underlain by a low velocity region is present in the upper crust at both locations; both segments possess well defined axial rift zones within which high- temperature hydrothermal activity has been observed.

The EPR at 12°50'N

A more detailed view of the segments reveals important differences. The northern segment is relatively short, and is bounded by small overlapping spreading centre offsets at 12°37'N and 12°54'N (Figure 1). The axial volcanic ridge is domed, and intermediate in cross-sectional size (Figures 1-3). The axial summit graben is wide (200-400 m) and deep (20-50 m), and is clearly fault-bounded. Although the AMC reflector in the upper crust is relatively continuous along strike (Figure 3b), it is extremely narrow, limited roughly to the width of the axial graben. The hydrothermal systems along the axial graben are well developed (Hekinian et al., 1984), and there is a sense that these systems are "mature"; high-temperature vents are numerous, and related mineral deposits are large relative to those found on the southern segment. The chemistry of the basalts collected along this segment are heterogeneous in both major and trace elements (Figure 4a), as well as in isotopic ratios. Both depleted and enriched basalts have been recovered. In general, the degree of compositional variability along this segment is as large as exhibited along the rest of the length of the northern East Pacific Rise (Langmuir et al., 1986). This high degree of variability occurs down to a very local scale and without regard to local structural setting (Hekinian et al., 1985). Taken together, these data suggest that this ridge segment is currently representative of one that has a reduced magmatic budget, which has led to limited homogenization of a heterogeneous source, a well developed axial rift graben, a stretched and fissured terrain that extends beyond the rift graben, and vigorous hydrothermal circulation.

The EPR at 9°30'N

In contrast, the southern segment is long, bounded at 10°10'N by the Clipperton transform fault and at 9°03'N by a moderately large-offset overlapping spreading centre. In the across-strike perspective, the ridge crest is broad, and its axis is characterized by a narrow (in some places 10-40 m, and generally less than 150 m), sometimes discontinuous axial rift that develops relief of only several metres. To a large degree, the morphology of the axial rift appears to be controlled by volcanic processes (drain-back and linear caldera-collapse). The smooth and broad morphology of the axial volcanic ridge (Figures 2 and 3), the relatively small axial summit graben, and the paucity of flanking faults across the crest indicate that this ridge segment is in a robust magmatic phase. This is also suggested by the strength and breadth of the axial magma chamber (Figure 3a). Hydrothermal vents are in evidence along the length of the axial rift (Figure 5), but judging from the smaller size of the vents, the smaller visible size of the related mineral deposits, and the greater density of vents, the hydrothermal system at this segment would appear to be considerably less "mature" than that of the northern segment rift.

The chemistry of basalts along the southern segment are strikingly uniform, in contrast with those of the northern

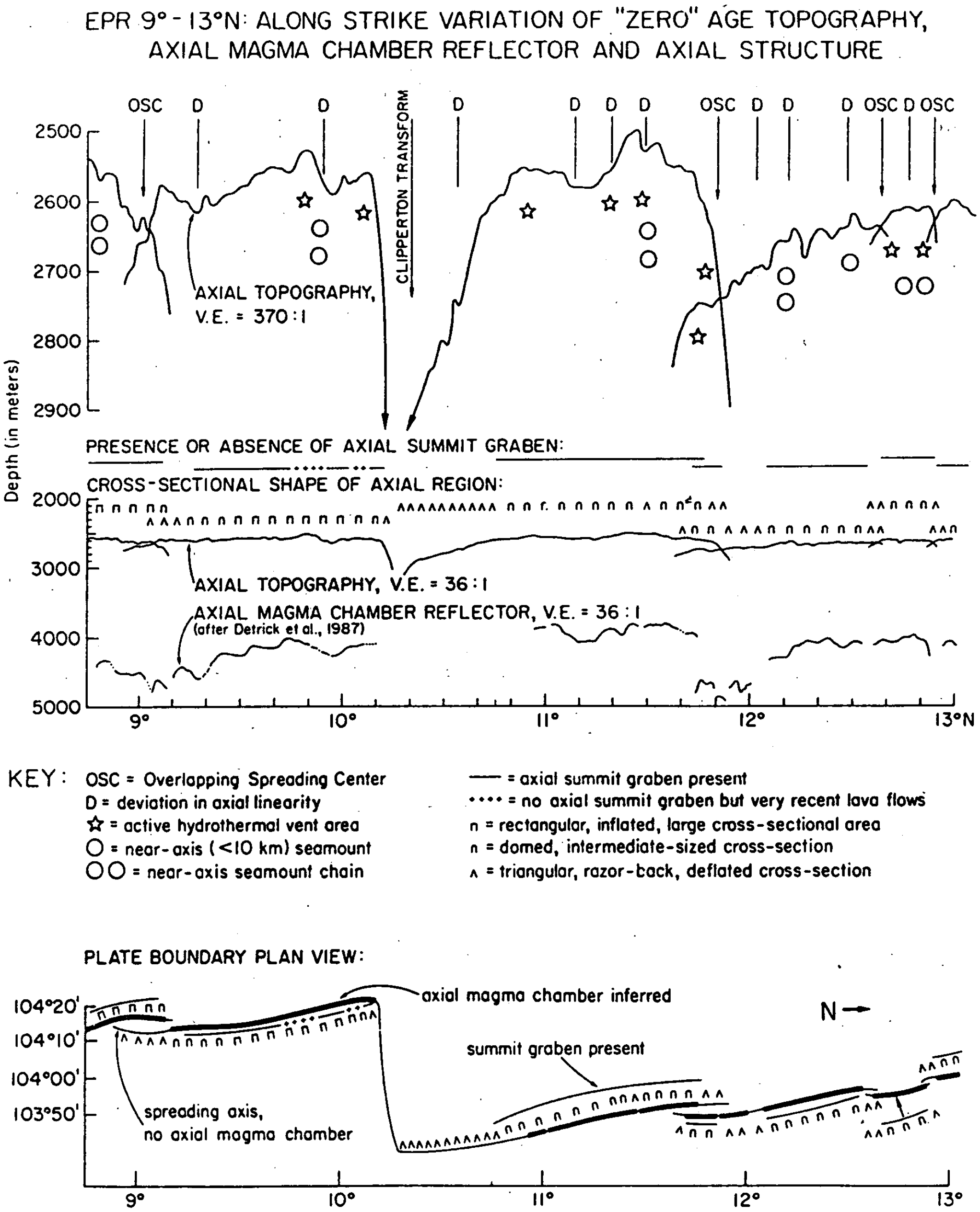
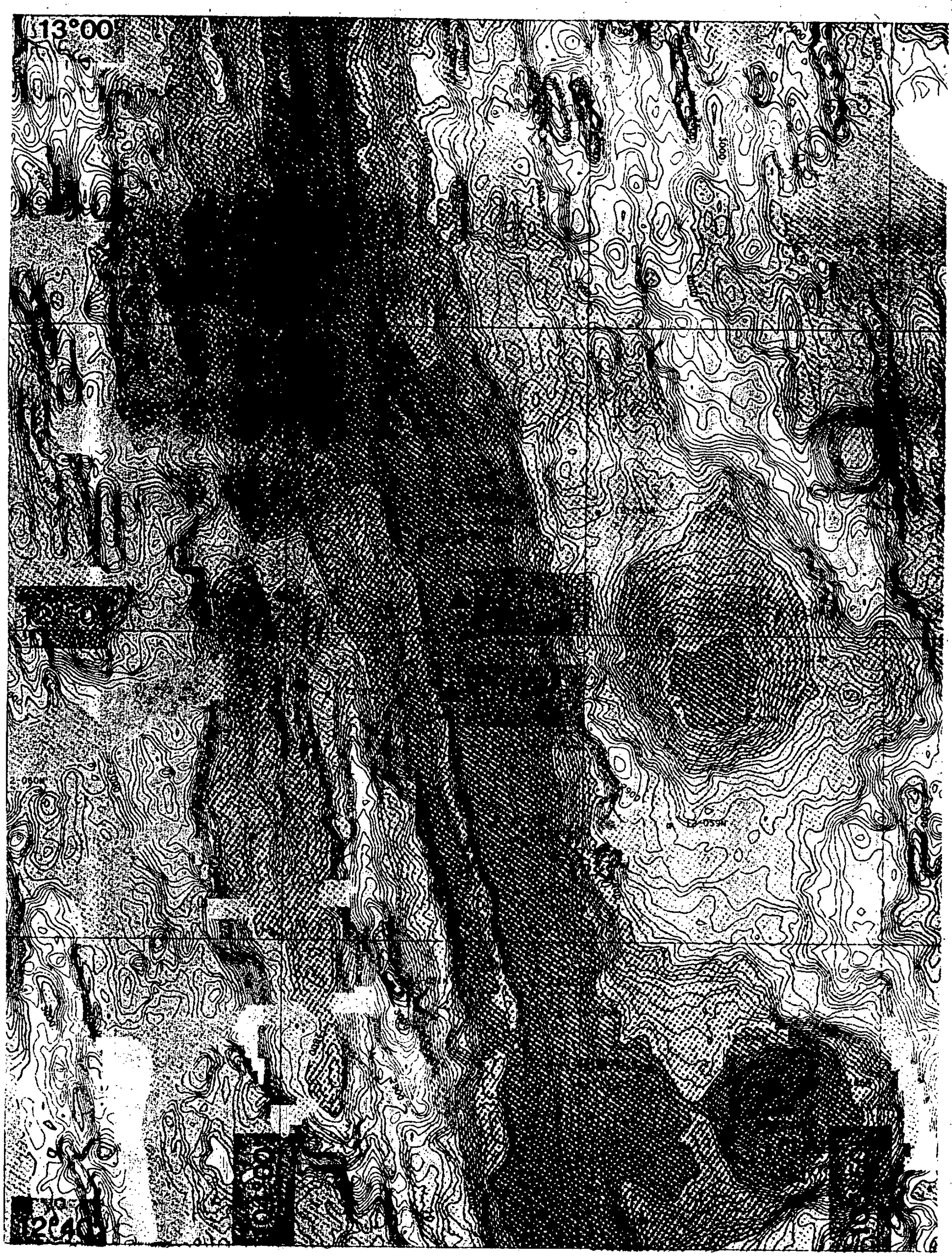


Figure 1. Morphologic and structural characteristics of the East Pacific Rise crest from approximately 9°N to 13°N (from MacDonald and Fox, 1988).

segment (Figure 4a). With the exception of one sample from 9°35'N (Batiza, pers. comm.), all samples recovered from the southern segment are depleted normal MORB's with a narrow range of Ba:TiO2 ratios. This contrasts with virtually all other segments of the EPR in the region, where substantial ranges of ratios are common. The southern ridge segment is also the sole segment where a large number of gabbroic nodules have been recovered. Two possible explanations for the chemical homogeneity could be: 1) an unusually homogeneous source region, or 2) more efficient mixing of the diversity of parental magmas that are supplied to the

A

Figure 2. Bathymetry of the EPR at the segments centered at (a) 9°30'N and (b) 12°50'N. Contours are shown at 10 m intervals. Depths within the darkest area centred on the crest are less than 2600 m in (a) and 2700 m in (b). The area covered by Figure 7a is outlined. Primary and alternate drill sites are shown in (a) and (b) respectively (from JOI/USSAC EPR Data Synthesis).



B

Figure 2. Continued.

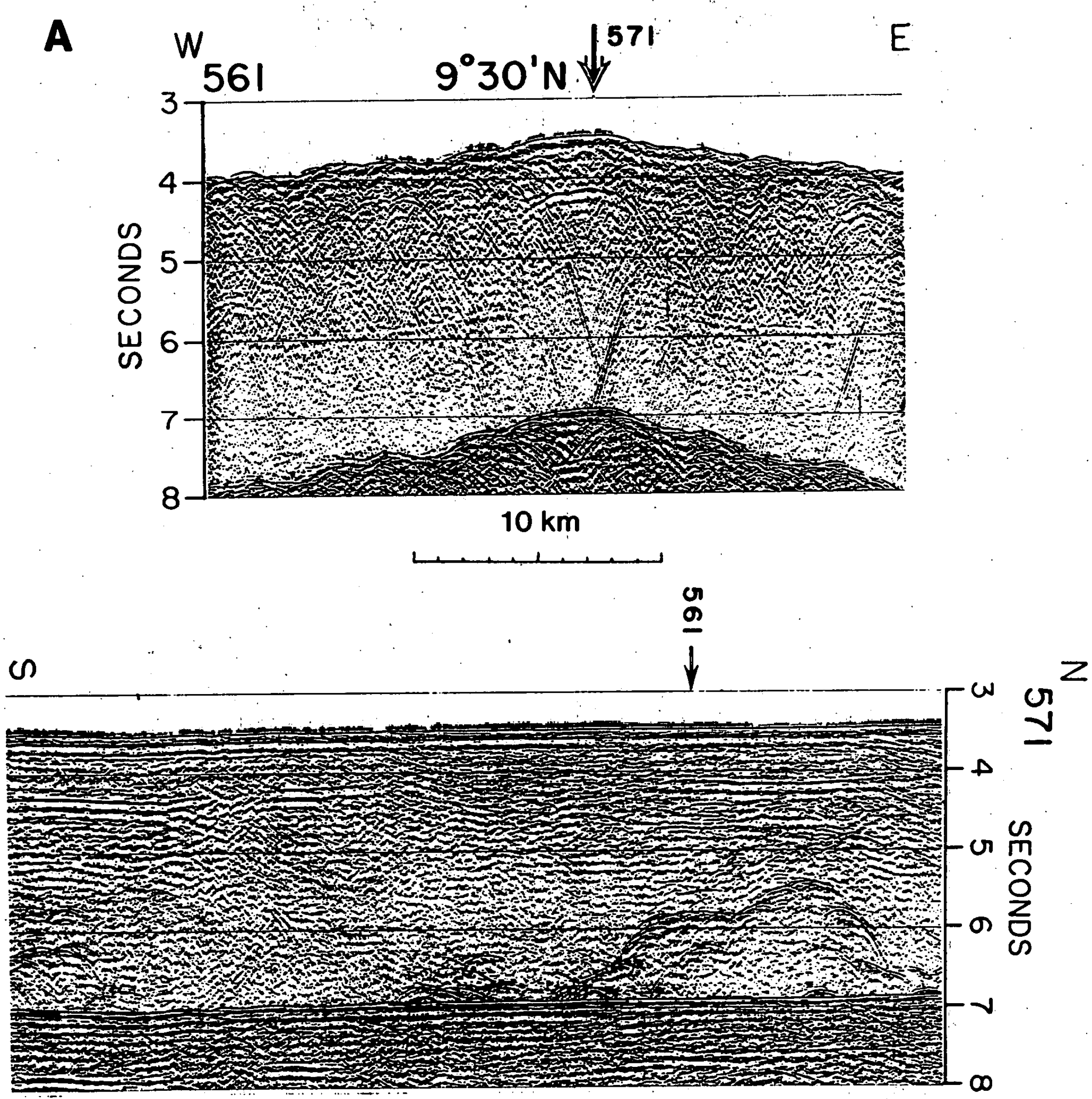


Figure 3. Multichannel seismic reflection profiles across and along the EPR at the (a) northern and (b) southern segments discussed in this report. A strong reflection inferred to be from the top of a narrow (across-axis) but continuous (along-axis) axial magma chamber (AMC) can be seen at a depth of slightly less than 1 s below the sea floor. Discontinuities in the AMC reflection long-axis are attributed to the ship's track deviating from the axis. The crossing points of the pairs of profiles are shown with arrows (data from Detrick et al., 1987; reproduced from the JOI/USSAC EPR Data Synthesis).

ridge axis. Compositions of the one enriched MORB recovered from the axis by Batiza, and of the Lamont seamounts (Fornari et al., 1988; Allan et al., 1990) suggest that source heterogeneity is present, however, and the mechanism of mixing in an unusually robust volcanic regime is more likely to be the one that causes the general compositional homogeneity at this segment.

Small but significant compositional variations can be seen in Figure 4b, where MgO contents and P2O5:TiO_2 ratios are plotted against latitude along the segment axis at an expanded scale. Variations are small but systematic on a segment-long wavelength. Local variability is also significant (see MgO number), and consistent

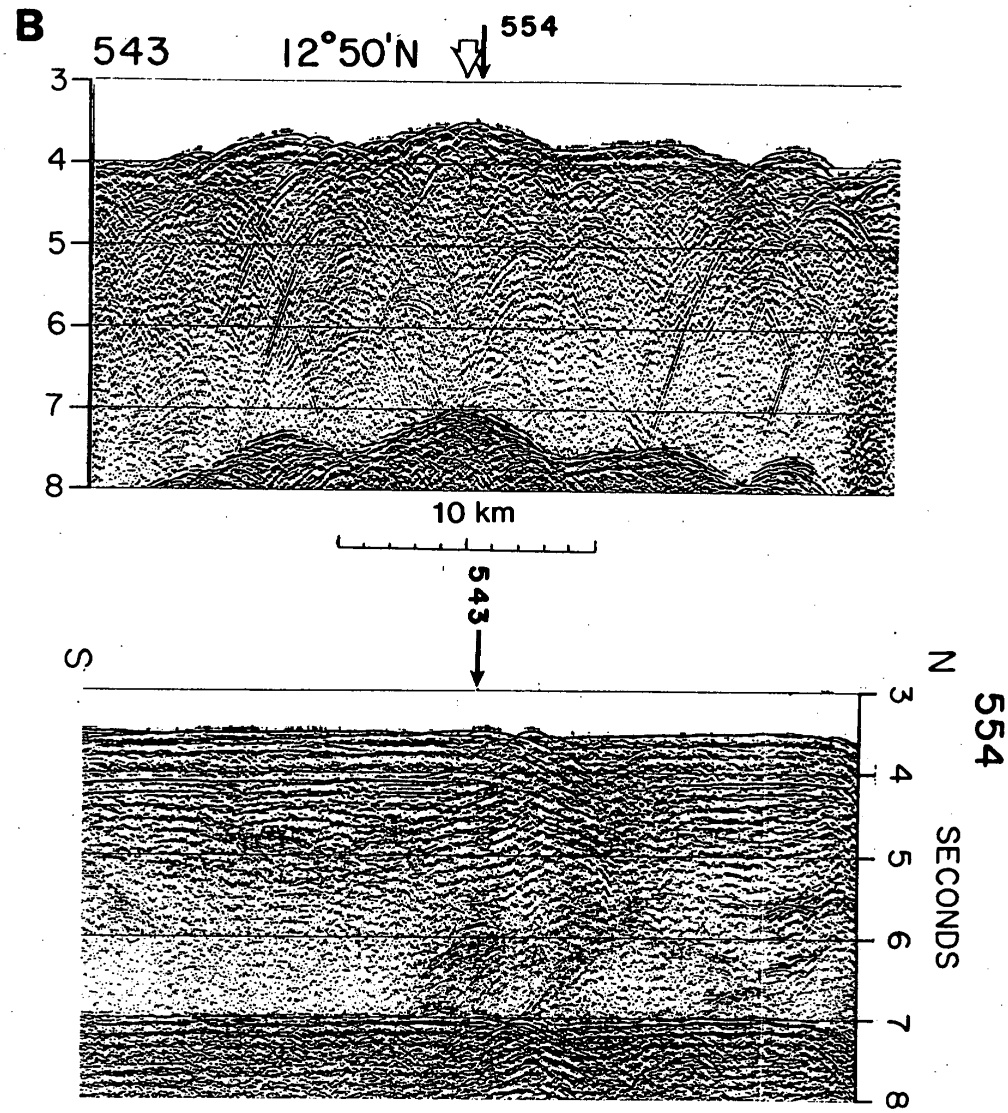


Figure 3b. See previous page.

with there being several liquid lines of descent that are organized with respect to devals in this region (Batiza, pers. comm.). Thus, although compositional variability is small, patterns of variability appear to be recognizable on at least two scales.

Segment Prioritization and Site Selection

Both the 9°30'N and 12°50'N EPR ridge segments fit the general segment selection criteria outlined in the previous EPRWG report well, and tentative drilling sites have been selected at both segments. This has been done for the purpose of providing alternate sites in the event that unexpected formational difficulties are encountered at the preferred segment. For the purpose of prioritising the segments, several factors are considered to be important. Two provide discordant guidance: The compositional simplicity of the southern segment makes it an arguably better site for studying compositional variability as a function of depth and time, whereas the greater hydrothermal maturity of the northern site makes it a more suitable site for addressing secondary hydrothermal objectives. A third factor that is related directly to the highest priority drilling objective, to drill as deeply as possible towards an axial magma chamber (AMC),

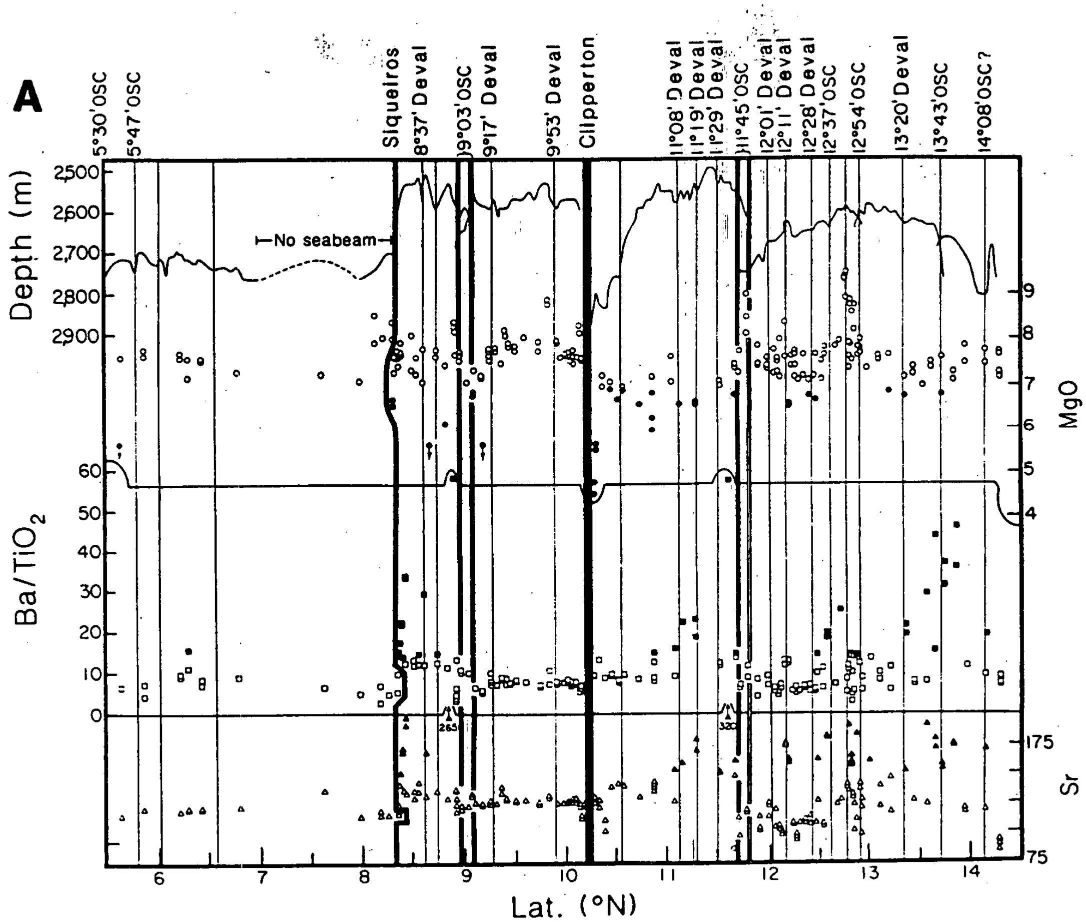


Figure 4. a) Compositional variations of axial basalts along the crest of the EPR plotted as a function of latitude, with the axial depth shown as in Figure 1 for reference. Thick vertical lines delineate major segment boundaries which occur at transform faults and large-offset overlapping spreading centres (OSCs). Thinner vertical lines indicate the locations of small-offset OSC's and "DEVALS". Filled symbols indicate compositions which display enriched tendencies (from Langmuir et al., 1986).

provides clear guidance, however: *The AMC reflector is broadest and best imaged along the southern (9°30'N) segment. This makes it the one preferred for the EPR drilling program.*

The targets for the axial pair of holes at the northern segment, selected by the proponents of proposal 357/E on the basis of current site survey information, are shown in Figure 2. The primary site (EPR-1a) is located along a dive transect about 2 km west of the axial graben in an unfaulted, pillow basalt terrain. The axial rift site (EPR-2a) is located within the rift graben about 3 km to the north, and near a well studied hydrothermal field where 280-330°C vent fluids have been sampled. The DPG found no reason to alter the location of either of these sites.

The axial sites on the southern segment (EPR-1 and EPR-2) have been located where the axis is locally simple, and where the generally strong AMC reflector displays its greatest breadth and amplitude. This occurs at a latitude of approximately 9°30'N where MCS line 571 crosses the ridge crest (Figure 3a). This location differs from the latitude selected for sites in proposal 321/E, although the latter was described as preliminary; no conflicts with the objectives of that proposal arise as a result of this change.

Constraints for further refining the

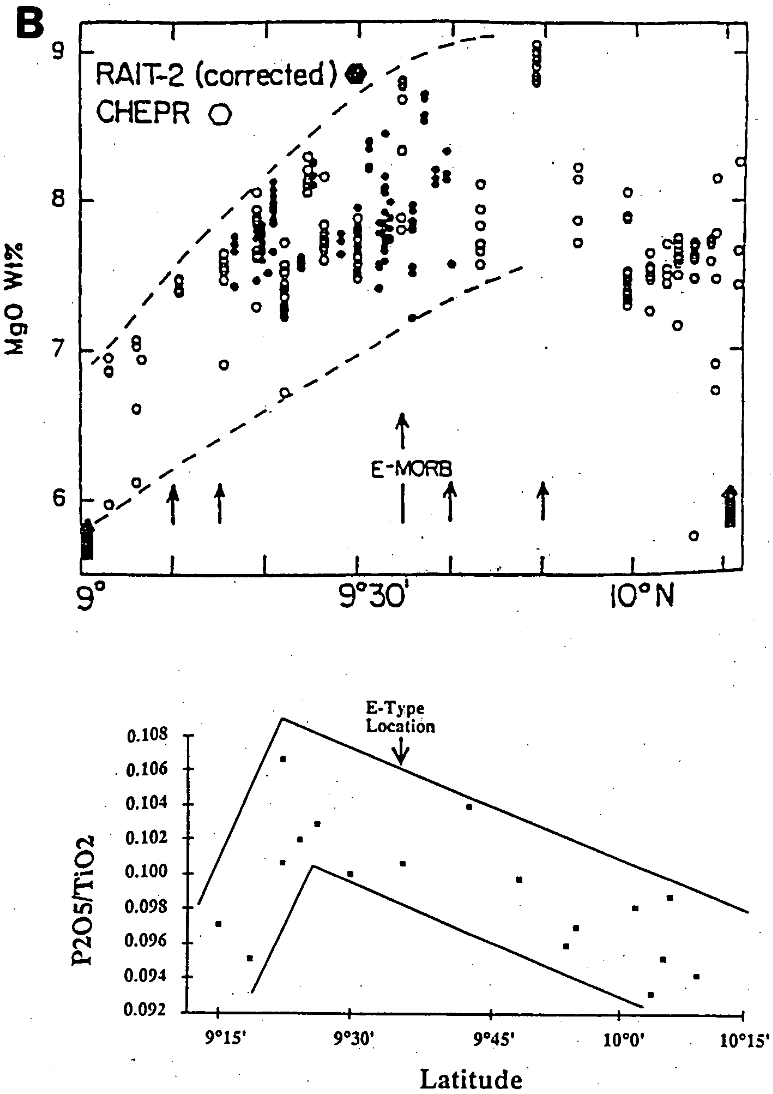


Figure 4. b) Compositional variations plotted as a function of latitude for the EPR axial segment immediately south of the Clipperton Fracture Zone.

position of the primary drilling targets on this ridge segment come from the acoustic and optical imagery of a recent ARGO cruise to the area (Haymon et al., 1990; Fornari et al., 1990). These data reveal the details of the axial rift zone, the distribution of hydrothermal activity, and the local morphology of the sea floor. A summary of these observations is shown in Figures 5 and 6. In the vicinity of the drill sites, two small deviations from axial linearity (DEVALS) occur at 9°28'N and 9°35'N. The MCS reflection line 561 and the drilling sites are located roughly in the middle of this 12 km long sub-segment of ridge bounded by the DEVALS. Along this portion of the ridge, the axial summit graben (ASG) varies in form from an extremely narrow trough (40-70 m wide, with 8-15 m high walls) to a wider (150-200 m) trough that at some locations includes a central depression 5-7 m deep and 20-40 m wide and occasional narrow (10-20 m) channels along the base of the outermost walls. On a fine scale, the edges of the ASG are ragged, rather than linear, with many reentrants and protuberances. This overall morphology suggests that the ASG formation may be intimately tied to collapse of the volcanic carapace resulting from drainback, and hence may be a syn- volcanic feature rather than a purely tectonic graben. The morphology of the ASG floor supports this notion: lobate, sheet, and autobrecciated flow surfaces, numerous collapse pits, lava pillars and other drainback features characterize the ASG. Clearly, drilling within the ASG may be initially difficult owing to the local complexity and high relief of the sea floor, although conditions may improve rapidly if massive intrusive volcanics (feeder dikes) lie at a relatively shallow depth. Outside the ASG, the seafloor is relatively unfissured and has considerably less local relief; this will make the initial establishment of a hole there considerably easier, although conditions anywhere within the upper few hundred meters of crust may be very similar to those at the sea floor within the ASG.

Prior to the ARGO survey, observations defining the extent and nature of

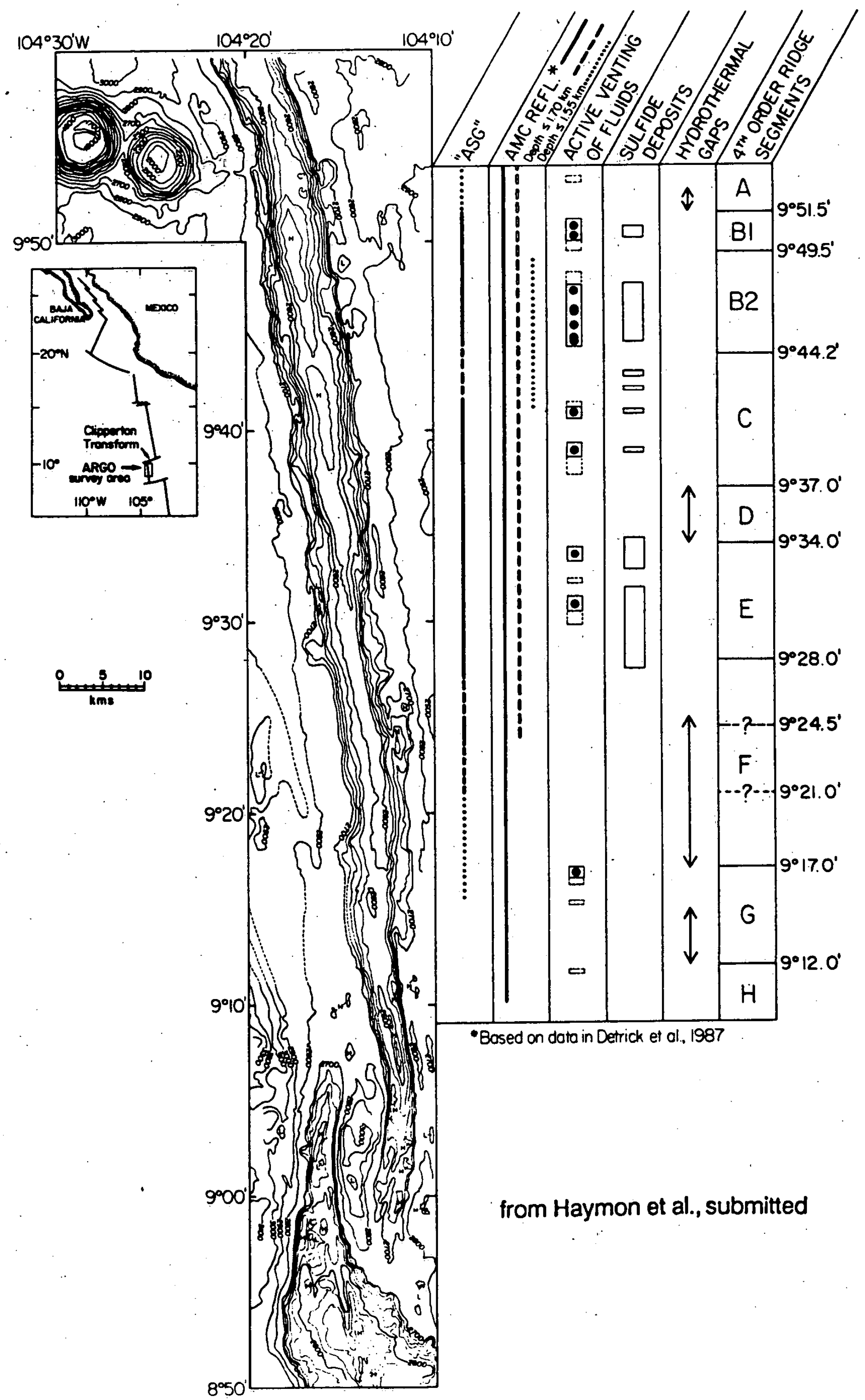


Figure 5. Distribution of tectonic, magmatic, and hydrothermal features along the crest of the EPR south of the Clipperton Fracture Zone, derived from published (Seabeam, MCS reflection, SeaMARC II) and new (ARGO side scan and optical image) data (from Haymon et al., 1990).

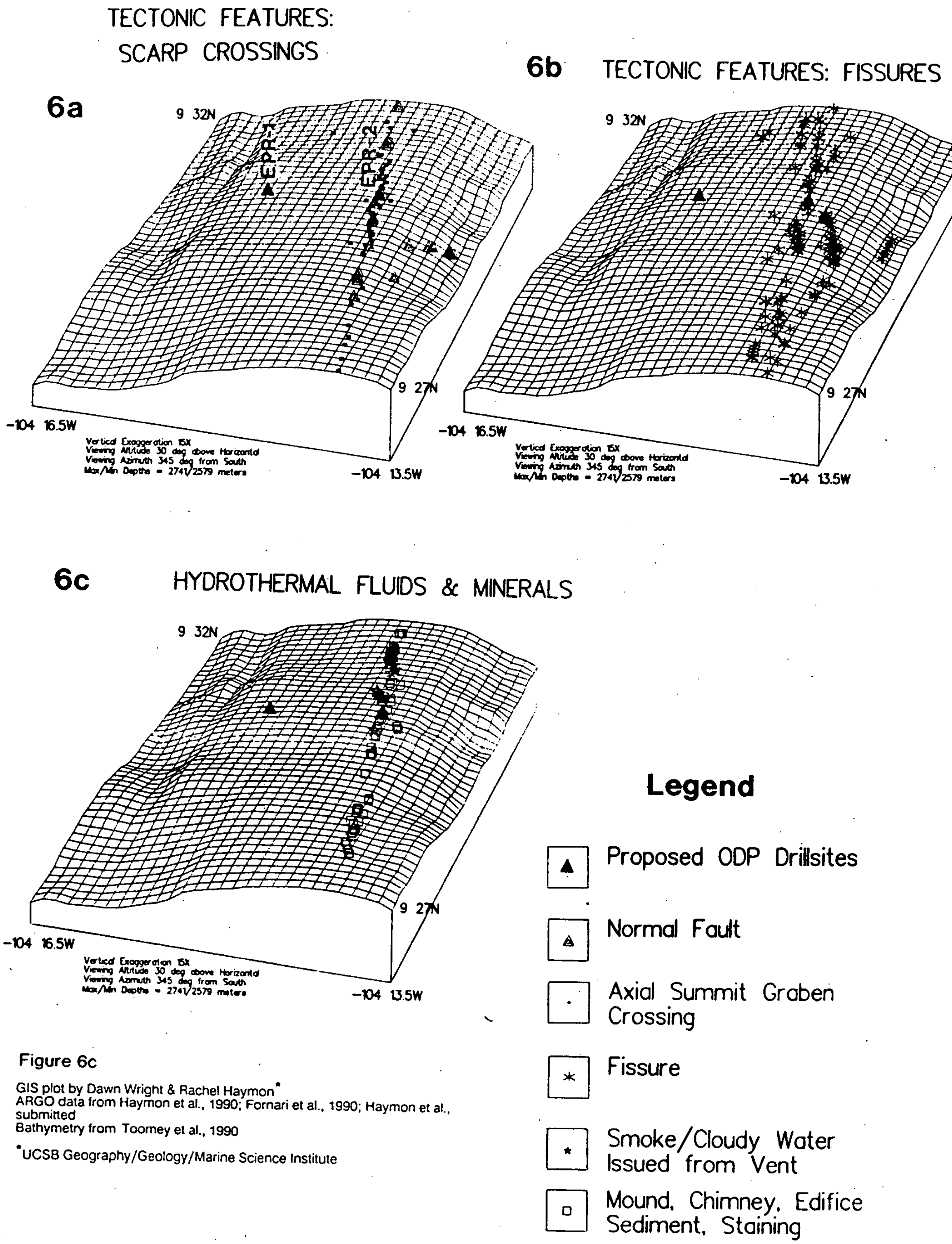


Figure 6. Detailed bathymetry (derived from a 80m gridded data set of Toomey et al., 1990) of the area of the EPR in the immediate vicinity of the drilling targets EPR-1 and EPR-2. Superimposed on the bathymetry are the locations of (a) tectonic scarps, (b) fissures, and (c) hydrothermal vents and deposits identified in ARGO optical image data.

thermal activity along the segment south of the Clipperton Fracture Zone were limited to those made by camera tows and by visual observations from Alvin (Kastens et al., 1986; Barone and Ryan, 1990; Fornari et al., 1988) along the northern part of the segment. Mapping with the ARGO system (Haymon et al., 1990) has permitted the distribution of hydrothermal vents and associated biological communities to be determined along the remainder of the segment between 9°09' and 9°54'N (Figure 5). One of the more active areas lies between 9°30' and 9°32'N (Figure 6c). Hydrothermal discharge is principally localized along the margins of the axial summit graben (ASG). From 9°30' south to 9°27.5'N, numerous hydrothermal deposits were mapped, but high-temperature activity appears to have ceased.

Further constraints on the location of the drilling sites along this ridge segment are provided by the results of a detailed seismic tomography experiment performed along this part of the ridge segment (Toomey et al., 1990). The results of this experiment have been inverted to reveal the three-dimensional velocity anomaly with respect to the area-wide average 1-d velocity structure. The anomalies, presented in two sections in Figures 7 a and b, show a number of characteristics that are commensurate with the surface structure of this part of the ridge segment revealed by Seabeam bathymetry and ARGO imagery, and that are relevant to the siting of holes: 1) A linear low-velocity volume (LVV) is situated beneath the ridge axis (Figure 5b). The LVV is narrow, 3-4 km wide at a depth of 2 km, and confined to sub-bottom depths greater than about 1.5 km, in agreement with the inferences from the MCS data. The cross-section of the LVV decreases as the DEVALS at 9°28' and 9°35' are approached, indicating that the high order segmentation of the ridge as observed in the surface morphology persists at depth. The LVV is ridge-parallel, but it is centred nearly 1 km to the west of the current topographic and structural ridge axis, commensurate with the asymmetry of the topography of the axial volcanic ridge, which has a gentler slope to the west than to the east. 2) A linear zone of high velocity is defined in the uppermost crust. This zone is centred along the current ridge axis, and persists to a distance of roughly 2 km on both sides. Beyond about 4 km from the crest, upper crustal velocities become relatively constant with distance. The high velocities near the surface may be indicative of a high proportion of dikes that have intruded the uppermost crust at the current ridge axis.

Sites located on the basis of all of these observations are shown in Figures 2a, 6, and 7 and given in the site summary Table 1. Criteria used for selecting the sites were as follows:

1) The highest priority site, EPR-1, is located 1 km west of a hydrothermally active portion of the axial rift zone, in a region of unfissured crust but directly over the centre of the axial LVV and the AMC reflector. Velocities in the uppermost crust at this location are high, although arguably lower than those at the same level beneath the axial rift zone.
2) The second priority site, EPR-2, is located within the ASG, and directly over the centre of the uppermost crustal high-velocity anomaly. The site lies midway between two active vents observed along the ASG, about 500 m from each.
3) Site EPR-3, the first "flank" site of a cross-axis array, is located roughly 7 km west of the axis, off the axial volcanic ridge (to sample the next oldest major volcanic unit that has had some history of low-temperature hydrothermal alteration), and well away from the axial LVV (so that the thermal structure of the young crust away from a crustal magma chamber can be observed).

The site locations given are felt to be

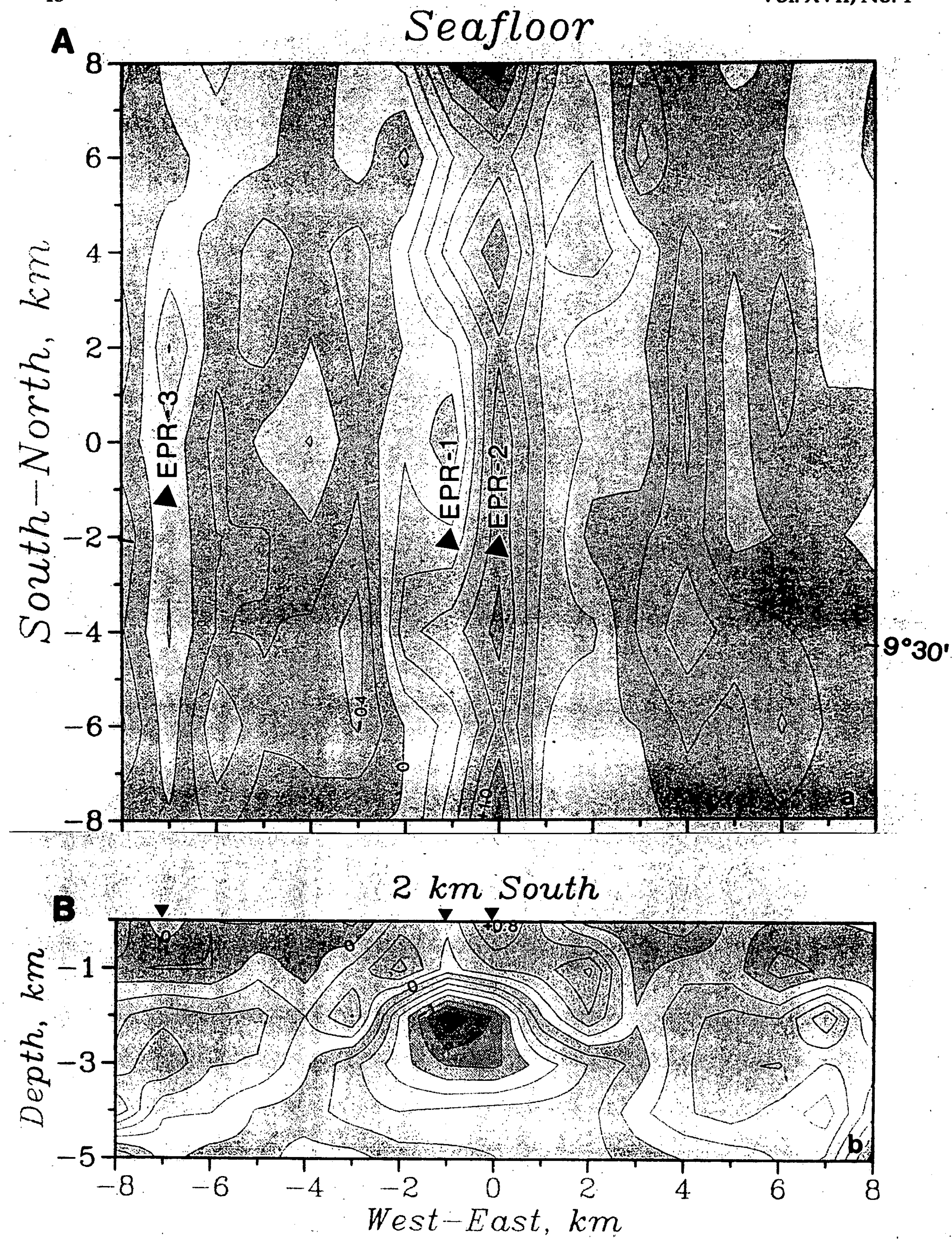


Figure 7. Crustal velocity anomalies (computed as local differences from an area-wide mean velocity-depth structure) for the area shown in Figure 2a. The plan view, (a), shows anomalies within the uppermost crust for the entire area. The approximately east-west cross-sectional view, (b), shows the velocity structure from the surface down to a depth of 5 km roughly at the position of the drill sites (shown by triangles) and the position of the MCS reflection line shown in Figure 3a (from Toomey et al., 1990).

hydrooptimal with respect to these criteria and in light of the site survey data available. Recommendations for the collection of additional data to further refine the placement of sites are given in the next section, however, and it is anticipated that the consideration of any new data acquired before drilling could affect the exact positions of the final drilling targets.

Table 1: Site Summary

Site	Location		Water Depth	Anticipated Penetration
EPR-1	9°30.2'N	104°14.5'W	2600 m	1500 m
EPR-2	9°30.2'N	104°15.1'W	2590 m	500 m
EPR-3	9°30.2'N	104°18.3'W	2840 m	500 m
Alternate Sites				
EPR-1a	12°44.0'N	103°56.0'W	2660 m	1500 m
EPR-2a	12°50.0'N	103°55.3'W	2630 m	500 m

Additional Site Survey Requirements

Although the ridge segments at both 9°30'N and 12°50'N are very thoroughly characterized, some additional work on existing data and some new site survey data would be highly desirable. Listed in a general order of priority, these are:

1) An interpretation of the integrated ARGO acoustic and optical image data set in the vicinity of the 9°30'N drill sites is being carried out for the purpose of identifying fissures, faults, hydrothermal activity, and volcanic flow morphology and age classification; careful perusal of these data is required to guide the final siting of holes EPR-2 and possibly EPR-1 so that local high volcanic or tectonic relief can be avoided. This will minimize problems associated with guide-base stability.
2) High-resolution (bottom source/bottom receiver) seismic refraction would be potentially very useful in selecting sites where the physical competency of the uppermost crust and the chances of successful penetration and core recovery are locally the greatest. Clearly, the planning of this work must be coordinated closely with the ARGO data interpretation. After drilling, integration of the logging, lithology, and physical properties data with the refraction results will be extremely valuable. Experiments should be carried out in the vicinity of all sites, including, if possible, the alternate sites at the 12°50'N segment. (A deep-source seismic experiment is tentatively scheduled for the Winter of 1991).
3) To augment the ARGO data, submersible mapping should be carried out in the vicinity of sites EPR-1 and EPR-2, and possibly EPR-3, so that the local sea floor structure and micro-topography is well resolved. Planning of this work should be done in close coordination with the seismic refraction study, possibly after initial results are available.
4) To place the drilling results in proper context of the detailed surface expression of hydrothermal activity and of vent fluid chemistry and temperatures, a submersible fluid sampling program should be carried out along the ridge segment in the vicinity of EPR-2. (An Alvin diving program that will include this and the work recommended in (3) above is tentatively scheduled for the Spring or Summer of 1991, although the results would not be required for the final siting of holes).
5) An electrical resistivity survey would be potentially very useful at both the primary and alternate sites to provide additional constraints on the variations of porosity and thus expected formation compentency.

6) Further processing of existing multichannel seismic data, including integration with the results of the seismic tomography experiment, should be completed. In addition to the multichannel data, a detailed grid of single-channel data exist in the same area. It is important that these data be properly compiled, as they contain reflections from the AMC.
7) A study of the hydrothermal signature in the water column over the 9°30′N segment should be completed to complement the vent sampling and drilling results. Detailed plume surveys using temperature and salinity, methane, manganese, and particulates have provided useful information at the northern EPR (Charlou et al., 1990) and other ridge segments. Although important, similar work at the 9°30′N segment does not have to be completed as a prerequisite to drilling.
8) Before finalizing the location of sites in the cross-axis transect (EPR-3 et seq.), a cross-axis rock sampling program should be completed. The distribution of off-axis samples is not sufficient at either the northern or the southern segment to guide properly the spacing of the holes from a petrologic point of view.

Drilling, Downhole Measurements and Sampling Strategy

Drilling and coring

All of the objectives of this program can be met only through a full integration of deep penetration, coring, logging, fluid sampling, and long-term observations. The program will be only a partial success if any part of the operation fails. If priorities must be assigned, *the highest must be placed with achieving a high rate of core recovery (at least 50%)*. If the DCS, which will receive its next testing on the initial EPR engineering leg, does not provide adequate recovery, additional efforts should be put into developing the capability to ream the holes so that standard diameter logging tools can be used to compensate for low core recovery.

The greatest difficulty in obtaining core is anticipated in the rubbly and incompetent upper tens of metres of the crustal section in which the bottom hole assembly (BHA) is to be set. It is in this same incompetent part of the crust that hole stability will pose problems to logging efforts as well; clearly, a conservative approach for deciding how deep to extend the BHA below the guide base is advised, in spite of the potential for lower core recovery in that section. Fortunately, recovery of rocks from the uppermost section is considered less important than recovery of rocks from greater depths. Nevertheless, some attention must be paid to core recovery in this shallow interval.

Downhole measurements and sampling

This drilling program offers a unique opportunity for gaining direct information about high-temperature hydrothermal circulation and associated alteration of the oceanic crust that can be obtained in no other way. To exploit this opportunity fully, considerable effort should be put into downhole measurements and fluid sampling. Both high temperatures and small hole diameter create significant problems for downhole operations; to allow high-temperature/slimline tool acquisition and/or development to be properly focused, we provide below an outline of the most important formational parameters that the drilling program should have the capability to measure.

Determining the temperature structure in the upper crust in the mid-ocean ridge environment is undoubtably the single most important goal of downhole operations. Temperature exerts a dominant control on the physical properties of water and on the reactions that take place between hydrothermal fluids and the host rock. Knowledge of the thermal structure will provide a strong constraint on the general nature of fluid circulation, and thus on the efficiency of heat transfer in the upper crust. As the knowledge of this parameter is so important, attempts to measure temperature should be made in as many ways as possible, such as via frequent bottom-hole measurements, multiple logs, lower-resolution but potentially very useful temperature indicator tabs, and long-term monitoring.

The next most important single measurement would be of the fluid conductivity, which could be used as an indicator of the salinity of the fluids. Fluid inclusions suggest that high- salinity fluids exist within the oceanic crust, although they have not been observed in vents at the sea floor. The presence or absence of high-salinity fluids has important implications both for mechanisms of heat transfer at depth (stably separated brine- and normal-phase convection cells could be present) and for alteration of the crust (high-salinity fluids are much more reactive).

Concentrations of many other major and minor ionic, dissolved gas, and isotopic species will provide important constraints on the nature of the fluid-rock interactions at various depths and temperatures in the hydrothermal system. Most require some form of pressurized fluid sampling. Geochemical logging also will be important toward these ends, and in particular to gain information about in situ fluid-mineral relationships. Gaps in knowledge of the fluid can be partially constrained by knowledge of the mineral alteration assemblage, and vice versa.

Both large- and small-scale resistivity measurements have been extremely useful for constraining porosity, particularly when combined with sonic velocity. Both should be included in a logging program, as should caliper and televiewer observations to provide information about formational fabric and to constrain the distribution and orientation of fractures and breakouts, which in turn provide information about fields of stress and sources of permeability. Permeability measurements will be particularly critical, and can be done most reliably in stages as drilling proceeds to incrementally deeper levels, with a packer set in the grouted-in surface casing. Finally, it would be useful to log levels of natural gamma radiation to provide constraints on lithology.

In light of the long intervals of time likely between drilling operations at the sites described in this document, it will be important that the holes be left hydrologically sealed at the end of each leg. Permeabilities in the upper crust at these sites are expected to be high, and unless prohibited, the long- term buoyancy-induced flow, which is likely to occur down the hole and into the formation, would make later thermal measurements and fluid sampling meaningless. Reentry cone seals, and a means to instrument the seals with pressure and temperature sensors down the hole, are currently under development and should be utilized in all holes in this program. A means to monitor the formation fluid conductivity at depth would also be highly desirable.

Operation time estimates

As presented in the previous EPRWG documment, a full East Pacific Rise drilling program would involve a total of six holes on the axis and in across- and along-axis arrays. A schedule for completing the two highest priority of these holes, based on current drilling and logging time estimates and on the assumption that no major technical difficulties will be encountered, is given in Table 2; five drilling legs are required. For the total program to be completed within a more reasonable time, average penetration rates need to be improved. One of the most effective ways to accomplish this will be by moving the DCS operation to the rig floor and utilizing full length pipe sections. This will greatly reduce pipe trip times. Hopefully, other improvements on mobilization and demobilization times, seal handling, and penetration rates can be realized, so that the times given in Table 2 will become substantial overestimates. If not, an extended EPR program could be

Table 2
Tentative EPR Operations Schedule

Leg	Site	Operation	Estimated Time
1	EPR-1	Transit, Victoria-EPR	13.5
		Set HRGB, drill BHA to 50 m, grout, mobilize DCS	10.1
		DCS drilling from 50 to 300 m	18.6
		Logging and downhole measurements	3.5
		Demobilize DCS	1.8
		Other activities and tests	2.5
		Set reentry cone seal (or grout)	2.0
		Transit, EPR-Panama	6.0
			Total days = 58.0
2	EPR-1	Transit, San Diego-EPR	6.8
		Recover seal, log T and sample fluids	3.0
		Mobilize DCS	3.0
		DCS drilling from 300 m to 750 m	30.4
		Logging and downhole measurements	4.0
		Demobilize DCS	1.8
		Set reentry cone seal	2.0
		Transit, EPR-Panama	6.0
			Total days = 57.0
3	EPR-1	As above, with DCS drilling to 1200 m	Total days= 57.0
4	EPR-1	Transit to EPR	6.8
		Recover seal, log T and sample fluids	3.0
		Mobilize DCS	3.0
		DCS drilling from 1200 to 1500 m	20.4
		Logging and downhole measurements	4.0
		Demobilize DCS	1.8
		Set reentry cone seal	2.0
	EPR-2	Set HRGB, drill BHA to 50 m, grout	8.2
		Transit to port	6.0
			Total days = 55.2
5	EPR-2	Transit to EPR	6.8
		Mobilize DCS	3.0
		DCS drilling from 50 to 500 m	30.4
		Logging and downhole measurements	3.5
		Demobilize DCS	1.8
		Set reentry cone seal	2.0
		Transit to port	6.0
			Total days = 53.5

unaffordable.

In this proposed schedule, the first leg will be primarily an engineering leg. Operations will include:

1) establishing a hard-rock guide base and grouting in a bottom hole assembly at site EPR-1;
2) drilling an additional 200-300 m at EPR-1 with the diamond coring system;
3) testing the available suite of slim-line logging and fluid sampling tools;
4) testing a reaming bit for enlarging the hole drilled with the DCS;
5) setting a reentry cone seal upon completion of the downhole measurements (or grouting off the lower portion of the hole if a seal cannot be emplaced).

If extreme formational difficulties are encountered at EPR-1 during the drilling in of the bottom hole assembly or with early phases of the DCS drilling, then efforts should be focused on establishing a deep hole at EPR-2. If formational problems are encountered at both sites, then consideration should be given to establishing a hole at the alternate sites EPR-1a or EPR-2a at 12°50′N.

If progress goes well, the second and third legs of the program should be devoted to deepening EPR-1. If formational or technical difficulties prevent deepening of either EPR-1 or EPR-2 to beyond a few hundred metres, drilling at EPR-3 should commence.

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Wireline Logging Services Report

LEG 131: NANKAI TROUGH

Continuous downhole logs provide the link between the (often discontinuous) recovered cores and the insitu formation accessed by the borehole. The primary objectives of the Leg 131 logging program were to accurately define the insitu physical properties in the toe of the Nankai accretionary prism, and thus determine the effect of the tectonic deformation processes. Particularly important is the decrease in porosity and fluid loss associated with the subduction zone sediment accretion process.

A major effort was made to obtain downhole measurements at this site, but with only limited success. Hole stability problems were severe; the upper portion of the section penetrated unconsolidated sands that readily washed out; the deeper portion penetrated clays with a large potential for swelling and hole blockage. In addition, there may have been tectonic stress-induced hole deformation.

The results of clay swelling estimates made on samples from ash-bearing intervals indicate a very high potential for swelling and blockage of the hole. In spite of the addition of the KCl, further wiper trips met with generally large and steady resistance over much of the drilled interval; ultimately, the decollement was considered too unstable to leave the pipe set across it, further limiting logging options.

Two short open hole logs were obtained with the seismic stratigraphy tool string; from 80-180 mbsf and 525-615 mbsf. The Lithoporosity and Geochemical tool strings obtained data through a variety of combinations of pipe, bottom-hole assembly and casing from the seafloor to 891 mbsf. These latter logs will require post-cruise editing and processing to give much useful data.

The velocity, resistivity and gamma logs in the open-hole intervals, particularly in the upper interval (Hole 808B), appear to reflect three clearly definable characteristics of the formation penetrated:

1) There is a general increase in velocity and resistivity with depth that probably reflects a systematic decrease in porosity.

2) There are sections with irregular alternating, upward-decreasing and upward-increasing velocity and resistivity, and the opposite trends in gamma (particularly uranium) response over several depth-scales ranging from a few meters to several tens of meters. These trends may reflect turbidite-like upward fining and coarsening sequences. Upward-fining trends may be somewhat more common.

3) There are a number of thin (less than 3 m thick) beds 5 to 10 meters apart of very high velocity and high resistivity, particularly in the upper interval. They have no strong gamma signature. These intervals probably represent low porosity coarse sand layers.

A number of velocity-porosity and resistivity-porosity relations were tried to fit the log data in the upper open-hole section, 80-180 mbsf, in order to obtain porosity data, and a velocity-porosity relation for use in interpreting seismic data. It is concluded that there are two dominant factors affecting the relation for terrigenous deep sea sequences that give different relations. The velocity-porosity relation is substantially different for data sets obtained from relatively unconsolidated sediments for which the porosity variation is associated with grain size (sand to mud), compared to the relation for porosity variation with depth associated with sediment consolidation and diagenesis. The Hamilton (1974) relation appears to fit the former, while the Hamilton (1978) relations appears to fit the latter. It is thus concluded that the latter relations are appropriate for use in converting regional velocities from seismic data to porosity.

Several temperature logs was obtained during logging at Site 808. They appear to be of good quality in general during the lowerings and on part of the upward logs.

The seafloor temperature (1.6°C) agrees well with nearby oceanographic data giving some confirmation of the calibration.

The temperature profile exhibits a roughly linear trend (+3 °C variation) with a gradient of about 50 mK/km, about half that of the gradient indicated by the WSTP at this site. This seems a reasonable recovery from the drilling disturbance to equilibrium temperatures (about 50%), assuming the WSTP temperatures reflect equilibrium.

Much of the depth interval logged at Site 808 was through the drill pipe, BHA or casing. Their presence has a pronounced effect on all of the responses. Not only does the extra thickness of pipe reduce the amplitude of the signal reaching the tool detectors, but the variable thickness of the drill string (joints, bottom-hole assembly) introduces offsets and regular spikes into the data. These variations in thickness have been carefully measured, and may be used in a deconvolution operation to estimate the true log signal.

Summary

ODP Leg 131 represents a major effort to obtain good logs through the toe of the accretionary wedge at Site 808. While a hole was successfully drilled to basement and a substantial amount of time was applied to logging, success was limited. A particular disappointment was that no logs could be obtained through the main subduction decollement. Hole instability problems were severe. The upper portion of the section penetrated unconsolidated sands that readily washed out and the deeper portion penetrated clays that were very subject to swelling and hole blockage. In addition, the site is in a region of strong tectonic compression; there is an unknown amount of hole collapse due to regional stress and there are indirect indications of high pore pressures in the deeper parts of the hole.

The main lithological variations in the section drilled as seen in the core are also evident in the logs. The primary lithology variation are the pronounced irregular variations between sand and mud, characteristic of turbidite sequences, particularly in the upper trench wedge part of the section. This variation is seen both in the gamma log and in the resistivity and velocity logs that are sensitive to porosity. Porosity dominates the latter two log responses at least in the upper part of the section. In the upper part of the hole the sands are inferred to have lower porosity than the muds.

On a larger scale, the main lithological units of the trench wedge turbidites and the deeper finer grained sections are resolved in the logs. The grain size generally decreases downward. There is some evidence of slightly more quartz in the mud and with depth as indicated in the core data. The compositional variations indicated by the logs (as in the core) are minor except where ash layers may be resolved.

Other features of the sediment section resolved in the log data, mainly that from the open-hole sections include: (a) some definition of the function describing the porosity decrease with depth, and an approximate velocity- porosity calibration that can be applied to regional seismic velocity data, (b) in the upper open-hole section, strong irregular upward fining and upward coarsening depositional cycles up to 25 m thick that are associated with variations in the trench turbidite sediment distribution regime, (c) primarily in the upper open-hole section, definition of very distinct thin (1 to 2 meter maximum) layers of high resistivity and high velocity, and with low inferred porosity that probably represent coarse sand layers.

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Third Party Tool Development

INTRODUCTION

Because of the complexity of downhole measurements required by scientific ocean drilling, ODP has historically relied in part on outside (i.e., "third party") development of various borehole devices. Some examples are the drillstring saddle packer, the Lateral Stress Tool (LAST), GEOPROPS (for measuring *in situ* physical properties), and the borehole seal. Support for such development comes from a variety of sources. In the U.S., third party tool development has generally been supported by the National Science Foundation, using funds earmarked for ODP and allocated to highly ranked, unsolicited proposals.

Because these tools must eventually make the transition from a developmental stage to actual deployment downhole, which puts them under the management and operation auspices either of the Borehole Research Group at LDGO (for wireline devices) or of ODP-TAMU (for all others), PCOM authorized DMP in 1988 to develop a set of guidelines for the overall process of monitoring third party tool development. The goal is to improve communications between cognizant management entities within ODP and outside investigators/agencies with interests in downhole measurements.

DMP completed its guidelines in January 1989, and PCOM approved those guidelines in May 1989. At DMP's request, and with the approval of the PCOM chair, those guidelines are reproduced here so that both their existence and general applicability will be clear to all concerned parties.

GUIDELINES FOR THE MONITORING OF THIRD PARTY TOOLS

There are two types of third party tools: Development Tools (instruments under development) and Mature Tools (established tools).

A.) For a tool to be considered an ODP Development Tool, and thereby scheduled for deployment, several criteria should be satisfied.

(a) There must be an identified principal investigator.

(b) LDGO (for wireline tools) or TAMU (for all others) should formulate a development plan in conjunction with the principal investigator, and then inform DMP of this plan.

(c) The development plan should:

- indicate the acceptance, desirability, financial and technical feasibility, and the usefulness of the measurements;
- identify development milestones;
- make provision for initial testing on land;
- satisfy safety considerations;
- specify shipboard requirements such as the data processing necessary to make the information accessible on board ship, any special facilities (emphasising areas where the tool is not compatible with existing hardware/software), and appropriate technical support;
- contain a statement of intent that the tool would be available for post-development deployment in ODP.

If DMP endorse the development plan, and subject to PCOM approval, the Panel will appoint a coordinator to monitor on behalf of the Panel the tool's progress through the development plan. The Panel monitor will receive reports from the Principal Investigator on request and will present these to DMP. DMP will review progress at regular intervals and will evaluate tool performance after each deployment. Day-to-day monitoring will be the responsibility of TAMU and LDGO. A tool cannot be regarded as an ODP Development Tool, and therefore cannot be scheduled for future legs, if it has not undergone the above procedure. All tools that are currently scheduled must have a development plan formulated as soon as possible. Once a tool has been accepted by DMP as a Development Tool, the Principal Investigator will be required to co-sign the development plan with TAMU or LDGO as appropriate as a visible accedence to the provisions of the plan. A Development Tool cannot be deployed on an ODP leg unless TAMU/LDGO and DMP are fully satisfied that the terms of the development plan have been fully met.

B.) For an ODP Development Tool to undergo the transition to an ODP Mature Tool, i.e. an established tool operated by TAMU or LDGO, there must be DMP endorsement. This endorsement will be given after Panel review of a proposal prepared by TAMU and/or LDGO and submitted to DMP. This proposal must satisfy DMP on the following counts:

- cost of routine operations including shipboard data processing;
- requirements for routine operations/ processing;
- availability of spare components;
- facilities for maintenance;
- existence of an operating/maintenance manual;
- safety considerations;
- long-term usefulness of data;
- established track record both in land tests and shipboard deployment.

Where several Development Tools are competing for the same Mature Tool slot, DMP will require tha appropriate contractor to evaluate all tools and submit their multiple-tool evaluations to DMP for Panel consideration.

C.) Where an established third party tool is loaned for use in ODP, this tool will have to satisfy the criteria in paragraph B in order to be accepted as the technical equivalent of an ODP Mature Tool. Tools which do not satisfy these criteria cannot be programmed for future ODP legs.

D.) Last-minute requests to include an unproven third party tool within an ODP leg will not be accepted.

Proposal News

CALL FOR ODP PROPOSALS FOR SUPPLEMENTAL SCIENCE

From now until June 1 1991, JOIDES (Joint Oceanographic Institutions for Deep Earth Sampling) will accept proposals for drilling-related science to be included as part of scheduled legs 141 to 147. The JOIDES Planning Committee (PCOM) may schedule as many as 10 days of such science during the FY 1992 ODP Program.

"Supplemental science" proposals to ODP must have the following characteristics:

1.) *They must involve exciting science which is consistent with thematic documents produced by ODP*, particularly COSODs I and II and the Long Range Plan (all of which are available from Joint Oceanographic Institutions, Inc., Suite 800, 1755 Massachusetts Ave., N.W., Washington, D.C. 20036-2102). Proponents are also referred to position papers produced by ODP's thematic panels, all of which have appeared in recent issues of the *JOIDES Journal*.

2.) *They must be "mature"*, containing all information pertinent for their thematic and safety review by ODP's scientific advisory structure. Guidelines for submitting a mature proposal have been previously published in the *JOIDES Journal*. For additional guidance on maturity matters, proponents are urged to contact the following in advance of proposal submission:

Mr. Carl Brenner, ODP Site Survey Data Bank, Lamont-Doherty Geological Observatory, Palisades, NY 10964
Telephone: 914-359-2900 x542

3.) *They must be short*, proposing only 1-4 days of operations, including transits away from the scheduled ship track. Operations can include but are not restricted to the following: drilling/coring a new site (not necessarily thematically related to the leg on which the supplemental science is proposed) and/or expanding coring/downhole observations at a previously designated and approved site.

These proposals will be reviewed either at scheduled meetings of ODP's advisory panels (now scheduled at various venues during the period February through May, 1991) or by mail. PCOM will make all decisions on supplemental science for the FY 1992 Program at its late August 1991 meeting in Germany.

For more information on this new policy, please contact:

Dr. Peter Blum, JOIDES Office, Institute for Geophysics, The University of Texas at Austin, 8701 North Mopac Boulevard, Austin, TX 78759-8345
Telephone: 512-471-0476
Fax: 512-471-0999
Telemail: JOIDES.UTIG

CHANGE IN THE NUMBERING OF PROPOSALS...

In October 1990 the JOIDES Office abandoned use of ocean-index letters (i.e., A, B, C, D, E) in proposal numbering. This step emphasizes thematically driven evaluation of drilling objectives according to COSOD and the Long Range Plan, as opposed to a style of ocean drilling that seeks to serve regional interests. The change is also expected to make administrative use of the reference number in the evaluation and planning process more consistent and simpler.

The following types of reference are now in use: **999——**, for a new proposal, **999-Rev**, for a revised version of 999——, and **999-Add**, for an addendum to 999—— or 999-Rev). Subsequent revisions and addenda are referred to as 999-Rev2 or 999-Add2, etc. Using the number alone, such as "**proposal 999**", refers to the latest version of 999, including relevant addenda if any.

Although the use of old reference numbers will not cause administrative confusion, the JOIDES Office will use new reference numbers consistently for new proposals as well as for old ones, and asks everyone in the advisory structure to do so from now on.

...AND A NEW PROPOSAL REFERENCE CATEGORY

PCOM decided at its Annual Meeting 1990 (Nov 28-Dec 1 in Kailua-Kona) to substitute up to 10 days during legs 141-147 from planned drilling legs with "supplemental" science (see ad on previous page). This policy is aimed at optimizing efficient use of the ship's locations and transits, and creating necessary flexibility in the planning process to do so. The JOIDES Office has therefore created a new proposal category S-1,2,3,n for supplemental science proposals competing for substitute time in a short-term planning process. The first S-proposal received at the JOIDES Office is listed below. S-proposal review will be based on JOIDES panel white papers, COSOD recommendations, panel mandates, and concerns of panel members, as is true for regular proposals.

PROPOSAL REVIEW PROCEDURES

Recently, the JOIDES advisory structure has received a number of complaints from proponents who do not feel they get enough, and timely enough, information/feedback concerning their proposal's evaluation. The JOIDES Office has responded by reviewing the evaluation procedure. A modified proposal review form (PRF) (see next page) was presented at the 1990 Panel Chairperson's Meeting in Kailua-Kona.

The purpose of the PRF is to pass information to a proponent on the review status of his/her proposal. PRFs are enclosed in proposal packages that are sent out by the JOIDES Office to thematic panels for their evaluation. Thematic panels are requested to evaluate in writing and assign appropriate check boxes on the PRF for any proposal, be it the panel's favorite or completely outside its mandate. After their spring and fall meetings, thematic panels return PRFs to the JOIDES Office, which sends them to proponents. Each proponent should therefore receive four evaluations of his/her proposal.

The modified PRF emphasizes the importance of information transfer from the JOIDES advisory structure to proponents. Slightly modified check boxes 1-5 indicate relative thematic importance of a proposal to a panel, and serve as an aid to evaluate thematically strong proposals. In order to make sure that panel members as well as proponents are aware of thematic evaluation criteria, panel mandates, general Long Range Plan objectives, and references to other related publications are now on the back of the modified PRF (not shown here). Another new feature are two check-boxes for relative maturity of a proposal according to published proposal submission guidelines (see *A Guide to the Ocean Drilling Program*, JOIDES Journal Special Issue, Vol. XIV, No. 4, December, 1988; available at JOI, Inc., Washington, DC). This modification prevents confusion regarding degree of maturity (a planning criterion independent of thematic strength) vs. thematic deficiencies (check boxes 2-4).The larger comment box reminds thematic panels to comment in detail on the ways to improve proposals which they review, if warranted.

The JOIDES Office encourages suggestions/feedback on further improvements of the PRF and the drilling proposal review process in general.

LISTING OF RECENT PROPOSALS

Received at the Joides Office from September 1990 through January 1991

Ref. No.	Abbreviated Title	Proponents	Affiliation	Received
387-Rev	Deep drilling of fast-spread crust, Hess Deep	Gillis& al.	US	09/04/90
247-Add2	Water mass conversion, glacial subarctic Pacific	(Zahn & al.)	CAN/US	09/17/90
286-Add2	Second add. to "Layer 2/3 Transition, Hole 504B"	Becker, K.	US	09/21/90
388——	Neogene deep water circul. & chem., Ceara Rise	Curry & al.	US/ESF(S)/UK	10/01/90
345-Add	Addenda to [345——]	Joyce & al.	US	10/05/90
389——	Cretaceous traverse, Western South Atlantic	Malmgren, B.A.	ESF (S)	10/29/90
362-Rev2	Chile margin triple junction	S.C. Cande & al.	US/UK	11/08/90
390——	Drilling in the Shirshov ridge region	Milanovsky & N.	SU	11/12/90
S-1	Lithofacies and cyclicity, Navy Fan	Piper et al.	CAN/US	11/21/90
334-Rev	S reflector and ultramafic bsmt., Galicia margin	Boillot, G., et al.	F/ESF(E)	12/27/90
391——	Formation of sapropels, eastern Mediterranean	Zahn, & al.	G/US/CAN	01/02/91

ODP Proposal Review Form

#

Title:

Proponent(s):

Evaluation by: ☐ LITHP ☐ OHP ☐ SGPP ☐ TECP

For panel mandates, Long Range Plan objectives, and reference to other relevant papers, see back page.

1. Proposal objectives are not within the mandate of this panel (as listed on back).
2. Does not address high-priority thematic objectives (as detailed in Long Range Plan).
3. Is of secondary interest to this panel if it is of high priority to some other panel.
4. Addresses high-priority objectives, but with deficiencies, as noted below.
5. Addresses high-priority objectives of this panel.

Level of proposal maturity: ☐ mature ☐ immature

Comments if within mandate of this panel (points 2-5):

Date returned to :

JOIDES Office
Institute for Geophysics
University of Texas at Austin
8701 Mopac Blvd.
Austin, TX 78759

Date forwarded to:

Bulletin Board

JOIDES MEETING SCHEDULE

Date	Place	Committee/Panel
1991		
06-08 February	College Station, TX	DMP
Feb.-March*	—	NARM-DPG
Feb.-March*	—	NAAG-DPG
27 Feb-28 Feb.	Ann Arbor, MI	A&G-DPG
28 Feb-02 March	Chapel Hill, NC	OHP
March*	—	SL-WG
05-07 March	College Station, TX	SGPP
14-16 March	La Jolla, CA	LITHP
14-16 March	Washington, DC	BCOM
18-20 March	College Station, TX	IHP
19-21 March	College Station, TX	SMP
21-23 March	Davis, CA	TECP
26-28 March	College Station, TX	SSP
23-25 April	Narrangansett, RI	PCOM
May 14-15	College Station, TX	PPSP
July 08-09*	Los Angeles, CA	TEDCOM
July 09-11	San Diego, CA	EXCOM
16-28 July	Cardiff, Wales	ex-IOP & Co-Chiefs
20-22 August	Hannover, FRG	PCOM
03 December	Austin, TX	Panel Chairmen
04-07 December	Austin, TX	PCOM
1992		
14-16 January	Bonn, Germany	EXCOM
21-23 April	Corvallis, OR	PCOM
Summer	Victoria, British Columbia	PCOM
Annual Meeting	Palisades, NY	PCOM

* Meeting not yet formally requested and/or approved

ANNOUNCEMENTS

The Role of the Southern Ocean and Antarctica In Global Change: An Ocean Drilling Perspective A Conference and Workshop

University of California, Santa Barbara, August 28-30, 1991
Sponsored by the JOI/U.S. Science Support Program and NSF Div. of Polar Programs

The Conference will stress the global perspective of paleo-environmental evolution of the Antarctic region largely from ocean drilling but also including results from continental and non-drilled sequences. A major charge will be to discuss and synthesize results within and among several Antarctic ocean drilling expeditions. The emphasis will be to develop a better understanding of the environmental and biotic evolution of the Antarctic region during the Cretaceous and Cenozoic and the effect this has had on global environmental evolution. Synthesis papers will result. The workshop will discuss and plan needed furture scientific initiatives to lead to future related proposals for further ocean drilling near Antarctica.

Applications are invited from individuals working in a broad range of disciplines related to Antarctic paleoenvironmental and biotic evolution. Participants may apply for funds to defray the cost of travel and lodging. Applications should be sent to:

Dr. James P. Kennett, Marine Science Institute, University of California, Santa Barbara, CA 93106.

Synthesis of Indian Ocean Drilling Results

Department of Geology, University of Wales, Cardiff, United Kingdom, July 16-18, 1991
Co-Convenors: David Rea, Robert Duncan, Rob Kidd, Ulrich von Rad, and Jeff Weissel

A three-day workshop with the specific intent of developing an inter-leg synthesis of the nine ODP cruises to the Indian Ocean will be held in July of 1991 in Cardiff. The goal of the workshop is to bring together scientists of all nations who participated in the Indian Ocean ODP drilling (Legs 115-123) and interested shorebased investigators to synthesize results on an ocean-wide basis and to prepare multiauthored articles for publication in a synthesis volume to be published by a scientific society. The convenors expect all participants to arrive with contributions in the hand and cooperation in the heart.

Modest JOI/USSAC support is available to help defray the costs of travel for U.S. scientists. Interested persons should contact one of the following:

Dr. David Rea, Dept. of Geol. Sciences, The University of Michigan, Ann Arbor, MI 48109-1063
FAX: (313) 763-4690, Telephone: (313) 936-0521, Bitnet: David_Rea@um.cc.umich.edu

Dr. Robert A. Duncan, College of Oceanography, Oregon State University, Corvallis, OR 97331-5503
FAX: (503) 737-2064, Telephone: (503) 737-2296

News from the European Consortium

The European Consortium for Ocean Drilling (ECOD) is preparing a document to accompany the Long Range Plan, as part of their strategy for renewal of participation in ODP beyond 1993.

Volume 45 of the *Memoria della Società Geologica Italiana* is in preparation. It contains some twenty papers presented at the international conference *Geology of the Oceans*, held in May 1990 in Terrasini, Sicily. The conference was organized by ESCO and cosponsored by the Geological Society of Italy and the European Science Foundation.

An ESCO workshop on the *Geology of Marginal Seas* will be held in Copenhagen in the spring of 1992. The conference will focus on drilling in marginal seas to study continental margin evolution, sea-level variation and climatic fluctuations, since climatic signals are amplified in semi-enclosed basins. A field trip to Iceland is planned.

Funding for Site Survey Augmentation

The JOI/U.S. Science Support Program has Site Survey Augmentation funds available to supplement drilling site data sets that are in all phases of planning. This program element includes support for:

- acquiring and/or processing data for sites being considered by JOIDES;
- mini-workshops that would bring together scientists to coordinate site-specific data for integration into a mature drilling proposal;
- "augmentation" surveys on ships of opportunity that would significantly enrich drilling-related science and/or acquire needed site survey data;
- U.S. scientists to participate in non-U.S. site surveys.

Site Survey Augmentation proposals may be submitted at any time. Priority will be given to augmentation of sites and/or themes that are high priority within JOIDES. As with all JOI/USSSP activities, it is important to clearly state how the work would contribute to U.S. plans or goals related to the Ocean Drilling Program. Note that the Site Survey Augmentation funds cannot be used to supplement NSF/ODP funded work.

Contact Ellen Kappel, JOI office, for further information and proposal guidelines: (202) 232-3900.

JOI/USSAC Ocean Drilling Graduate Fellowship

The Joint Oceanographic Institutions, Inc./U.S. Science Advisory Committee is seeking doctoral candidates of unusual promise and ability who are enrolled in U.S. institutions to conduct research compatible with that of the Ocean Drilling Program. The one-year award is now $20,000 to be used for stipend, tuition, benefits, research costs and incidental travel, if any. Applications are available from the JOI office and should be submitted according to the following schedule:

ODP Cruise	Applic. Deadline
Leg 140 504B* or Hess Deep	May 1, 1991
Leg 141 Chile Triple Junction	May 1, 1991
Leg 143 Atolls & Guyots A	May 1, 1991
Leg 144 Atolls & Guyots B	May 1, 1991
All shorebased work	January 1, 1992

* If cleaning operations successful on Leg 137.

Call or write to the JOI office to receive applications and further information.

JOI/USSAC Ocean Drilling Fellowship Program
Joint Oceanographic Institutions, Inc., Suite 800
1755 Massachusetts Ave., NW
Washington, DC 20036-2102
Tel. (202) 232-3900

ODP Open Discussion via Bitnet

Recently ODP instituted a BITNET LISTSERVER. This is an open discussion service to which individuals subscribe *via* Bitnet. It permits exchange of information among all subscribers. Currently, the list administrator (Anne Graham of ODP Science Operations) sends a report of the previous week's shipboard scientific and operations activities to all subscribers. Site summaries are distributed as soon as they are received at ODP from the ship, usually the day after a site is completed. Periodically, an updated cruise schedule and brief descriptions of upcoming cruises are sent out. Any subscriber may send files to the list for distribution. A file sent *via* Bitnet to the list address (ODP-L@TAMVM1) will be distributed automatically to all subscribers.

Anyone with a Bitnet computer link can subscribe. At present there are subscribers in the U.S., Canada, Europe, Australia and Japan. There is no charge for subscribing to the listserver.

To subscribe, send a brief Bitnet command to LISTSERV@TAMVM1 consisting of the words "SUBSCRIBE ODP-L YOUR_NAME" (where YOUR_NAME really is your first and last names). For example, people on VAX/VMS systems using the JNET networking software will send a command that looks like this: $SEND LISTSERV@TAMVM1 "SUBSCRIBE ODP-L YOUR_NAME" but it may be different according to the command language your computer system uses. If you have any questions, your own friendly local system manager should be able to help. As a last resort, you may send a Bitnet message to Anne Graham (ANNIEG@TAMODP) requesting that you be added to the ODP-L subscription list.

ODP BIBLIOGRAPHY AND DATABASES

ODP Science Operator

Texas A&M University, College Station, Texas 77845-9547

Proceedings of the Ocean Drilling Program, Initial Reports and Scientific Results

	Initial Reports		Scientific Results	
	Vol.	Published	Vol.	Publ.
Leg 101	101/102	Dec 86	101/102	Dec 88
Leg 102	101/102	Dec 86	101/102	Dec 88
Leg 103	103	Apr 87	103	Dec 88
Leg 104	104	July 87	104	Oct 89
Leg 105	105	Aug 87	105	Oct 89
Leg 106	106/109/111	Feb 88	106/109	Jan 90
Leg 107	107	Oct 87		
Leg 108	108	Jan 88	108	Dec 89
Leg 109	106/109/111	Feb 88	106/109	Jan 90
Leg 110	110	Apr 88	110	May 90
Leg 111	106/109/111	Feb 88	111	Dec 89
Leg 112	112	Aug 88	111	Dec 89
Leg 113	113	Sept 88	112	May 90
Leg 114	114	Nov 88		
Leg 115	115	Nov 88	115	Sept 90
Leg 116	116	Jan 89	116	Sept 90
Leg 117	117	June 89	113	Aug 90
Leg118	118	May 89		
Leg 119	119	Sept 89		
Leg 120	120	Nov 89		
Leg 121	121	Nov 89		
Leg 122	122	Jan 90		
Leg 123	123	June 90		
Leg 124	124	June 90		
Leg 125	125	Aug 90		
Leg 126	126	Aug 90		
Leg 127	127	Sept 90		
Leg 128	128	Sept 90		

Technical Notes

No. 1: Preliminary time estimates for coring operations (Revised Dec 86)

No. 3: Shipboard Scientist's Handbook (Revised 1990)

No. 5: Water Chemistry Procedures aboard the *JOIDES Resolution* Sept 86)

No. 6: Organic Geochemistry aboard *JOIDES Resolution*- An Assay (Sept 86)

No. 7: Shipboard Organic Geochemistry on *JOIDES Resolution* (Sept 86)

No. 8: Handbook for Shipboard Sedimentologists (Aug 88)

No. 9: Deep Sea Drilling Project data file documents (Jan 88)

No. 10: A Guide to ODP Tools for Downhole Measurement (June 88)

No. 11: Introduction to the Ocean Drilling Program (Dec 88)

No. 12: Handbook for Shipboard Paleontologists (June 89)

Scientific Prospectuses and Preliminary Reports

	Prospectuses		Prelimin. Rpts.	
	Vol.	Published	Vol.	Published
Leg 129	29	Aug 89	29	Feb 90
Leg 130	30	Oct 89	30	May 90
Leg 131	31	Oct 89	31	June 90
Leg 133	33	May 90	33	Nov 90
Leg 134	34	June 90	34	Jan 91
Leg 135	No 35	Sept 90		
Leg 136	36	Dec 90		
Leg 137	No 37	Jan 91		

Engineering Prospectuses and Preliminary Reports

	Prospectus		Prelimin. Rpts.	
	Vol.	Published	Vol.	Published
Leg 132	2	Nov 89	2	Sept 90

Other Items Available

Brochure: The Data Base Collection of the ODP - Database Information

Ocean Drilling Program brochure (English, French, Spanish, German or Japanese)

ODP Sample Distribution Policy

Micropaleontology Reference Center brochure

Instructions for Contributors to ODP *Proceedings* (Revised Oct 90)

ODP Engineering and Drilling Operations (New)

Multilingual brochure with a synopsis of ODP (English, French, Spanish, German and Japanese)

ODP Posters (Ship poster and corinmg systems poster)

ODP After Five Years of Field Operations (Reprinted from the 1990 Offshore Technology Conference proceedings).

ODP Data Available

ODP databases currently available include all DSDP data files (Legs 1-96), geological and geophysical data from ODP Legs 101-129, and all DSDP/ODP core photos (Legs 1-129). More data are available as paper and microfilm copies of original data collected aboard the JOIDES *Resolution*. Underway geo-physical data are on 35 mm microfilm; all other data are on 16 mm microfilm.

All DSDP data and most ODP data are contained in a computerized database (contact the ODP Librarian to find out what data are available electronically). Data can be searched on almost any specified criteria. Files can be cross-referenced so a data request can include information from multiple files.

Computerized data are currently available on hard-copy printouts, magnetic tape, or through BITNET.

Photos of ODP/DSDP cores and seismic lines are available. Seismic lines, whole core and close-up core photos are available in black and white 8x10 prints. Whole core color 35-mm slides are available.

The following are also available: (1)

ODP Data Announcements containing information on the database; (2) Data File Documents containing information on specific ODP data files; (3) ODP Technical Note No. 9, "Deep Sea Drilling Project Data File Documents," which includes all DSDP data file documents.

To obtain data or information contact: Kathe Lighty, Data Librarian, ODP/TAMU, 1000 Discovery Dr., College Station, TX 77845-9547, Tel: (409) 845-8495, Tx: 792779/ODP TAMU, BITNET: %DATABASE@TAMODP, Omnet: Ocean.Drilling.TAMU.

Small requests can be answered quickly, free of charge. If a charge is made, an invoice will be sent and must be paid before the request is processed.

Data Available from the Geophysical Data Center

Computerized data from the DSDP are now available through NGDC in compact-disc read-only-memory (CD-ROM) format. The DSDP CD-ROM data set consists of two CD-ROMs and custom, menu-driven, access software developed by NGDC with support from JOI/USSSP. 500 complimentary copies of the DSDP CD-ROMs are being offered to U.S. researchers in academia and government, courtesy of JOI/USSSP. An additional 200 copies of the set are available on a cost recovery basis.

Volume I of the 2-disc set contains all computerized sediment/hardrock files, the Cumulative Index (Paleontology, Subject, and Site), bibliographic information, age and fossil codes dictionaries, an index of DSDP microfilm, sediment chemistry reference tables, and copies of DSDP documentation for each data and reference file.

Volume II contains all digital downhole logging data from the DSDP, including some data digitized for the CD-ROM set by the Woods Hole Oceanographic Institution under contract to JOI/USSSP. All of the data are in the Schlumberger Log Information Standard (LIS) format, some ASCII and Gearhart-Owen data have been translated to LIS by WHOI for the CD-ROM. All DSDP underway and geophysical data are on disc 2, including bathymetry, magnetics, and navigation in the MGD77 format (no data for Legs 1-3; navigation only for Legs 4, 5, 10, 11; SEG-Y single channel seismic data not included). Volume II also contains the DSDP Core Sample Inventory and color/monochrome shaded relief images from several ocean views.

DSDP data files can be provided on magnetic tape according to user specifications. NGDC can also provide correlative marine geological and geophysical data from other sources. NGDC will provide a complimentary inventory of data available on request. Inventory searches are tailored to users' needs.

Information from DSDP Site Summary files is fully searchable and distributable on floppy diskette, as computer listings and graphics, and on magnetic tape. NGDC is working to make all DSDP data files fully searchable and available in PC-compatible form. Digital DSDP geophysical data are fully searchable and available on magnetic tape. In addition, NGDC can provide analog geological and geophysical information from DSDP on microfilm. Two summary publications are available: (1) *Sedimentology, Physical Properties, and Geochemistry in the Initial Reports of Deep Sea Drilling Project Vols. 1-44: An Overview*, Rept. MGG-1; (2) *Lithologic Data from Pacific Ocean Deep Sea Drilling Project Cores*, Rept. MGG-4.

Costs for services are: $90/2-disc CD-ROM data set, $90/magnetic tape, $30/floppy diskette, $20/microfilm reel, $12.80/copy of Rept. MGG-1, $10/copy of Rept. MGG-4. Costs for computer listings and custom graphics vary. Prepayment is required by check or money order (drawn of a U.S. bank), or by charge to VISA, Mastercard, or American Express. A $10 handling fee is added to all shipments ($20 for foreign shipments), and a $15 fee is added to all rush orders. Data Announcements describing DSDP data sets are available at no charge, as are inventory searches of correlative (non-DSDP) geological and geophysical data available from NGDC. For details contact:
Marine Geology and Geophysics Division, NOAA/NGDC, E/GC3, Dept. 334, 325 Broadway, Boulder, CO 80303; Tel (303) 497-6339; Fax 303-497-6513); Internet cjm@ngdc1.colorado.edu.

Sample Distribution

The materials from ODP Leg 128 and 129 are now available for sampling by the general scientific community. The twelve-month moratorium on cruise-related sample distribution is complete for Ocean Drilling Program Legs 101-129. Scientists who request samples from these cruises are no longer required to contribute to *ODP Proceedings* volumes, but may publish in the open literature instead.

All sample requests received at ODP are entered into the Sample Investigations Database. Anyone may request a search. Some common types of searches include on-going research for particular holes or legs, current research in a specific field of interest, or publications resulting from DSDP or ODP samples. At present, the most efficient way to access this database is to request a search by contacting the Assistant Curator of ODP.

Request processing (number of weeks to receive samples) during the period Jan 1990 through December 1990:

Repository	Avg. No. Weeks Processing	Total No. Samples
ECR	11	13,954
GCR	8	11,424
WCR	8	4,171

Available from: Karen Riedel, ODP, Public Rlations, Texas A&M University, 1000 Discovery Drive, College Station, TX 77840.

Coring Poster

ODP has a poster: "Scientific Coring Beneath the Sea," available for distribution. The poster features individual coring systems developed for scientific ocean drilling including the rotary core bit, advanced piston coring and extended core barrel. Eric Schulte of Engineering and Drilling Operations designed and produced the poster.

Brochures

Updated ODP brochures in English, French, Spanish, and German are now available. A brochure featuring engineering developments is also available.

Reprints

Reprints of the 1990 Offshore Technology Conference paper, *"The Ocean Drilling Program: After five years of field operations,"* is available from Karen Riedel. The paper, written by P.D. Rabinowitz, L.E. Garrison, et al., features the significant results of Legs 100-124. The paper also describes in detail Legs 124E-135. An ODP Operations Summary outlines the data from each cruise including number of sites, number of holes and percent recovery.

ODP Wireline and Logging Services

Lamont-Doherty Geological Observatory, Palisades, NY 10964.

Wireline Logging Manual (New Edition, Sept 1990)

ODP Site Survey Data Bank

Lamont-Doherty Geological Observatory, Palisades, NY 10964.

The JOIDES/ODP Data Bank received the following data between September 1, 1990 and November 30, 1990. For additional information on the ODP Data Bank, please contact Dr. Carl Brenner at Lamont-Doherty Geological Observatory, Columbia University, Palisades, NY 10964.

- From N. Pisias (OSU): Drafted SeaBeam bathymetry charts and navigation plots for all proposed Eastern Equatorial Pacific drillsites.
- From J.-Y. Collot (Villefranche, France): Multipso MCS Line 1031, with corresponding navigation, in the Aoba Basin area.
- From P. Buhl (LDGO): Processed CONRAD 2038 CDP and ESP seismic profiles from the Hawaiian arch area, to document proposed OSN pilot hole program.
- From J. Collins (WHOI): Single channel seismic profile and GLORIA record, with corresponding navigation chart and bathymetric listings, from USGS *Farnella* cruise in the area of proposed site OSN-1.
- From R. Hyndman (PGC, Canada): Selected MCS lines from the DIGICON survey of the Vancouver Margin.

ODP Long Range Plan

Get your own copy of the Long Range Plan. The ODP Long Range Plan portfolio is now available from the JOI office. If you would like to receive a copy, contact:
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Scientific Seamount Drilling, Tony Watts and Rodey Batiza, conveners.

Vertical Seismic Profiling (VSP) and the Ocean Drilling Program (ODP), John Mutter and Al Balch, conveners.

Dating Young MORB?, Rodey Batiza, Robert Duncan and David Janecky, conveners.

Downhole Seismometers in the Deep Ocean, Mike Purdy and Adam Dziewonski, conveners.

Science Opportunities Created By Wireline Reentry of Deep-Sea Boreholes, Marcus G. Langseth and Fred N. Speiss, conveners.

Wellbore Sampling, Richard K Traeger and Barry W. Harding, conveners

South Atlantic and Adjacent Southern Ocean Drilling, James A. Austin, convener.

Measurements of Physical Properties and Mechanical State in the Ocean Drilling Program, Daniel K. Karig and Matthew H. Salisbury, conveners.

Paleomagnetic Objectives for the Ocean Drilling Program, Kenneth L. Verosub, Maureen Steiner and Neil Opdyke, conveners.

Cretaceous Black Shales, Michael A. Arthur and Philip A. Meyers, conveners.

Caribbean Geological Evolution, Robert C. Speed, convener.

Drilling the Oceanic Lower Crust and Mantle, Henry J.B. Dick, convener.

Role of ODP Drilling in the Investigation of Global Changes in Sea Level, Joel S. Watkins and Gregory S. Mountain, conveners.

Ocean Drilling and Tectonic Frames of Reference, Richard Carlson, William Sager and Donna Jurdy, conveners.

ODP Shipboard Integration of Core and Log Data, Kate Moran and Paul Worthington, conveners.

Drilling of the Gulf of California, Berndt Simoneit and J. Paul Dauphin, Conveners.

East Pacific Rise Petrology Data Base (Vols. I-III), Charles Langmuir, compiler.

Report of the Second Conference on Scientific Ocean Drilling (COSOD II), JOIDES, sponsor.

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Special Issue No. 4: Guide to the Ocean Drilling Program, September 1985 (Vol. XI)

Special Issue No. 4: Guide to the Ocean Drilling Program, Supplement One, June 1986 (Vol. XII)

Special Issue No. 5: Guidelines for Pollution Prevention and Safety, March 1986 (Vol. XII)

Special Issue No. 6: Guide to the Ocean Drilling Program, December 1988 (Vol. XIV)

JOIDES Resolution Operations Schedule

			Days			
Leg	Program	Cruise Dates	Transit	On Site	Total	In Port
135	Lau Basin	22 Dec. '90-28 Feb. '91			68	Honolulu, 28 Feb. -02 Mar. '91
136	OSN-1	03 Mar.-20 Mar. '91	1	16	17	Honolulu, 20 Mar. '91 (Scientific Party Change)
137	Hole 504B	21 Mar.-01 May '91	19	22	41	Panama, 01-05 May '91
138	E. Equatorial Pacific	06 May-05 July '91	22	38	60	San Diego, 05-09 July '91
139	Sedimented Ridges I	10 July-11 Sept. '91	6	57	63	Victoria, 11-15 Sept. '91
140	504B*/Hess Deep	16 Sep.-12 Nov. '91	18	39	57	Panama, 12-16 Nov. '91
141	Chile Triple Junction	17 Nov.-13 Jan. '92	18	39	57	Valparaiso, 13-17 Jan. '92
142	Engineering, EPR	18 Jan.-19 Mar. '92	25	36	61	Honolulu, 19-23 Mar. '92
143	Atolls & Guyots A	24 Mar.-19 May '92	18	38	56	Guam, 19-23 May '92
144	Atolls & Guyots B	24 May-19 July '92	16	40	56	Honolulu, 29-23 July '92
145	North Pacific Transect	24 July-21 Sept. ' 92	23	36	59	Seattle, 21-25 Sept. '92
146	Cascadia	26 Sept.-21 Nov. '92	6	50	56	San Diego, 21-25 Nov. '92
147	Engineering EPR**/Hess Deep	26 Nov. '92-21 Jan. '93	14	42	56	Panama Into the Antlantic

* If cleaning operations are successful on Leg 137 ** If DCS Phase III System is ready