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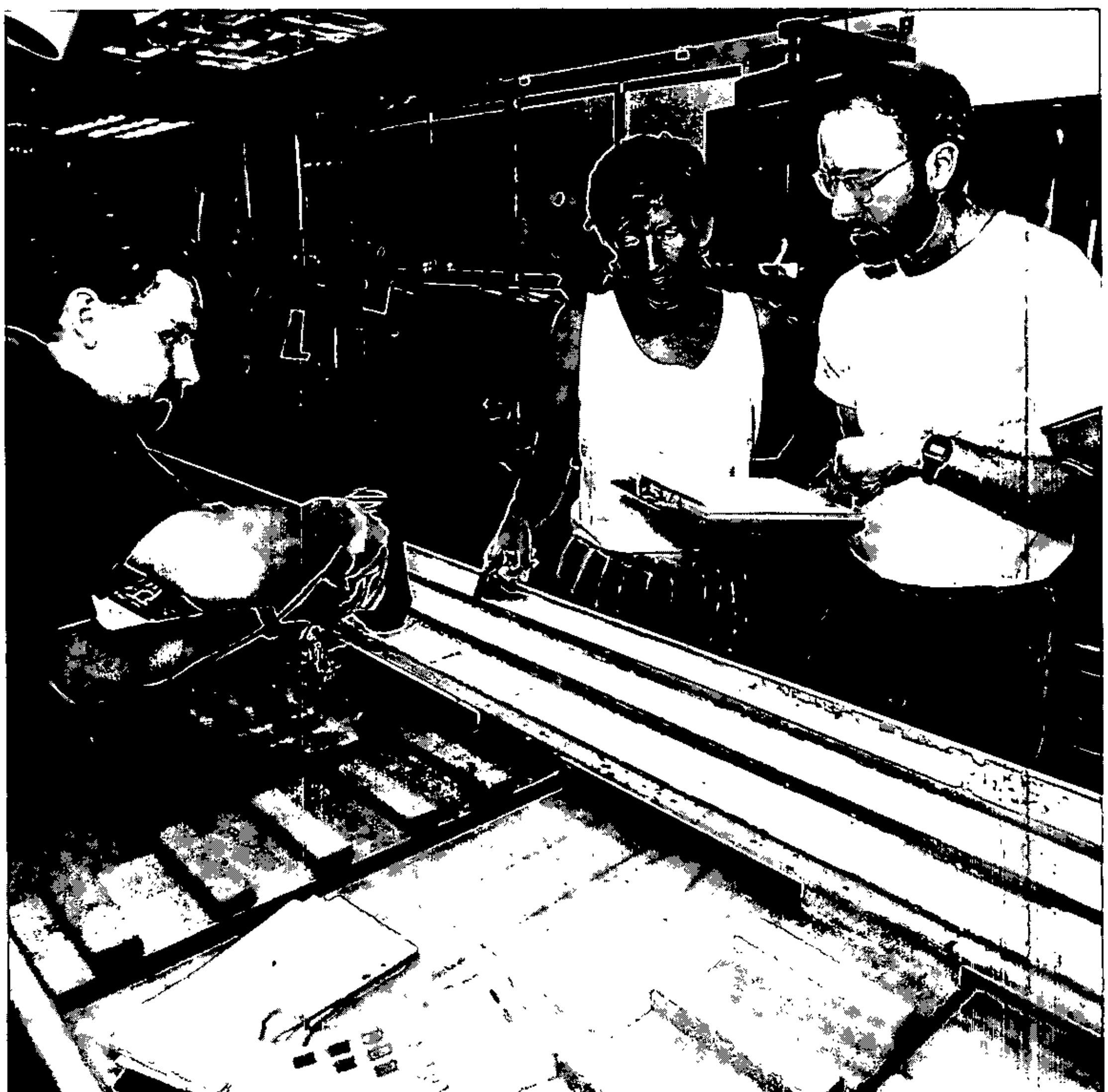
JOIDES Journal

VOL. XVI, No. 2, June, 1990



JOIDES Journal

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FOCUS

Drilling in the early 1990s

The Planning Committee is obligated to plan the general direction of the drilling vessel a few years in advance of drilling, as well as to plan the specific program one year in advance. For a number of years PCOM concentrated its efforts on the short-term planning. At its April 1990 meeting the Planning Committee did set the general direction of the *JOIDES Resolution* for the next 4 years.

In their recent meetings, the four thematic panels evaluated the proposals submitted to JOIDES, in terms of their objectives as published in the COSOD reports and panel White Papers, and with regard to the probability of success based on the status of engineering advancements, site surveys, and similar factors. Panel rankings and a map are in this issue of the Journal with the PCOM Meeting Report. After examining how the panels ranked the programs, and seeing how those programs were distributed on the globe, PCOM approved the following motion:

Recognizing the thematic priorities of the advisory panels, the Planning Committee has decided that the JOIDES RESOLUTION will operate in two areas in the four years beginning April 1990, i.e., the Atlantic Ocean north of the equator and the Pacific Ocean. A preferred scenario is that the ship will continue in the Pacific until October 1992 and transit then to the Atlantic for a program that will continue through the completion of this 4-year plan.

This means that beyond the legs in the current FY90 and 91 Program Plans, FY 92 will be in the Pacific, and FY93 and at least the first one-half of FY 94 will be in the North Atlantic.

PCOM will decide on its FY92 Plan at the Annual Meeting in Hawaii in late November 1990. Essentially, that will mean selecting six legs in the Pacific from among those ranked highest by the thematic panels (that will be either six science legs, or one engineering-science leg followed by five science legs if deepening 504B ends FY91). The present overall ranking by thematic panels is about as follows:

- Chile Triple Junction (Leg I or Legs I & II)
- Cascadia Margin

  next a relative gap
- Atolls, Guyots, and Aprons (Leg I or Legs I & II)
- Sedimented Ridges, Leg II
- East Pacific Rise Bare-rock, Leg I
- Hess Deep
- North Pacific Transect

  next a relative gap
- Bering Sea
- Peru Gas Hydrates

The Site Survey Panel in its July meeting will scrutinize the data for the 9 programs. The thematic panels, at their fall meetings, will rank the programs in the prospectus; that probably will resemble the just-completed ranking, but may differ depending on DPG reports, SSP analysis of data, number of legs and their sequence, tool development, or newly reviewed proposals from any ocean. PCOM will determine the Program Plan for FY92 in November.

In preparation for Atlantic drilling in FY93 and early FY94, PCOM approved two DPGs: one for North Atlantic Rifted Margins [both volcanic and non-volcanic] and one for North Atlantic Arctic Paleoceanographic Gateway. Proponents of "the top five North Atlantic programs" of each thematic panel have been informed that they should be endeavoring to bring their proposals to maturity so that they will be ready if chosen for drilling. Two of the panels do not at this time have 5 Atlantic programs north of the Equator, and there is some duplication between panels; the present overall ranking by thematic panels is about as follows:

- New Jersey Margin Sealevel
- Northernmost Atlantic Paleoceanography: Arctic Gateway
- North Atlantic Non-volcanic Rifted Margins
- MARK Area: Long Section of Upper Mantle
- TAG Area: High-temperature Hydrothermalism

- North Atlantic Volcanic Rifted Margins
- Barbados Accretionary Wedge
- Vema FZ: Transition, Layer 3 to Mantle
- Equatorial Atlantic Transform Margins
- Vema FZ: Transition, Layer 2 to Layer 3

  next a relative gap
- Cayman Trough
- Mediterranean Gateways
- West Florida Margin Sealevel

As has been stated in the recent past, thematic panels will have the opportunity each year to revise their rankings. The thematic ranking of programs is summarized in tables and a map in this issue of JOIDES Journal. By definition, not all programs can be "highest" ranked, but proponents not in the general 4-year plan should not despair. PCOM must emphasize that this plan will be amended each spring, by adding to the distal end and probably by modifying some of the middle. On the other hand, proponents in the highest groupings are not automatically assured of drilling. The program plan of each year can hold only a few legs from several programs. Therefore all proponents should, if possible, sharpen their proposals, and all panels will keep an open mind about all proposals.

<u>Preparation for drilling beyond the early 1990s</u>.

First, the prospects and problems with drilling deeper than 1.5 to 2 km concerns PCOM and each of the thematic panels -- some panels more so than others. Reports were received at the April PCOM meeting from the recent TEDCOM meeting, to which thematic panels sent scientists, and from the recent joint LITHP and TECP meeting, which was attended by engineers. As a result of extensive conversation with Charles Sparks, Chair of TEDCOM, and Mike Storms, TAMU engineer, PCOM will form a Working Group on Deep Drilling. The PCOM Chairman, the TEDCOM Chairman, and the thematic panel chairmen are consulting to formulate an appropriate membership and mandate for the Working Group for presentation to PCOM at its August 1990 meeting. The group probably will first meet to augment the next TEDCOM meeting (26-27 September). It should include persons experienced in deep drilling (with appropriate oil-industry and Russian, German, Swedish, and other hard-rock participation). This group will look at ways to proceed towards planning for deep drilling, including systems for coring and bore-hole control, platform required, estimates of time and costs, and advisory and operational structures in parallel or within JOIDES-ODP.

Ralph Moberly
Planning Committee Chairman

LONG-RANGE PLAN

The recently published Ocean Drilling Program Long-Range Plan Portfolio is now available. The portfolio contains a 16-page color brochure as well as the Long-Range Plan which outlines scientific objectives into the year 2002. If you would like a copy, please contact Jenny Granger, JOI, Inc., Suite 800, 1755 Massachusetts Avenue, NW, Washington, DC 20036-2102; Tel: (202) 232-3900.

JOIDES RESOLUTION OPERATIONS SCHEDULE

LEGS 132 - 139

LEG	AREA	DEPARTURE		ARRIVAL		IN PORT	DAYS AT SEA*
		LOCATION	DATE	LOCATION	DATE		
131	Nankai	Guam	04/01/90	Pusam, Korea	06/02/90	06/02 - 06/06	62
132	Engineering II	Pusan, Korea	06/07/90	Guam	08/05/90	08/05 - 08/09	59
133	N.E. Australia	Guam	08/10/90	Brisbane, Australia	10/11/90	10/11 - 10/15	62
134	Vanuatu	Brisbane, Australia	10/16/90	Suva, Fiji	12/17/90	12/17 - 12/21	62
135	Lau Basin	Suva, Fiji	12/22/90	Suva, Fiji	02/18/91	02/18 (Crew Change)	58
136	Transit OSN-1 Engineering 3A	Suva, Fiji Honolulu, HI Honolulu, HI	02/19/91 03/04/91 03/18/91	Honolulu, HI Honolulu, HI Panama	03/01/91 03/18/91 04/21/91	03/01 - 03/03 (1/2 day) 04/22 - 04/26	10 14 34 Total: 62
137	E. Equatorial Pacific Neogene	Panama	04/27/91	San Diego, CA	06/26/91	06/26 - 06/30	60
138	Sedimented Ridges I	San Diego	07/01/91	Victoria, B.C.	09/02/91	09/02 - 09/06	63
139	Engineering 3B or 504-B	Victoria, B.C.	09/07/91	Panama	11/06/91	11/06 - 11/10	60

Revised 05/04/90

LEG 129: OLD PACIFIC CRUST PRELIMINARY REPORT

INTRODUCTION

Correlations of Mesozoic magnetic anomaly sequences in the Pacific Ocean by Larson and Chase (1972) indicates that the world's oldest oceanic crust lies centered in the far western Pacific and that isochrons become concentrically younger. Recent magnetic anomaly mapping (Fig. 1) has revealed the oldest part of this tectonic pattern and has extended the Mesozoic magnetic reversal time scale from M29 of Cande *et al.* (1978) to M37. The oldest M-lineations may have recorded the magnetic-reversal/sea-floor-spreading history of the early Late Jurassic (165 Ma), which was preceded by a magnetic quiet zone ranging back to the Middle Jurassic (175 Ma).

The inference that the M17 and older isochrons coincide with Jurassic sediments and basement rocks is based entirely on conclusions drawn from geophysical data such as those just cited. Prior to Leg 129, no Jurassic material had ever been recovered from this region, whose size is approximately that of the contiguous United States or western Europe. Past attempts to drill and recover Jurassic sediments and basement rocks in this area have been frustrated by ubiquitous chert layers of generally Late Cretaceous age and by widespread, but probably not ubiquitous, volcanic material of Late Cretaceous age that blanketed much of the older strata in the area. These geologic units and the lack of multichannel seismic (MCS) data to define their depths, thicknesses, and lateral boundaries have led to previous "blind drilling" on Jurassic basement locations (Fig. 1) that have all terminated in Cretaceous material of various types [cherts; Deep Sea Drilling Project (DSDP) Site 452 ; volcaniclastics, DSDP Sites 199 and 585; basalt flows and sills, DSDP Sites 61, 169, and 462].

The recent magnetic anomaly mapping cited above, and the joint MCS expeditions by French and American investigators (Abrams *et al.*, 1988), have led to a much better understanding of the tectonic and geologic history of the area. These investigations have also provided seismic imaging of drill sites in the Pigafetta and East Mariana basins, where Jurassic sediments and Jurassic oceanic crust were drilled and recovered on ODP Leg 129 with the advanced drilling technology aboard *JOIDES Resolution*.

OBJECTIVES

Age Calibration of Jurassic Magnetic Reversals

The available magnetic and seismic data suggest that the Pigafetta and East Mariana basins are underlain by oceanic crust of Late Jurassic to probably Middle Jurassic age (Fig. 1). The younger, northwest parts of the basins may be Kimmeridgian to Oxfordian (anomalies M22 to M25; Late Jurassic), whereas the middle parts may be Oxfordian to Callovian (anomalies M29 to M37), that is, ~160-165 Ma. Towards the southeast, within the Jurassic magnetic quiet zone, the crust may be as old as Bathonian to Bajocian (Middle Jurassic, ~165-175 Ma), a time of extremely frequent magnetic reversals (Steiner *et al.*, 1987).

So far, the oldest magnetic anomalies dated in the world's oceans are M23 to M26 (Fig. 2), which have been sampled at two sites in the North Atlantic (DSDP Sites 100 and 105). Several sites on younger M-anomalies have yielded a reasonable calibration for the post-M25 anomaly sequence. Drilling in the area of older anomalies of the M-series offered an exceptional opportunity to extend the geomagnetic time scale further back into the Jurassic, and possibly to calibrate the series of reversals described from land sections (Steiner and Ogg, 1988).

Within the Jurassic quiet zone of Pigafetta Basin, Handscumacher *et al.* (1988) observed an important change in the character of the magnetic signature. Small-amplitude anomalies were observed on all aeromagnetic tracks that extend southeast of M37, but could not be correlated. Farther southeast of this magnetic quiet zone an abrupt change in amplitudes and regional field intensity was interpreted as a possible structural boundary roughly parallel to the

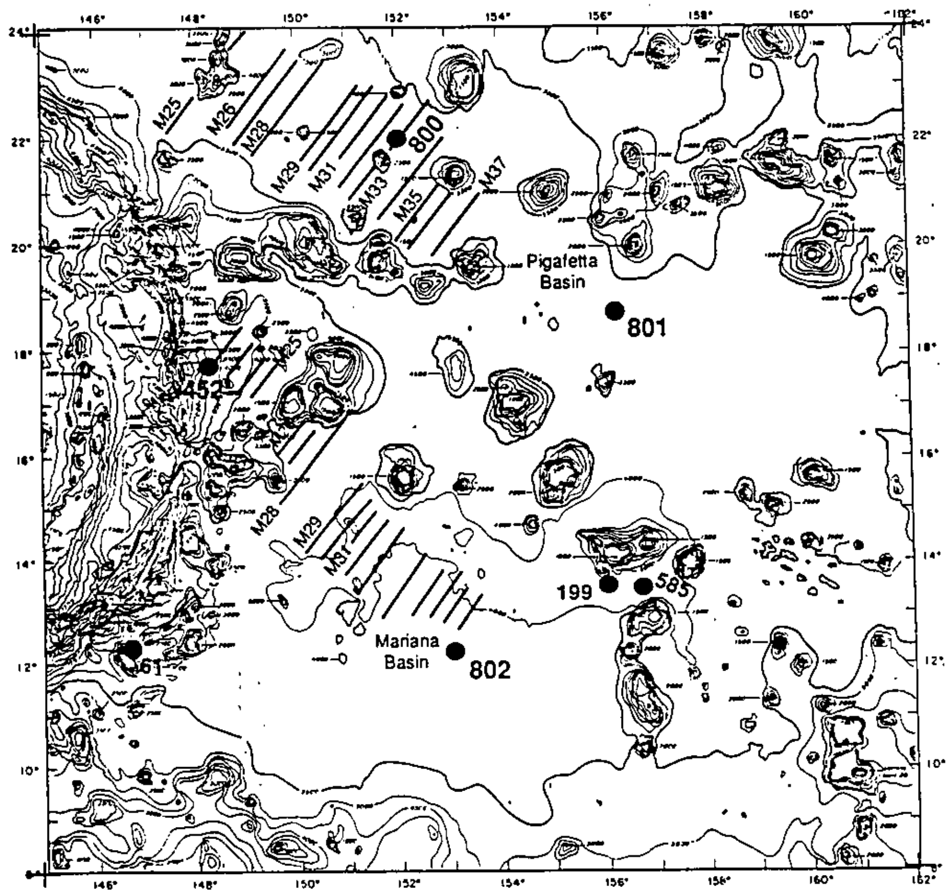

Figure 1. ODP site locations superimposed on Jurassic magnetic lineations and regional bathymetry (in meters, from Carl Brenner, personal communication) of the East Mariana and Pigafetta basins. Only the sites located in the deep basins of the western Pacific are shown.

isochrons. This area may represent the location of the original microplate from which the present-day Pacific plate evolved (Handschumacher, *et al.*, 1988). It is also possible that this area could mark the edge of the middle Cretaceous volcanic complex that extends farther south.

Jurassic Sediments and Early History of the Ocean

The main interest in Jurassic sediments from the Pacific is that they chronicle the paleoenvironment of the Jurassic superocean, which covered two-thirds of the Earth at that time, but for which we have no direct record. The only other samples of pelagic "deep-sea" Jurassic sediments come from Tethyan fold belts and DSDP sites in the proto-Atlantic, both of which correspond to relatively restricted marine conditions. The most recent attempts to recover Jurassic sediments in the Pacific were at locations where thick lava flows and sills of middle-to-Late Cretaceous age proved impossible to penetrate (DSDP Site 461, Nauru Basin), or where thick accumulations of volcaniclastic material

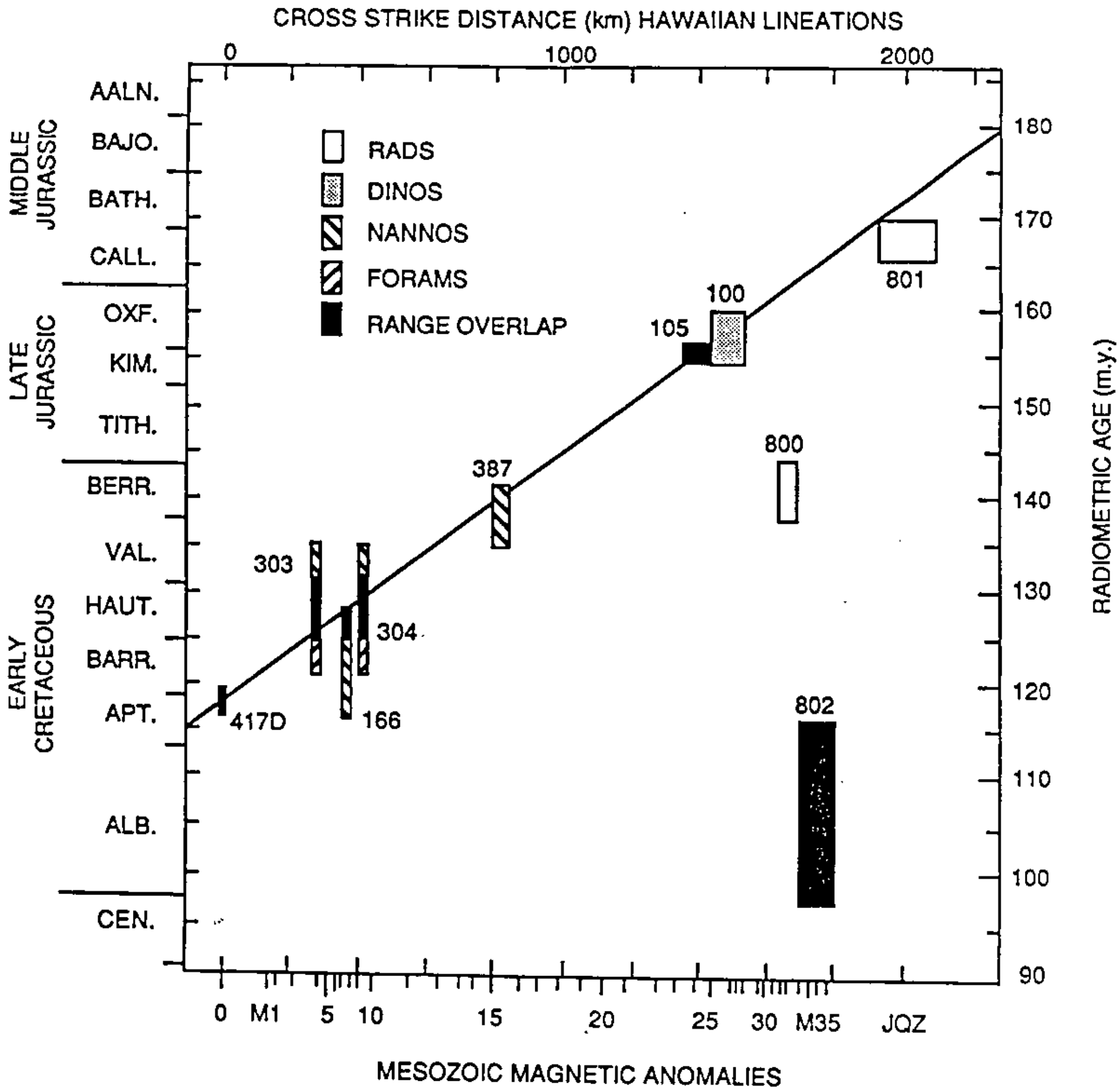

Figure 2. Time calibration plot of the Mesozoic magnetic anomalies M0 to M37 and the preceding magnetic quiet zone. Magnetic anomalies plotted as distance across the Hawaiian lineations for M0 to M25. M25 to M37 normalized to that parameter. Geologic time scale and radiometric ages from Harland *et al.* (1982), modified by Kent and Gradstein (1985) at the Tithonian/Kimmeridgian boundary. Oldest paleontological ages in various DSDP and ODP holes shown as rectangles. Vertical lengths of paleontological age ranges taken from *DSDP Initial Reports* except for Site 100 (Zotto *et al.*, 1987) and 105 (Gradstein and Sheridan, 1983). Horizontal lengths show magnetic age ranges from Larson and Hilde (1975) for DSDP Sites 303, 304, 166, 100 and 105, and *DSDP Initial Reports* for Sites 387 and 417. ODP Sites 800, 801 and 802 show paleontological ages from this report. Magnetic age ranges determined by R.L. Larson.

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had expanded the sedimentary section beyond the capabilities of the drillship (DSDP Site 585, East Mariana Basin). The sedimentary section depicted on seismic profiles through the Pigafetta Basin resembles that of the Ptolemy Basin located north of the Marcus-Wake swell, where DSDP Site 307 was drilled to basement of Berriasian (earliest Cretaceous) age beneath 300 m of sediment on anomaly M21. The average sediment thickness in the East Mariana Basin is about 300-500 m, and there was a very good chance of obtaining sediments of Jurassic age. The main difference between the Leg 129 sites and those drilled previously, apart from the older age of the basal sediments, is the age of the chert layers. The chert was expected to be younger in the Pigafetta Basin and younger still in the East Mariana Basin because of the difference in time of equatorial crossing for the three areas (Lancelot and Larson, 1975). Sediment thicknesses and acoustic signatures appear compatible with this interpretation. Leg 129 intended to sample Jurassic sediments in the area of the M-anomalies and within the Jurassic quiet zone, where no age determination can be made otherwise.

Geochemical Reference Sections

The proposed drilling locations also fulfilled, in part, objectives commonly referred to as "geochemical reference sections." These objectives include determining the composition of sediments and igneous oceanic crust adjacent to a subduction zone for comparison with the geochemical characteristics of the neighboring arc volcanism. In the Western Pacific the main variable on the "input" side of the geochemical reference equation may be the presence or absence of large volumes of Cretaceous volcanic material in the deep basins now being subducted. The petrology, igneous or sedimentary nature, and depth in section of this material would greatly affect the geochemical "output" signature at Western Pacific island arcs. It probably would have much greater variability than the original Jurassic oceanic crust and is much more accessible to the drill in the Western Pacific. Also, drilling into basement in this region offered a uniqu opportunity to assess the *in-situ* physica properties of old oceanic crust created a fast spreading center, because prese tectonic models assume that the Pigafetta and East Mariana basins were both created at a 6-8 cm/yr spreading half-rate.

While none of the Leg 129 drilling sites in the Pigafetta or East Mariana basins are directly adjacent to their associated subduction zones, seismic profiles throughout both of these basins suggest that the sites have acoustic sections typical of each basin in question. It is unlikely that any significant diagenesis or other alteration will occur at these sites between now and their eventual subduction. Furthermore, all sites occur in fracture-zone-bounded "compartments" that extend to the Western Pacific subduction zones. Thus the nature of the sedimentary and crustal sections can be related to those specific subduction zones and their associated backarc volcanism.

Cretaceous Volcanic Complex

It was probable that these sites would encounter material generated by the middle Cretaceous volcanic event, either as volcaniclastics or as solid sills and flows. However, multichannel seismic data and recent magnetic anomaly mapping allowed location of sites typical of large parts of the regional geology of those basins. Leg 129 drilled through the middle Cretaceous volcanics to underlying seismic reflectors that may be older material. Sampling this middle Cretaceous volcanic complex will provide additional understanding of the timing, dimensions, and petrology of this major igneous province. In addition, sampling the seismic stratigraphy at these locations will allow "calibration" of the seismic stratigraphy in large parts of both of these basins.

Crustal Magnetization and Paleolatitudes

In addition to what we consider to be the primary objectives (age of the oldest magnetic lineations and Jurassic paleoenvironments), a number of other objectives were met with these drill sites.

Crustal magnetization objectives also were within the scope of Leg 129 drilling. Paleolatitudes measured on basement rocks and logging measurements that recovered the complete remanent magnetization vector are also of prime interest. They will allow reconstruction of the latitudinal motion and rotation of the Pacific plate during the Jurassic. This latter point is especially important for modeling the overlying sedimentary stratigraphy that is very sensitive to crossings of the equatorial high-productivity zone.

LEG 129 SITE DESCRIPTIONS

Site 800
21° 55.38' N
152° 19.32' E
Water Depth: 5686 m

Site 800 (proposed site PIG-1) is located in the northern Pigafetta Basin on magnetic anomaly lineation M33, 40 nmi northeast of Himu Seamount. Its presumed age is Jurassic based on an extrapolation of the Japanese magnetic lineation pattern that is contained in the same spreading compartment to the northwest. Hole 800A consists of the following stratigraphic sequence:

0-38 mbsf: Tertiary to upper Campanian zeolitic brown clay.

38-78 mbsf: Upper Campanian to Turonian red chert and porcellanite corresponding to the top of the reverberant layer on the seismic records.

78-229 mbsf: Cenomanian to lower Albian gray chert and silicified limestone with increasing amount of silicified limestone downsection, grading into some nannofossil chalk at the base of the sequence.

229-450 mbsf: Aptian volcaniclastics, well indurated and possibly emanating from Himu Seamount 40 nmi to the southwest that is radiometrically dated at 120 Ma (Aptian-Barremian), with scattered included radiolarites. The volcaniclastics contain spectacular turbidite and debris flow features including graded beds, cross-bedding, tear-up structures, and penecontemporaneous deformation.

450-498 mbsf: Hauterivian to Berriasian laminated claystone, red with scattered black banding and green reduction halos. Hard red chert occurs at the base of the sequence.

500-545 mbsf: Basaltic dolerite; massive, moderately coarse crystallization with no internal cooling unit boundaries. The basalt is more finely crystallized at its top. No glass or palagonite was observed macroscopically, and large, elongated clinopyroxene crystals were present throughout. Relatively fresh, unweathered material was observed throughout, except for the top 1 m. The basalt corresponds to a flat, high amplitude seismic reflector that is essentially acoustic basement in this area.

Drilling operations terminated at 545 mbsf owing to a tight spot in the hole at 350 mbsf, probably related to swelling of clays in the volcaniclastic section. Three logging runs with standard tools were conducted from 45 to about 300 mbsf.

Site 801
18° 38.54' N
156° 21.58' E
Water Depth: 5682 m

After a 20-yr search, the Jurassic Pacific has been found at last. Site 801 (proposed site PIG-3A) lies in the central Pigafetta Basin on a magnetic quiet zone southeast of and presumably older than, the M25-M37 magnetic lineation sequence. Holes 801A, 801B, and 801C consist of the following stratigraphic sequence:

0-56 mbsf: Tertiary to Campanian, brown pelagic clay.

56-118 mbsf: Campanian to Turonian brown chert and porcellanite.

118-310 mbsf: Cenomanian and Albian volcaniclastic turbidites with minor radiolarite near the base.

310-435 mbsf: Lower Cretaceous (Valanginian) to Upper Jurassic (Oxfordian) brown radiolarite with dark brown chert and abundant manganese.

435-453 mbsf: Middle Jurassic (Callovian) umber-colored radiolarite and claystone with strong hematite enrichment probably indicative of hydrothermal activity during or just after deposition. The oldest dated sediment is interbedded with the basalts in the underlying unit at 465 mbsf where the *T. conexa* zone of Matsuoka and Yao (1986) has been identified. This radiolarian assemblage is the same as the basal radiolarian sequence of DSDP Site 534 which was recalibrated by Baumgartner (1987) to lie at the ~170 Ma Callovian-Bathonian boundary. The absence of carbonate in this ridge-crest, equatorial-paleolatitude sedimentary facies suggests that the Late-Middle Jurassic superocean was characterized by extremely low rates of carbonate production and/or preservation.

453-594 mbsf: Middle Jurassic basement. Interbedded basaltic sheet flows, thin sills, and silicified claystone are at the top of the sequence. Pillow basalts begin at 484 mbsf and exhibit concave pillow structures with chilled margins, variolitic textures, and microcrystalline interiors. A remarkable hydrothermal concretion occurs between 511 and 521 mbsf that is chrome yellow and silica cemented. It is underlain by pillow basalts that are extremely altered directly beneath the hydrothermal deposit and become fresher toward the bottom of the hole. These mainly extrusive volcanics are the first *in-situ* Jurassic basement samples ever recovered from the Pacific Ocean.

Standard logging, including a repeat run with the Formation Microscanner (FMS) was completed from 56 to about 460 mbsf with the wireline heave compensator operating.

<u>Site 802</u>
12° 05.78' N
153° 12.62' E
Water Depth: 5969 m

Site 802 (proposed site EMB-2A) is located in the central Mariana Basin, at the southeastern end of a magnetic lineation sequence partially identified to the northwest as M22 to M31, which predicts a Late Jurassic basement age. Extrusive basalt underlies upper Aptian-Albian (Lower Cretaceous) claystones, suggesting that the basement age should be revised upward by 60 m.y. at this location, or that original Jurassic basement, and perhaps a significant sedimentary section, has been covered by subsequent Cretaceous lava flows. The overlying sediment section consists mainly of redeposited material, suggesting massive lateral transport over long distances (>300 km) or unmapped large elevations in the more immediate vicinity. Hole 802A consists of the following stratigraphic sequence:

0-15 mbsf: Neogene brown pelagic clay.

15-159 mbsf: Miocene tuff consisting of well indurated and well preserved hyaloclastites and volcaniclastic turbidites, presumably derived from the Caroline Island volcanic chain.

159-254 mbsf: Miocene to Eocene tuff, chalk, claystone, volcaniclastic turbidites and debris flows, apparently all redeposited.

254-330 mbsf: Upper Paleocene nannofossil chalk.

330-348 mbsf: Maestrichtian zeolitic pelagic claystone.

348-460 mbsf: Campanian volcaniclastic turbidites with clay, claystone, silty claystone, porcellanite, and debris flows, mainly redeposited.

460-516 mbsf: Cenomanian to upper Aptian-Albian brown claystone, calcareous claystone, radiolarian limestone, and volcaniclastic turbidites with wood fragments in the lowest 2 cores.

516-560 mbsf: Extrusive basalt, uniformly fine-grained with multiple cooling units and no included sediment. Sheet-flow volcanism with some evidence for pillow basalts is suggested. The chilled zone immediately below the sediment contact suggests that the uppermost basalts were recovered.

Standard logging was conducted within the interval 110-320 mbsf after eliminating a bridge above this interval and encountering another at its base. A vertical seismic was unsuccessful because the tool became stuck in the hole, requiring the logging cable to be severed and terminating operations at this site.

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Table 1. Leg 129: Site Occupation Summary

Hole	Latitude (°N)	Longitude (°E)	Water Depth*	Number of Cores	Cored (m)	Recovered (m)	Percent Recovered	Total Penetr. (m)
800A	21°55.38	152°19.32	5686	61	544.5	152.7	28.0	544.5
801A	18°38.57	156°21.57	5682	20	186.0	31.5	16.9	186.0
801B	19°38.52	156°21.58	5682	44	317.2	59.2	18.7	503.2
801C	18°38.54	156°21.59	5674	12	100.6	60.6	60.2	594.3
802A	12°05.78	153°12.62	5969	62	559.8	165.0	29.5	559.8

*Depths are drill-pipe measurements corrected to sea level.

LEG 130: ONTONG JAVA PLATEAU PRELIMINARY REPORT

INTRODUCTION

The area drilled on the northeastern margin of the Ontong Java Plateau during Leg 130 (Fig. 1), was chosen to provide a depth transect of carbonate deposition in the western equatorial Pacific. Along this transect the intent was to recover a complete record of Neogene, Paleogene, and Late Cretaceous ocean history, with the goal of achieving a detailed reconstruction of paleoceanography and paleoclimate, in a well-constrained time frame. The unique geological setting of the plateau has led to the accumulation and preservation of a thick cover of pelagic sediments, apparently undisturbed in many areas. Thus, this region is eminently suitable for high-resolution studies of globally significant paleoceanographic signals. In addition, there was the expectation that paleoceanographic events could be traced in the physical properties of the sediment, and that a link to the seismic record would allow both three-dimensional regional mapping, and long-distance correlation. See the back cover for a summary of recovered sediment as a function of age. Last, but not least, the origin and tectonic history of the Ontong Java Plateau itself constituted an important objective of our studies. See the February, 1990 issue of the *JOIDES Journal* for a more extensive summary of cruise objectives.

DRILLING RESULTS

Leg 130 sailed from Guam on 23 January 1990 and drilled five sites on the Ontong Java Plateau to address these objectives (Fig. 2 and Table 1). During the 62.7 days of Leg 130 operations, 51.2 days were spent on site while underway time added up to 11.5 days. Part of the underway time included seismic surveys over the drillsite locations. Chief Scientists were Dr. Wolfgang Berger (University of Bremen) and Dr. Loren Kroenke (Hawaii Inst. Geophysics); Dr. Thomas Janecek was ODP Staff Scientist.

Site 803

Site 803 is situated on the equatorial northeastern margin of the Ontong Java Plateau in 3415 m of water at latitude 2°26.0'N and longitude 160°32.5'E (Fig. 2). It was drilled as part of the Neogene depth transect to serve as a deep-water anchor site. The site was located on an R/V *Thomas Washington* single-channel seismic (SCS) line acquired during the ROUNDABOUT Cruise 11 "DANCER" survey between proposed sites OJP-4 and OJP-4B, upslope from a mid-section reflector (MSR).

Site 803 was occupied for 9.7 days. A total of 991.3 m was cored at four holes, 552.4 m by APC (103% recovery), 394.9 m by XCB (63% recovery), and 44 m by RCB (33% recovery). Total core recovery was 837.4 m. The four holes drilled were cored as follows: Hole 803A, APC 0 to 55.5 mbsf; Hole 803B, APC 0 to 61.3 mbsf; Hole 803C, APC 19 to 237.5 mbsf; Hole 803D, APC 0 to 217.1 mbsf, XCB 217.1 to 612.0 mbsf, RCB 612.0 to 656.0 mbsf.

The recovered sediments were divided into three units. The uppermost unit, Unit I, ranges from upper Eocene to Pleistocene, and consists of nannofossil ooze and chalk to foraminifer nannofossil ooze and chalk. Unit II (563.7- 621.8 mbsf) ranges from middle to upper Eocene and consists of approximately 58 m of nannofossil chalk with radiolarians, radiolarian nannofossil chalk, nannofossil radiolarite, and minor amounts of chert. Unit III (621.8-626.3 mbsf) ranges from lower Upper Cretaceous to middle Eocene and is composed of claystone and clayey siltstone, with minor radiolarian-rich intervals. Resistivity logs suggest that this lithology continues from 621.8 mbsf to basement at 630.4 mbsf.

The record is continuous from the Pleistocene to the lower Miocene where there is a significant stratigraphic break at 245.9 mbsf (15.9-21.3 Ma), the first of three major stratigraphic breaks encountered above the Cretaceous/Tertiary (K/T) boundary. The other two occur across the Paleocene-Eocene boundary (~45-~58 Ma), at 621.8 mbsf, and in the Paleocene (~58-~66 Ma) immediately below. The section

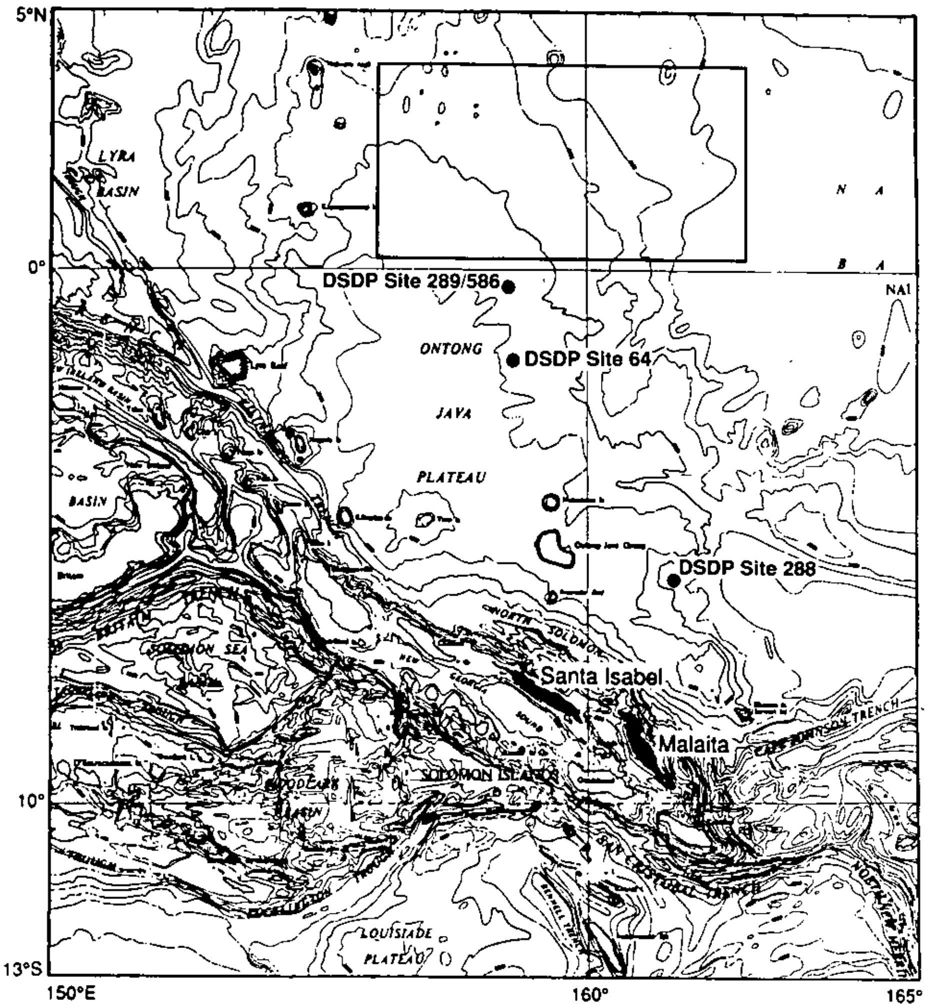

Figure 1. Bathymetry of the Ontong Java Plateau (after Kroenke et al., 1983), showing the location of DSDP Sites 64, 288, and 289/586. Box shows location of Leg 130 drilling. Contour interval is 500 m.

below the K/T boundary, which was penetrated at 622.25 mbsf, is condensed and presumably also contains several substantial hiatuses.

In Unit I, the ooze/chalk transition occurs between 210 and 220 mbsf and provides the basis for division into Subunits IA and IB. The logging data suggest that this transition extends over 60 m in the sedimentary column. Subunit IA (0-217 mbsf) consists of nannofossil ooze, nannofossil ooze with foraminifers, and foraminifer nannofossil ooze. The foraminifer content is high in the Pleistocene and adjacent upper Pliocene ooze and decreases downhole through the first 30 to 60 mbsf, so that most of the subunit is nannofossil ooze. There is a slight increase in foraminifer content within upper Miocene sediments, somewhat below the middle of the section. Bioturbation is ubiquitous. Colors are dominantly various types of white and light gray; the Pleistocene section also exhibits colors with a yellowish hue. Faint green, purple, and red color bands are common, except in the upper middle Miocene nannofossil ooze (ca. 14 Ma to 10 Ma). These appear to have an origin analogous to "Liesegang" rings, which arise through diffusion along redox gradients surrounding objects containing reducing matter.

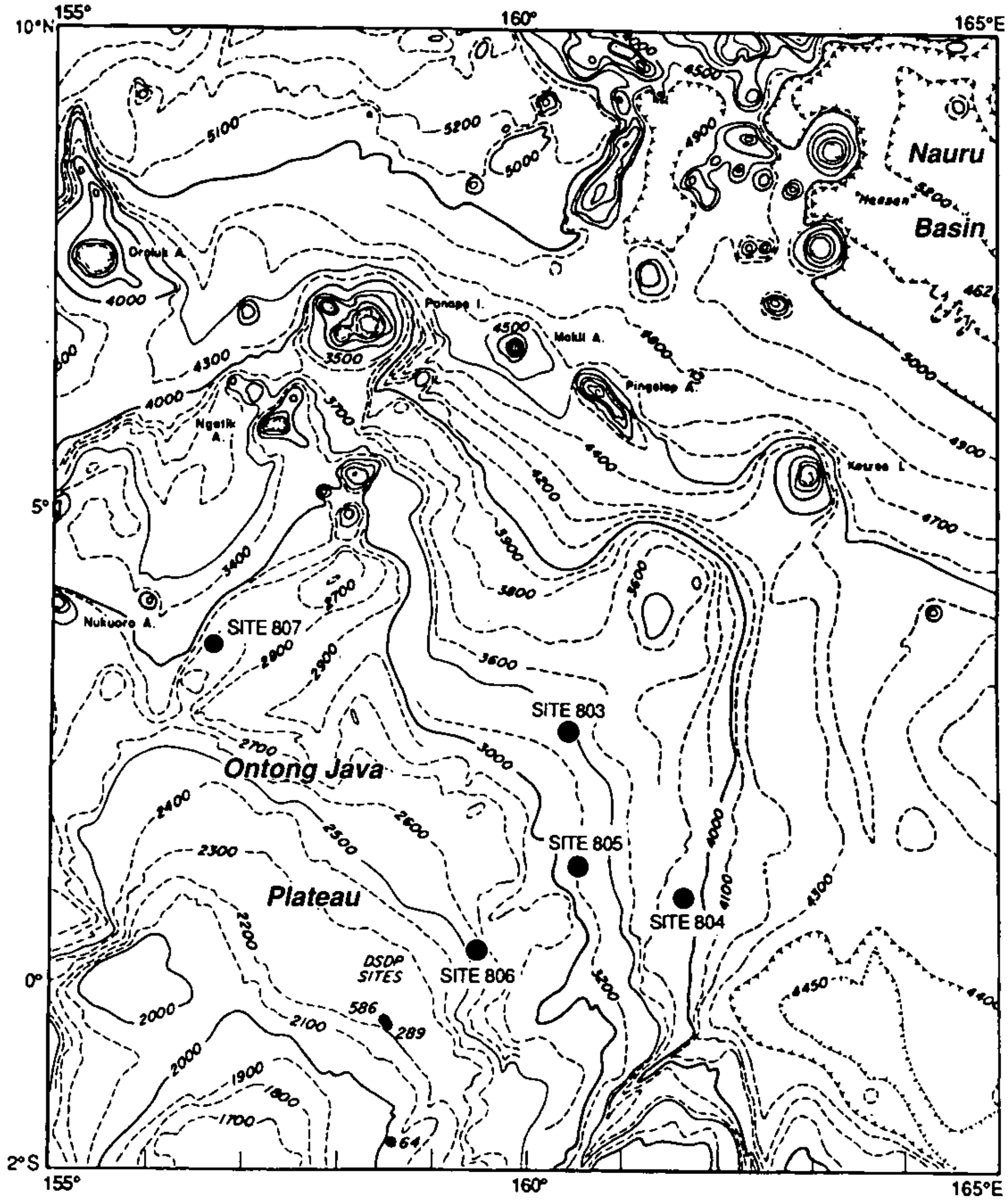

Figure 2. Bathymetry, in meters, of the northwestern part of the Ontong Java Plateau (after Mammerickx and Smith, 1985). The location of the Leg 130 sites (Sites 803-807) together with those from DSDP Leg 7 (Site 64), Leg 30 (Site 289), and Leg 89 (Site 586) are shown for reference.

Sediment instability is indicated by microfaulted and discordant color banding at several levels in the section, especially in the lower Pliocene and uppermost Miocene ooze, but also within the upper and middle Miocene portions.

One thin discrete ash layer is present in Unit I (at 181.2 mbsf in Hole 803D) that clearly ties the recovered section to the logging data.

Subunit IB (217-563.7 mbsf) consists of

nannofossil chalk and nannofossil chalk with foraminifers. Its upper boundary is marked by a shift to higher velocity in the log data, with only one more low-velocity layer downhole, between 240 and 250 mbsf. Subunit IB is much like the younger Subunit IA, except for lithification. Colors are similar, as is intensity of bioturbation. Color banding appears in lower Oligocene sediments (ca. 420-520 mbsf). The bands become more abundant, more intense, and more distinct downhole in this interval. They are continuous across and through burrows.

Radiolarians are present in low proportions throughout the section, but their abundance never exceeds 7% in smear slides. Minor amounts of chert were recovered at 546.15 mbsf, in lowermost Oligocene sediments. A marked decrease in pore-water silica in the vicinity of this level indicates the onset of silica precipitation. Chert formation and enhanced grain cementation in the upper Eocene chalk is probably responsible for the local high-velocity layers detected in the logs at 521-541 mbsf, 546-558 mbsf, and below 564 mbsf.

Unit II (564-621.8 mbsf) consists of interbedded upper to middle Eocene nannofossil chalk with radiolarians, radiolarian nannofossil chalk, and nannofossil radiolarite. Drilling disturbance was significant in this unit. Minor amounts of chert were recovered. These lithologies produce distinctive records in physical properties, logging data, and seismic reflection profiles. Chert presumably is more abundant than the coring reveals: it may appear as a thin bed with high values in the resistivity log, with high sonic velocities, and may be responsible for a major reflector on seismic profiles at that depth.

Unit III (622-626.3 mbsf) is surprisingly thin for the age range (middle Eocene-early Late Cretaceous). It is composed of dark claystone and siltstone, predominatly by deep-sea siliciclastic sediments. Unit III also contains a complete Cretaceous/Tertiary boundary sequence as well as several major unconformities.

In Unit IV (630.4 - 656.0 mbsf), nine basalt subunits were recognized on the basis of intercalated limestones or breccias. Their age is Albian or older. The basalts are predominantly aphyric, fine-grained, and nonvesicular tholeiites. On-board XRF measurements indicate that the basalts are fairly well evolved and, in terms of their Zr/Nb ratio (14-17), distinct from both normal midocean-ridge basalt (Zr/Nb > 30) and typical ocean island tholeiites (Zr/Nb commonly < 12). Slight compositional variations within the basalts suggest that they may have been derived from more than one parental magma.

Site 804

Site 804 is located in the western-equatorial Pacific, on the northeastern margin of the Ontong Java Plateau (latitude 1°00.3'N, longitude 161°35.6'E, Fig. 2) in 3870 m of water, 375 km eastnortheast of DSDP Site 289/586. The objective in drilling this site was to obtain a continuous sedimentary record to serve as the deepwater end member on the Neogene depth transect, designed to recover depth-related paleoceanographic signals. A high-resolution carbonate record in a sublysoclinal setting was anticipated for studies of dissolution and biostratigraphy.

The site was positioned using an R/V *Thomas Washington* single channel seismic (SCS) line acquired during the ROUNDABOUT Cruise 11, on the crossing SCS line of D/V *JOIDES Resolution.* The site is near the center of a slight depression about 4.5 km wide. The location is close to a significant offset in basement levels between the plateau and the deep ocean floor. Episodic shaking from earthquakes, basement relief, and perhaps the presence of clay-rich layers at this water depth apparently create conditions favorable for large-scale slumping and debris flow on the flanks of the plateau. Removal of support at greater water depths, by carbonate dissolution, also may play a role in fostering mass movement (Berger and Johnson, 1976). Selection of a suitable site to drill was difficult under these conditions, and the site chosen was less than ideal for the purposes of the transect.

The ship spent 3.15 days on this site, coring 498.9 m of sediment, and recovering 465.9 m. Three holes were drilled. Hole 804A, a dedicated hole, was APC cored to 48.7 mbsf into upper Miocene sediments with 104% recovery. Hole 804B was APC cored to 137.7 mbsf into middle Miocene sediments with 103% recovery. It was abandoned when the core barrel became stuck in the hole. Hole 804C was APC cored to 120.3 mbsf, with a recovery of 100% on average. Below this depth coring by XCB proceeded to 312.5 mbsf where it terminated in lower Oligocene sediments. Average recovery for the XCB section was 80%. There was no logging.

The sediment retrieved is Neogene in age, except for the five deepest cores in Hole 804C, which recovered upper Oligocene chalk (Cores 130-804C-29X to 130-804C-33X). The entire column, from the earliest deposits to the seafloor, was classified as nannofossil ooze and chalk and is considered as one lithologic unit. Major breaks are in the upper Oligocene (hiatus at 270 mbsf, 28.2-25.2 Ma) and at the lower to middle Miocene transition (hiatus at 197 mbsf, 18.614.6 Ma).

There is a condensed section or hiatus in the lower Pliocene, between 5 and 4 Ma (46 to 43 mbsf), and possibly within the middle Miocene, between 13 and 11 Ma (near 160 mbsf). Disturbance of layers (other than from coring) is evident in the section spanning the major hiatus from the lower to middle Miocene (210 to 187 mbsf) and between 42 and 110 mbsf (most of the upper Miocene). It is especially prominent between 70 and 80 mbsf (7-8 Ma).

Two subunits were recognized in this rather uniform section of bioturbated ooze and chalk. They are separated by the ooze/chalk transition at 181 mbsf (middle Miocene, ca. 13 Ma).

The younger section of the unit (Subunit IA, 0-181 mbsf) comprises Pleistocene to middle Miocene nannofossil ooze with foraminifers, nannofossil ooze, and nannofossil ooze with radiolarians. The oozes are light brown in the top 20 to 40 mbsf, grading into white ooze, with color banding (related to "Liesegang" diffusion rings) down to 100 mbsf. The banding (green and reddish hues) is best expressed between 44 and 59 mbsf (uppermost Miocene and lowermost Pliocene) and is well developed between 71 and 90 mbsf. Banding is disrupted and distorted in the disturbed layers mentioned, within sediments of latest Miocene age (ca. 7 to 8 Ma). Two turbidites near 93 mbsf attest to redeposition within the middle upper Miocene (ca. 11 Ma).

The older portion of the unit (Subunit IB, 181-312.5 mbsf) consists of middle Miocene to upper lower Oligocene nannofossil chalk and nannofossil chalk with radiolarians. Colors are yellowish white, pale brown, and white. Radiolarian-bearing sediments are common in this subunit, with a strong radiolarian maximum in the lower Miocene (near 200 mbsf), just below the lower/middle Miocene hiatus. Also at this depth are indications of ooze/chalk clasts and distorted bioturbation features, as mentioned.

Site 805

Site 805 is located in the western-equatorial Pacific, on the northeastern margin of the Ontong Java Plateau (latitude 1°13.7'N, longitude 160°31.8'E; Fig. 2) in 3188 m of water. The objective in drilling this site was to obtain a continuous record to serve as the intermediate member of a depth transect of Neogene sediments, designed to recover depth-related paleoceanographic signals.

Positioning was based on two crossing SCS lines acquired by the R/V *Thomas Washington* during the ROUNDABOUT Cruise 11. The site lies within a gently sloping valley about 3.5 km wide, and flanked by low ridges along either side. The seismic profiles show continuous reflectors, with little or no disturbance .

The ship spent 6.17 days on this site, drilling three holes and coring 1134.8 m of sediment, of which 992.6 m was recovered. Hole 805A, a dedicated hole, was APC cored to 50.5 mbsf into upper Pliocene sediments, with 103% recovery. Hole 805B was APC cored to 263.2 mbsf, where refusal occurred at the boundary between upper and middle Miocene sediments; recovery was 103%. The hole was continued by XCB coring to 473.3 mbsf, with 210.1 m of sediment cored and 173.6 m recovered (83% recovery). Coring was terminated about halfway through a thick section of lower Miocene sediments. Hole 805C was APC cored to 235.8 mbsf (100% recovery), at which point XCB coring was initiated. Drilling terminated in upper Oligocene sediments at 611.0 mbsf, with 80% recovery in the XCB-cored interval. The hole then was logged.

The sediment retrieved is Neogene in age except for the nine deepest cores in Hole 805C, which recovered Oligocene chalk. The entire column, from the earliest deposits to the seafloor, is considered one lithologic unit and was classified as nannofossil and foraminifer-nannofossil ooze and chalk. The average sedimentation rate over the entire interval is estimated at 21.5 m/m.y. No stratigraphic breaks were detected. However, sedimentation rates fall to rather low values (below 10 m/m.y.) between 10 and 18 Ma.

Two subunits were recognized in this quite uniform section of bioturbated ooze and chalk. They are separated by the ooze/chalk transition at 282.5 mbsf in Hole 805B (base of Core 130-805B-30X) and at 293.7 mbsf in Hole 805C (base of Core 130-805C-31X) (upper middle Miocene, ca. 11.4 Ma). The transition is gradational and shows alternating layers with varying degrees of lithification.

The younger section of the unit (Subunit IA, 0-290 mbsf) comprises Pleistocene to middle Miocene nannofossil ooze, nannofossil ooze with foraminifers, and foraminifer-nannofossil ooze. Radiolarian content is low . The oozes are light gray in the top 30 mbsf, grading to white. Color banding is common throughout the unit and is very well expressed in the uppermost Miocene. Color bands are coarse and irregular in Subunit IA. Some large burrows have well developed concentric color rings ("Liesegang" rings), indicating redox gradients as the cause for color banding. Microfaulting was observed in Core 130-805B-18H at 166 mbsf (middle upper Miocene), and tilting of color bands is seen at the middle/upper Miocene boundary. Sediments are generally soft, but the lowermost part of Subunit IA (283-293 mbsf) contains more lithified intervals. A shift toward higher seismic velocities occurs near the top of that zone, and another at the ooze/chalk transition at about 294 mbsf.

The older section of the unit, Subunit IB (290-611 mbsf), consists of 317 m of nannofossil chalk, nannofossil chalk with foraminifers and foraminifer-nannofossil chalk, of middle Miocene to late Oligocene age. The color is dominantly white. Color banding occurs throughout but becomes rare below 504 mbsf, in the lowermost Miocene. It includes bundles of pseudo-laminae, *i.e.*, fine-scale "Liesegang" banding showing sharp individual boundaries. Microfaulting is generally absent except near 310 mbsf (ca. 12 Ma), near the top of the subunit.

Recovery in the chalk subunit was good down into lower Miocene sediments. Recovery dropped below 450 mbsf (Core 130-805C-47X) and became quite poor below 520 mbsf (Core 130-805C-55X), near the Oligocene/Miocene boundary. Even where recovery was very good, core contents are largely disjointed chunks and chips, with evidence for grinding of chalk on chalk. This type of recovery is typical for the material below 370 mbsf. The Oligocene/Miocene boundary is located near 525 mbsf and apparently is without hiatus. Sedimentation rates for the deep chalk section are typically between 10 and 20 m/m.y.

Paleomagnetic stratigraphies were produced for the uppermost section of Holes 805B and 805C. Only the Brunhes Chron and part of the Matuyama could be identified. The sedimentation rate since 1.7 Ma was determined to be 17.1 m/m.y.

Chemical gradients in interstitial waters at this site are generally similar to those at Sites 803 and 804, reflecting the calcareous/siliceous nature of the sediments and the paucity of organic material. A somewhat higher supply of organic matter at this shallower site, perhaps because of the shallower depth, tends to produce slightly stronger gradients. Calcium and magnesium gradients are influenced by basalt-alteration reactions at depth and show the usual negative correlation. Strontium concentrations reflect recrystallization processes, that took place in younger sediments at this site than at the other two, owing to the higher sedimentation rates. Dissolved silica shows a steady increase with depth, except for a minor reversal of this trend just above the ooze/chalk transition.

The lithology of Site 805 is the same as that of Sites 803, 804 and 289. The carbonate content at Site 805 typically reaches values above 90% throughout the section except in the Pleistocene portion and at the upper and lower boundaries of the middle Miocene. In the Pliocene values hover about 90%. The carbonate stratigraphy of Site 803 is quite similar in long-term trends as well as in some of the detail. Site 804 also has similar trends, although they are disturbed there by hiatus formation. On the whole, percentages are between 5% and 10% lower and fluctuate more strongly than in Site 805. Mean grain size is typically between 12 and 25 µm at Site 805, with maxima near the Pleistocene/Pliocene boundary and in the uppermost and lowermost upper Miocene. Minima occur in the middle of the lower Pliocene and in the upper half of the upper Miocene.

Smear-slide abundance patterns of the major fossil groups are quite similar between Sites 803 and 805. To establish differences, a more quantitative analysis than was done on board will be necessary. Site 804 patterns are different, presumably owing to dissolution of carbonate and hiatus formation there.

The ooze/chalk transition lies at 290 mbsf (ca. 11-11.5 Ma) at Site 805. It is deeper and younger here than at Site 803 (217 mbsf, ca. 14-14.5 Ma) but shallower than at Site 289 while being roughly synchronous with it (350 mbsf, ca. 11.5 Ma). Thus, the comparison of Site 805 with Site 289 supports the hypothesis of Schlanger and Douglas (1974) that age (*i.e.*, conditioning during deposition) is an important parameter in the rate of lithification; the comparison with Site 803 does not. It appears that an increased overburden may accelerate the process of lithification, but not all that much.

Rates of accumulation were about 10-30% lower at Site 805 than at Site 289, on the whole, in keeping with the greater depth of Site 805. The rates were higher than at Site 803 by a factor of between 1.2 (upper Miocene) and 1.9 (early Pliocene, middle and early Miocene). For Pleistocene sediments, rates are unusually low at all three sites (805, 803, 289). Also for this period, the sedimentation rate of Site 805 actually exceeded that of Site 289. This suggests strong winnowing during this period, with downslope transport of fine material presumably mitigating the winnowing effect at Site 805.

<u>Site 806</u>

Site 806 is located on the northeastern margin of the Ontong Java Plateau, close to the equator (latitude 0°1 9.1'N, longitude 159°21.7'E; Fig. 2) in 2523 m of water. The site represents the shallow end member of a transect designed to detect depth-related paleoceanographic signals in Neogene sediments. The objective in drilling at this location was to obtain a continuous record in an undisturbed setting, with maximum sedimentation rates, which could serve as a standard section against which all others could be measured.

Positioning was based on a SCS line acquired by the R/V *Thomas Washington* during the ROUNDABOUT Cruise 11. The site is at the proposed location OJP-1 on a 2-km-wide terrace interrupting a gentle incline sloping to the northeast. The sedimentary sequence apparently is complete and undisturbed, with the seismic profile showing a full set of reflectors which are readily correlated with those at Site 289/586.

The ship spent 7.9 days on this site,

drilling three holes, and coring 1414.4 m of sediment of which 1275.9 m was recovered. Hole 806A, a dedicated hole, was APC cored to 83.7 mbsf into upper Pliocene sediments with 103% recovery. Hole 806B was APC cored to 320.0 mbsf, where refusal occurred, within the lower upper Miocene; recovery was 105%. The hole was continued by XCB coring, to 743.1 mbsf, with 423.1 m of sediment cored and 331.2 m recovered (78.3% recovery). Coring was terminated within lowermost Miocene sediments, when the objective (recovery of the Neogene section) was judged to have been reached. The hole was then logged, with the pipe pulled to 92 mbsf. Hole 806C was APC cored to 309.6 mbsf (103.6% recovery), at which point XCB coring was initiated. Cores were taken from 309.6 to 541.7 mbsf; from that point, a center bit was used to 599.0 mbsf, where a spot core was taken to obtain sediments from an interval with poor recovery in Hole 806B. A full core was obtained. Drilling then was then with a center bit, to 740 mbsf, at which point four cores were taken (740.0 to 776.4 mbsf), spanning the Oligocene/Miocene boundary. The XCB coring operation drilled 278 m and recovered 203 m of sediment (73% recovery) at this hole.

The sediment retrieved is Neogene in age, except for the four deepest cores in Hole 806C, which recovered Oligocene chalk (Cores 130-806C-59X to 130-806C-62X). The entire column, from the earliest deposits to the seafloor is considered as one lithologic unit and was classified as foraminifer nannofossil ooze and chalk to nannofossil ooze and chalk with foraminifers. No stratigraphic breaks were detected; apparently depositional history was continuous from the late Oligocene (ca. 27 Ma) to the present. The average sedimentation rate over the entire Neogene may be estimated at 31.6 m/m.y, the highest of any site drilled on Leg 130. Depending on assumptions made about the age of biostratigraphic tie points, the range of fluctuation lies between 15 and 55 m/m.y., or between 20 and 45 m/m.y.

Two subunits were recognized in this rather uniform section of bioturbated ooze and chalk, on the basis of degree of consolidation. They are separated by the ooze/chalk transition, placed at 339.4 mbsf in Hole 806B (Core 130-806B-37X), and at 338.5 mbsf in Hole 806C (Core 130-806C-37X) (lowermost upper Miocene, ca. 10 Ma). The transition is gradational and shows alternating layers of varying degree of lithification, beginning at about 200 mbsf in both holes, looking downhole.

Subunit IA, 0-339 mbsf) comprises Pleistocene to upper middle Miocene foraminifer nannofossil ooze to nannofossil ooze with foraminifers. Foraminifer content is significantly higher than at previous Leg 130 sites (Sites 803-805) and is estimated as between 15% and 30%, on average. Radiolarian content is low. Bioturbation is common throughout; it appears to be more strongly expressed than at the previous sites. "Liesegang" banding is common throughout the subunit, although fainter and more diffuse in appearance than at Sites 803 to 805. The best examples are near the bottom of the subunit. Authigenic pyrite was found associated with burrows, and a slight odor of H_2S was noted on occasion upon opening the cores. Microfaulting was rare. Sediments are generally soft, but in the lowermost part of Subunit IA more lithified intervals appear (below 200 mbsf). Coring was impeded in one instance owing to porcellanite nodules (310 mbsf, ca. 8.2 Ma, Core 130-806C-34X) near the level of APC refusal. The shallowest porcellanite nodules were found at 240 mbsf (ca. 6.7 Ma). A marked change in the velocity depth gradient (associated with a brief reversal) occurs just above this depth level (at 220 mbsf). At the ooze/chalk transition (339 mbsf), the character of the velocity profile changes: above this level highfrequency variations are pronounced; below it, they are indistinct.

Subunit IB (339-776.4 mbsf), consists of 436 m of foraminifer nannofossil chalk to nannofossil chalk with foraminifers, with a few intervals of nannofossil chalk, ranging from the lower upper Miocene to the upper Oligocene. Foraminifer content is high down to about 600 mbsf (ca. 20 Ma) and decreases below that level. Radiolarian content is low throughout.

The color is predominantly white. Color banding occurs throughout; bands become thinner and more distinct with depth in the subunit. Small-scale flaser bedding is present. Bioturbation is ubiquitous. Rare, centimeter-size porcellanite nodules were observed at several levels (350 mbsf, 510 mbsf). The depth gradient of dissolved silica is reduced at 350 mbsf and between 450 and 550 mbsf, possibly in response to precipitation.

The Oligocene/Miocene boundary lies between 740 and 750 mbsf and apparently is without hiatus (although recovery is poor at this level). Sedimentation rates for the deep chalk section vary between 20 and 30 m/m.y., the same as for the upper portion of the chalk subunit.

Paleomagnetic stratigraphic determinations were attempted for the uppermost section of Holes 806B and 806C. The Brunhes/Matuyama boundary could not be identified. However, magnetic susceptibility seems to be measurable well into the Pliocene, opening the possibility for the study of Milankovitch-type cycles using magnetic properties.

Chemical gradients in interstitial waters at this site are generally similar to those at Sites 803 to 805, reflecting the calcareous/siliceous nature of the sediments and the paucity of organic material. A somewhat higher supply of organic matter at this site, presumably owing to the shallower depth, tends to produce slightly stronger gradients. Sulfate concentrations especially show this influence of organic supply and decrease by almost 50% over the length of Hole 806C, with most of the decrease occurring by 222 mbsf. Alkalinity increases correspondingly in the upper section but decreases below 250 mbsf presumably in response to precipitation of carbonate. Calcium and magnesium gradients are influenced by basalt-alteration reactions at depth and show the usual negative correlation. Strontium concentrations reflect recrystallization processes, which apparently are more vigorous here than at the previous sites, owing to the higher sedimentation rates.

Dissolved silica shows a steady increase with depth except for a minor reversal of this trend near the ooze/chalk transition (350-360 mbsf).

Excellent logs were obtained for sound velocity and density at Site 806. The fact that this site is characterized by continuous sedimentation makes these logs especially valuable. Laboratory velocities and bulk densities provide control for the upper part of the record, which could not be logged. Bulk density and sound velocity increase with depth more or less as expected. Bulk-density values are near 1.6 g/cm3 at 100 mbsf and increase to 1.9 g/cm3 by 700 mbsf. If expressed as average density increase per age interval (0.15 g/cm3 per 10 Ma), the overall gradient is exactly identical to that of Site 586. It is noticeably higher than that of Site 805, which has a distinctly lower sedimentation rate. Thus, both depth of burial and age govern this parameter. Sound velocity is 1.65 km/s at 100 mbsf, and increases by 0.13 km/s per 100 m down to 250 mbsf, where the gradient changes to 0.18 km/s per 100 m. The stronger gradient presumably shows the effects of carbonate precipitation below 250 mbsf, as seen in the interstitial water measurements.

<u>Site 807</u>

Site 807 is located on the northern margin of the Ontong Java Plateau (latitude 3°36.4'N, longitude 156°37.5'E, 2810 m water depth; Fig. 2). The site was positioned using an R/V *Thomas Washington* SCS line acquired during the EURYDICE cruise 9 survey (1975); it was resurveyed during Leg 130. Site 807 is located on the northern rim of the high plateau, roughly 475 km northwest of DSDP Site 289/586, within a shallow basement graben about 0.5 km from the footwall of the northern side of the graben. The sedimentary section is thick, about 1.13 s of twoway traveltime in the SCS profile, and shows layering disturbed by only minor thickening along the graben walls in the lower portion of the section. This site appeared to offer the best opportunity for recovering one of the most complete depositional sequences present on the plateau as well as basement samples.

Site 807 was occupied for 24.3 days. 1701.2 m of Neogene, Paleogene, and Upper Cretaceous sediments were cored, 533.0 m by APC (101.9% recovery), 568.5 m by XCB (79.8% recovery), and 599.7 m by RCB (27.4% recovery). 148.7 m of basement (dated as Early Cretaceous) was cored, representing the deepest basement penetration yet achieved on a Pacific oceanic plateau, and recovered 87.6 m of basalt and 0.6 m of interbedded sediment. Three holes were drilled as follows: Hole 807A was APC cored to 254.4 mbsf and XCB cored to 822.9 mbsf, Hole 807B was APC cored to 278.6 mbsf, and Hole 807C was RCB cored from 780.0 to 1528.4 mbsf. Holes 807A and 807C also were successfully logged to total depth, and a complete set of geophysical measurements was obtained (including FMS data from Hole 807C).

The recovered sediments were divided into three lithologic units. Unit I (0-968.0 mbsf) is composed mainly of Pleistocene to upper/middle Eocene nannofossil ooze and chalk with foraminifers, with lesser amounts of foraminifer nannofossil ooze and chalk as well as nannofossil ooze and chalk. Unit I (968.0-1351.4 mbsf) is composed of upper/middle Eocene to upper Campanian limestone, chert, nannofossil chalk and nannofossil chalk with foraminifers. Unit III (1351.4-1379.7 mbsf) is composed of lower Cenomanian to upper Albian-Aptian claystone and siltstone with varying amounts of radiolarians and limestone. Igneous basement at Site 807 is represented by one lithologic unit, Unit IV (1379.7-1528.4 mbsf), which is predominantly composed of Albian-Aptian basalt.

The record is continuous from the Pleistocene to the upper Oligocene where a stratigraphic break occurs at 702.4 mbsf (ca. 2830 Ma), the first of four stratigraphic breaks encountered above the Cretaceous/Tertiary boundary. Other breaks occur in the middle Eocene at 996.8 mbsf, at 1073.0 mbsf, and at 1094.8 mbsf (ca. 4043 Ma, 45-46 Ma, and 47-50 Ma respectively). Much of the Paleocene to middle Eocene section is condensed, except for part of the upper Paleocene. The K/T boundary was crossed at 1193.2 mbsf, with an apparently complete boundary sequence recovered. The section below the K/T boundary also probably includes one or more stratigraphic breaks, in particular between the upper Campanian limestone and the lower Cenomanian claystone-siltstone sequences at 1351.4 mbsf and near the Aptian-Albian limestone basalt contact at 1379.7 mbsf in Core 130-807C-74R.

Sedimentation rates decreased from 20 m/m.y. in the late Maestrichtian to about 3 m/m.y. in the early Paleocene. Mid-ocean volcanism, probably of hot-spot origin, apparently was initiated on or near the Ontong Java Plateau in latest Maestrichtian time, as evidenced by the ash layer deposited just below the K/T boundary at Site 807. The volcanism peaked in the late Paleocene (ca. 57 Ma) and then receded, disappearing entirely by middle Eocene time (ca. 54 Ma). After an initial low of 2 m/my in the early/middle Eocene (ca. 54-51 Ma), sedimentation rates increased in the Paleogene, peaking at 35 m/m.y. in the late middle Eocene (ca. 45-43 Ma). Hiatuses, however, also occurred in the middle Eocene (ca. 50-47 Ma, 46-45 Ma, and 42-40 Ma). Volcanism was initiated again in early-late Oligocene time (ca. 3226 Ma), this time perhaps of tectonic origin as a result of flexure of thick plateau crust as the Ontong Java Plateau crossed the outer rise of the Melanesian Trench and docked against the Melanesian Arc. A jump in sedimentation rate to 38 m/m.y. occurred in the early Oligocene (ca. 32-30 Ma), followed by another hiatus (ca. 28-30 Ma). Deposition thereafter was uninterrupted. Sedimentation rates ranged from 30 m/m.y. across the Oligocene/Miocene boundary (ca. 28- 22 Ma), through 16-18 m/m.y. in the early to early late Miocene and early Pliocene (ca. 22-4 Ma), to 44 m/m.y. in the late Miocene (ca. 85 Ma) before dropping to the Quaternary rate of about 15 m/m.y.

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Table 1. Leg 130: Site Occupation Summary

Hole	Latitude (°N)	Longitude (°E)	Water Depth*	Number of Cores	Cored (m)	Recovered (m)	Percent Recovered	Penetration (m)
803A	02°26.01'	160°32.48'	3477	6	55.5	57.99	104.49	544.5
803B	02°26.01'	160°32.48'	3484	7	61.3	58.18	94.91	61.3
803C	02°25.99'	160°32.45'	3669	23	218.5	226.13	103.57	237.5
803D	02°25.99'	160°32.45'	4080	71	656.0	494.96	75.45	656.0
804A	01°00.28'	161°35.62'	3922	6	48.7	50.52	103.74	48.7
804B	01°00.28'	161°35.62'	4010	15	137.7	141.61	102.84	137.7
804C	01°00.28'	161°35.62'	4185	33	312.5	273.78	87.61	312.5
805A	01°13.68'	160°31.76'	3250	6	50.5	52.22	103.41	50.5
805B	01°13.68'	160°31.76'	3671	50	473.3	444.89	94.00	473.3
805C	01°13.69'	160°31.77'	3810	64	611.0	495.46	81.09	611.0
806A	00°19.11'	159°21.68'	2616	9	83.7	85.95	102.69	83.7
806B	00°19.11'	159°21.69'	3264	78	743.1	666.36	89.67	743.1
806C	00°19.11'	159°21.70'	3308	62	587.6	523.62	89.11	776.4
807A	03°36.42'	156°37.49'	3638	86	822.9	716.74	87.10	822.9
807B	03°36.39'	156°37.49'	2817	30	278.6	280.18	100.57	278.6
807C	03°36.37'	156°37.48'	4345	93	748.4	52.84	33.78	1528.4

*Depths are drill-pipe measurements corrected to sea level.

LEG 132: ENGINEERING PROSPECTUS

INTRODUCTION

Leg 132 (Engineering Leg II) is the second of a series of cruises designed to support the development and operational refinement of hardware and techniques that will be required to meet the ODP scientific mandate of the future. Since the technical complexity of high-priority scientific problems continues to grow, so does the demand for dedicated ship time. Although ODP/TAMU continues to emphasize thorough shore-based testing of developmental equipment, these tests cannot adequately model the offshore marine environment in which the tools are to be operated. Dedicated engineering legs are therefore invaluable to successful attainment of the required technology.

LEG 132 ENGINEERING OBJECTIVES

Leg 132 is scheduled to depart Pusan, Korea, on 7 June 1990 and arrive in Guam on 5 August 1990. Engineering goals will remain a priority throughout the leg. However, several important scientific objectives may also be investigated. The leg will be 59.0 days long and will conduct coring operations in three distinct areas of the western and central Pacific Ocean (Fig. 1). Three sites (ENG-5, ENG-6 and ENG-7) will be occupied (Table 1). Each site has been selected to maximize the value and efficiency of the engineering test objective while at the same time providing an opportunity to obtain valuable scientific information in the selected areas.

During the first dedicated engineering leg, Leg 124E, the concept of deploying a mining-type diamond coring system (DCS) from a floating vessel was demonstrated to be feasible. Though the objective to core in basement (basalt) was not accomplished during Leg 124E, a significant amount of operational and technical information was obtained. The DCS was deployed in weather and heave conditions that in many instances exceeded original design parameters. The handling and operational characteristics of the core-drill platform are now well defined. As a result of the DCS testing on Leg 124E, modifications to the DCS platform, top drive, secondary heave compensator, and coring equipment will allow the system to be streamlined and made operationally more efficient for Leg 132 tests.

Primary engineering goals for Leg 132 include evaluating the DCS system in problematic geologic environments, and testing new techniques for spudding and controlling unstable formations. As such, the test plan for Leg 132 is focused on the ability to spud a hole in bare rock, stabilize fractured or unstable formations, and deploy the DCS for coring operations in crystalline rock, interbedded chalk/chert formations, and in shallow-water carbonate formations prevalent on atolls and guyots. At this time, DCS technology holds the most promise for successfully achieving future scientific objectives in these environments. In addition, it is anticipated that the coring system will be tested at higher speeds (200-500 rpm) and be deployed to deeper operating depths (2700-3000 m) than during Leg 124E.

<u>Primary Engineering Goals</u>

(1) Evaluating the overall performance and efficiency of the Phase II (4500-m capability) DCS in water depths ranging from 1000 to 3000 m. The DCS is to be evaluated in three distinctive geological environments.
(2) Deploying and testing the new "mini" hard-rock guide base (HRB) designed for more efficient and economical spudding on bare or fractured rock.
(3) Deploying and testing a modified re-entry cone designed for compatibility with the DCS mini-riser tensioning system.
(4)Evaluating techniques and hardware for establishing and maintaining upper hole stability to allow successful deployment of the DCS for operational scientific coring in unstable formations.
(5) Evaluatine the HRB or re-entry cone/API drill string tensioning system for possible future use as a drill-string mini-riser.

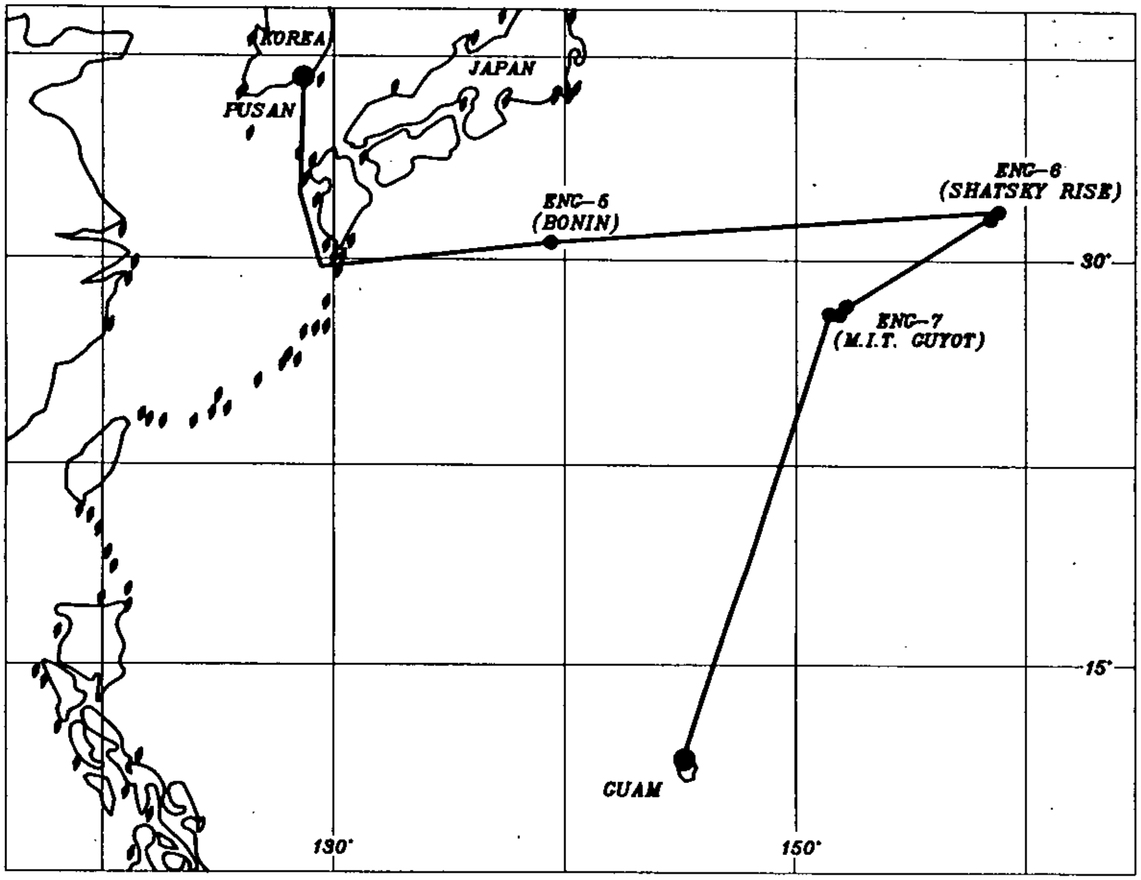

Figure 1. Location of sites proposed for drilling on ODP Leg 132.

Specific Engineering and Operational Objectives for Leg 132:

Mini Hard-Rock Guide Base/Upper Hole Stabilization

(1) Test gimbal concept for greater rotational freedom of re-entry cone.
(2) Evaluate use of weighted cement (with steel punchings) for ballast.
(3) Evaluate use of ODP API drill pipe as a min-riser in deeper water and at higher rpm than was attempted on Leg 124E. Note: There is no plan to include return circulation to the rig floor at this time.
(4) Install and evaluate performance of a new tapered stress joint above the breakaway mechanical tensioning device.
(5) Evaluate use of a mechanical tensioning tool to hold tension on guide base.
(6) Test a modified 16-inch casing hanger designed to accept a mechanical testing tool and landing seat for a modified back-off sub.
(7) Evaluate drill-in/back-off release mechanism allowing use of the bottom hole assembly (BHA) for spudding in bare, fractured rock and for upper hole stabilization.
(8) Evaluate adaption of mini-riser tensioning system to standard re-entry cone design.

Diamond Coring System Phase II 4500-Meter Capability

(1) Continue evaluation of DCS in offshore environment.
(2) Operate and evaluate an upgraded version of the HQ-3 core-barrel system.
(3) Test redesigned heavy-duty, self-winding wireline winch for core-barrel retrieval.
(4) Operate and evaluate upgraded dual-cylinder secondary heave-compensation system with simplified computer network.

(5) Evaluate use of safer, operationally improved, DCS platform.
(6) Operate and evaluate new electric top-drive system with higher load and higher torque capability.
(7) Deploy and evaluate high strength tubing (DCS core string) in a production mode and locate nodal vibration points at varied rpm and string lengths.
(8) Evaluate new umbilical design for DCS platform.
(9) Evaluate new upgraded DCS mud-pump system.
(10) Evaluate performance of new hybrid drill-in bit for drilling BHA into fractured basalt.

LEG 132 DRILL SITES

Site ENG-5 (Table 1) is located east of Kyushu and south of Yokohama, Japan, in the Bonin back-arc basin. This site will be occupied for approximately 20.8 days while evaluating the "mini" HRB, bare-rock spudding/hole-stabilizing techniques, and performance of the improved Phase II (4500-m) DCS in fractured crystalling rock.

Site ENG-6 is located ~912 nmi east of ENG-5 on the Shatsky Rise. About 13.8 days will be spent at this site deploying a modified re-entry cone/casing system and coring with the DCS through interbedded chalk/chert sequences. If the new version of the Navi-Drill core barrel (NCB) and sufficient time are available, the NCB may be deployed and evaluated in an adjacent XCB hole.

The third site, ENG-7), is located southwest of the Shatsky Rise on M.I.T. Guyot. A back-reef site is proposed, and two other sites, one a reef site and one a lagoonal site, have been identified as alternatives. A total of 11.9 operational days is scheduled for this site, during which another "mini" HRB system will be set. Coring operations with the DCS through reefal limestone formations will be conducted. Again, pending hardware and time availability, the NCB coring system may be deployed and evaluated in an adjacent borehole.

LEG 132 ENGINEERING AND DRILLING OPERATIONS TEST PLAN

Test Plan for Site ENG-5

Upon arrival in the vicinity of ENG-5 (Bonin backarc) an optimum "bare-rock" site location will be selected during an underwater television survey. A pilot hole (Hole A) will be spudded and drilled using a conventional 9.5-inch positive displacement mud motor (PDM). Drilling this hole will establish the degree of formation stability and will determine the number of drill collars that can be conservatively drilled at the primary HRB location (Hole B). Hole A will also provide information necessary for proper location of the back-off sub in the drilling BHA. Hole A will be drilled with a standard tricone bit, so there will be no provision for recovering core.

After completing a drill-pipe round trip, the new "mini" HRB will be deployed and landed on the seafloor. Another pipe trip will be made to make up the drilling BHA and back-off sub. That assembly will re-enter the HRB and be drilled with the PDM to the appropriate depth. After landing and latching the lower portion of the BHA in the HRB, it will be released using a back-off sub. The released collars will provide the casing required for deploying and coring ahead with the DCS system. A round trip will then be made to remove the PDM and deploy the mini-riser tensioning joint. Once the API drill string has reengaged the HRB assembly, then the DCS coring system will be deployed. The plan is to core at least 150 m beyond the emplaced BHA in the fractured, bare crystalline rock environment.

Test Plan for Site ENG-6

Evaluation of the DCS at ENG-6 (Sahtsky Rise) will differ from the bare rock deployment at ENG-5 in that there will be soft sediment overlying chert/chalk horizons at ~125 mbsf. At this site a conventional pilot hole (jet-in test) will be conducted (Hole A) prior to deploying a modified re-entry cone with attached 16-inch conductor pipe (Hole B). Modification of the standard ODP re-entry cone will allow attaching the API drill string (5-inch or 5.5-inch pipe) and tensioning as was done with the mini HRB at ENG-5. Once the re-entry cone and casing have been installed, a round trip will be made to make up the drilling BHA and back-off sub. That assembly will then be deployed as described for ENG-5. The plan for the hole is to core a minimum of 150 m beyond the emplaced BHA into an interbedded chert/chalk formation.

Test Plan for Site ENG-7

At site ENG-7 (M.I.T. Guyot), DCS operations will be conducted on an atoll containing shallow-water reefal limestone formations. Upon arrival in the vicinity of ENG-7, an optimum "bare-rock" site location will be selected during a limited underwater television survey. A pilot hole (Hole A) will be spudded and drilled using a conventional 9.5-in positive displacement mud motor (PDM). Drilling the hole will establish the degree of formation stability and will determine the number of drill collars than can be conservatively drilled in at the primary HRB location (Hole B). Hole A will also provide information necessary for proper location of the back-off sub in the drilling BHA. Hole A will be drilled with a standard tricone bit, with no provision for recovering core.

After completing a round trip, the second "mini" HRB of the leg will be deployed and landed at the sea floor. Another round trip will be made to make up the drilling BHA and back-off sub. That assembly will re-enter the HRB and be drilled with the PDM to the appropriate depth. After landing and latching the lower portion of the BHA in the HRB, it will then be released using a back-off sub. The released collars will provide the casing required for deploying and coring ahead with the DCS system. The plan is to core at least 150 m beyond the emplaced BHA into the shallow-water reefal limestone formations.

SCIENTIFIC OBJECTIVES

The scientific objectives of Leg 132 are closely related to the development and successful use of the DCS. The DCS is designed to improve both coring and recovery of rock. Leg 132 will test the DCS in three environments. A successful test in each should provide materials of sufficient coherence and continuity to understand detailed relationships of lithology, stratigraphy, and diagenesis or alteration.

Although only a nominal 150 m of corir is planned at each site, the results will have a bearing on plans for drilling in similar environments elsewhere. The three environments are: (1) fractured, uncemented pillow basalts in axial, hydrothermally active regions of spreading ridges; (2) Mesozoic sequences of layered chert-porcellanite and chalk with alternating hard-soft characteristics; and (3) reef-lagoon deposits with contrasting coarse (loose) and fine-grained (firm) characteristics atop a Cretaceous guyot in the western Pacific. Previous experience with conventional rotary coring procedures is that although coring can proceed in the chert/chalk and reef/lagoonal facies, recovery is typically too poor, particularly in the soft or coarse intervals, to provide either biostratigraphic control or sufficient material for study of the pore fluids and the mechanisms of diagenesis. Critical intervals, which we have reason to believe should exist based on exposures of comparable age on land (e.g. black shales rich in organic carbon), have apparently been missed in several of the chert/chalk sequences cored in the Pacific to date.

In pillow basalts at young ridges, coring results have been even worse. The drilling literature concerned with this is replete with accounts of torn-up core bits, blown-off BHAs, poor (or no) recovery, and endlessly foiled attempts to drill holes more than a few tens of meters deep. Coring such basalts has been a major concern of scientists interested in crustal drilling, and was an important motivation in the development of the DCS. The results of drilling on Leg 132 will determine the feasibility of two drilling legs planned for the East Pacific Rise in 1992-3.

The location targeted for ENG-5 is at or near an axial volcanic high not covered by turbidites from the nearby arc. Submersible observations (Taylor, Brown *et al.*, 1990) establish that the terrain is primarily pillow basalts thinly dusted with sediment. Site selection will be based on a pre-drilling television survey to find the best location for a bare-rock guide base.

At ENG-6, the target is a bedded chert-chalk sequence of Aptian-Albian age beneath an unconformable cap of largely eroded Paleogene-Neogene chalks and oozes ~125 m thick exposed on a flank of Shatsk Rise (Fig. 1). Previous drilling on DSDP Legs 6, 32 and 86 (Fischer, Heezen *et al.*, 1971; Larson, Moberly *et al.*, 1975; Heath, Burckle *et al.*, 1985) recovered primarily broken chert or porcellanite fragments in materials of this age from Shatsky Rise. The sedimentary rocks are of interest because they were deposited in moderate depths. Thus, they presumably preserve both siliceous and calcareous microfossil assemblages that were not all preserved in deeper waters at these times. Moreover, coring elsewhere in the Pacific together with observations in Franciscan exposures in California (Sliter, 1989) suggest that the intervals of high silica productivity recorded by the cherts was associated with or punctuated by intervals of anoxia, which may have been widespread at certain levels in the water column during the Cretaceous. Although scattered organic-rich sediments deposited at these times requires the precise multifaunal biostratigraphic control that only continuous recovery can provide.

Finally, at ENG-7, we plan to core both eroded reefal and lagoonal facies atop M.I.T. Guyot in the western Pacific (Fig. 1). Guyots with their flat summits were first described as simple wave-beveled volcanic islands that subsided below sea level (Hess, 1946). Expeditions in 1951, 1970 and 1988, however, showed that many guyots are capped with calcareous reefs of generally mid-Cretaceous age (Hamilton, 1956; Matthews *et al.*, 1974; Heezen *et al.*, 1973; Winterer *et al.*, 1989). The latest expedition established that a number of guyots are actually drowned and submerged atolls with thick reefs enclosing well stratified lagoonal sediments. Multibeam high-resolution bathymetric surveys revealed a characteristic summit morphology of a well defined reef perimeter enclosing an interior with complex relief, but in general indicating partial removal of uppermost lagoonal sediments by processes of karsting and wave erosion during periods of emergence of the summits in the Cretaceous.

The specific location of ENG-7 is just within the lagoonal facies in a shallow depression immediately behind a reef segment. The coring will provide the first coherent recovery of a lagoonal sequence atop a guyot, but the placement of the site will also allow recovery of coarser reefal material cast into the back reef by the action of waves and storms. Site location here will depend on results of a pre-drilling television survey required for placing a bare-rock guide base. The surface of the guyot is encrusted with ferromanganese oxides and phosphatized Cretaceous limestone, constituting a hard ground that will not allow washing in of casing conductor pipe with a conventional re-entry cone. The rocks cored below the hard ground will provide information on the lithological constitution of a central Pacific Cretaceous atoll, the community of organisms that dwelled there, and probably the mechanism of timing of reef extinction. Evidence for an interval of emergence and karst development may be derived from the diagenetic history of the rocks and the light-isotope compositions of their authigenic carbonate minerals.

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TABLE 1. LEG 132 ENGINEERING TEST PROGRAM

Site	Latitude (°N)	Longitude (°E)	Water Depth (m)	Drilling Depth (mbsf)	Drilling Time (days)	Logging Time (days)	Total Time (days)
ENG-5	31°03.00'	139°53.00'	1750	1900	20.7	0	20.8
ENG-6	32°19.60'	157°50.78'	2625	2875	13.8	0	13.8
ENG-6A	32°19.00'	157°50.75'	2625				
ENG-7	27°18.80'	151°53.15'	1360	1510	11.9	0	11.9
ENG-7A	27°18.35'	151°53.15'	1340				
ENG-7B	27°19.45'	151°53.05'	1360				

PROPOSALS RECEIVED BY THE JOIDES OFFICE

January through May, 1990

Ref. No.	Theme/Area	Author(s)	Country	Date Rcvd
365/A	Conjugate Passive Margin - N. Atlantic	J. Austin & al.	US/CAN/FR	1/90
366/A	Labrador - Greenland (Preliminary)	M.H. Salisbury	CAN	1/90
367/C	Cool Water Carbonate Margin - S. Australia	N.P. James	CAN	2/90
368/E	Jurassic Pacific Crust - Return to 801C	R.L. Larson & al.	US/UK	2/90
369/A	Deep Mantle Section in the MARK Area	C. Mevel & al.	FR	2/90
370/A	Magmatic process & Natural Tracers - Oceanographer FZ	H.J.B. Dick & al.	US/CAN	2/90
371/E	Nova-Canton Trough	K. Becker & al.	US	2/90
372/A	Water Circ. & Vertical Chem. Gradients Cenozoic	R. Zahn	CAN	2/90
373/E	Revisiting Site 505	M.D. Zoback & al.	US	3/90
374/A	Mantle Heterogen.-Oceanographer FZ	H.J.B. Dick & al.	US	3/90
375/E	Deep Crustal Drilling - Hess Deep	H.J.B. Dick & al.	US	3/90
376/A	Layer 2/3 Boundary - Vema FZ	J.M. Auzende & al.	FR	3/90
377/F Rev.	Global Network Ocean Bottom Seismoms.	G.M. Purdy & al.	US	3/90
378/A Rev.	Barbados Accretionary Wedge	R.C. Speed & al.	US/UK/FR	3/90
379/A	Mediterranean Sea	J. Mascle	FR	3/90
380/A Rev.	Clastic Apron of Gran Canaria	H.-U. Schmincke & al.	FRG	3/90
381/A	Continental Shelf and Slope of Argentina	B.T. Huber	US	3/90
382/A	Upper Mantle-Lower Crust - Vema FZ	E Bonatti	US	5/90

LEG 133: NORTHEAST AUSTRALIA PROSPECTUS

INTRODUCTION

Five physiographic regions define offshore northeastem Australia: the platforms of the Great Barrier Reef and the Queensland and Marion plateaus, and the basins of the Queensland and Townsville troughs. Drilling off northeastem Australia will allow detailed study of the evolution of these carbonate platforms and adjacent basins. Leg 133 will sample Oligocene to Holocene sediments at 12 sites along 2 transects (Fig. 1; Table 1). Scientific drilling off the northeast Australian margin has two primary objectives:

The first is to define the sedimentary response to global sea-level changes in the Late Cenozoic and Quatemary. Two approaches will be applied through the study of shelf-margin progradational onlap sequences and marginal-plateau reef stratigraphy. Along the margins of the Great Barrier Reef, low-sea-level, shelf-edge, deltaic, siliciclastic progradative and middle- and top-of-slope fans alternate with high-sea-level onlapping sequences and are overlain by high- and low sea-level aggradational couplets correlated to periods of reef growth. These sedimentary sequences are clearly visible on seismic sections and drilling will provide the ground truth essential for testing the major tenets of the global sea-level hypothesis. Sites on the upper slope close to the margin hinge will define a shallow-water sea-level signal, whereas those on the lower slope and in the Queensland Trough will define the related shelf-to-basin stratigraphy and deep-water sea-level signature.

Sites proposed for the Queensland and Marion plateaus will drill into Miocene and Pliocene reefs, which grew in oceanic situations. An absolute eustatic sea-level fall of 150-200 m in the middle to late Miocene has recently been defined from these reefs.

The second objective is to define the influence of paleochemistry, paleoclimate, and paleoceanography on the initiation, growth, and demise of carbonate platforms, and the effect of shifting from temperate to tropical latitudes (or vice versa) as a result of plate motion, on the biological and lithological facies types in an environment analogous to the Jurassic eastern margin of the U.S.A. These objectives are best achieved in pure carbonates where the climatic and oceanographic signatures are well preserved. Sites are proposed on the Queensland and Marion plateaus aimed at the Neogene and Pliocene-Pleistocene reefal and periplatform sequences. Sites in the adjacent troughs will define the relationship of facies to climate and oceanography throughout the late Paleogene and Neogene.

In addition to the primary objectives, the drill sites have been chosen (1) to define the slope-to-basin variations on both sides of a rift basin in order to evaluate facies and stratigraphic models of passive-margin evolution; and (2) to define the diagenetic history of contrasting mixed carbonate-siliciclastic and pure carbonate margins in an environment undersaturated with respect to aragonite and high-magnesium calcite at relatively shallow water depths.

Drill sites have been located along two transects: one oriented east-west across the Queensland Trough and the other north-south across the Townsville Trough.

QUEENSLAND TROUGH TRANSECT

The schematic section in Figure 2 is based on a series of tied east-west seismic profiles that extend across the Queensland Trough from the Great Barrier slope to the westem flank of the Queensland Plateau. The section illustrates the general structural style of the trough and its margins. Shallow (1.7 s TWT) planated basement tilt blocks occur beneath the westem Queensland Plateau (CDP 200-1100) and are bounded by relatively steep, westerly dipping rotational normal faults. Half grabens formed by these blocks contain easterly dipping Upper Cretaceous (?) syn-rift sections up to about 800 m thick. The tilt blocks, and in some places the synrift section, were eroded during the formation of the Paleocene "breakup" unconformity, which corresponds to the commencement of seafloor spreading in the Coral Sea Basin to the northeast.

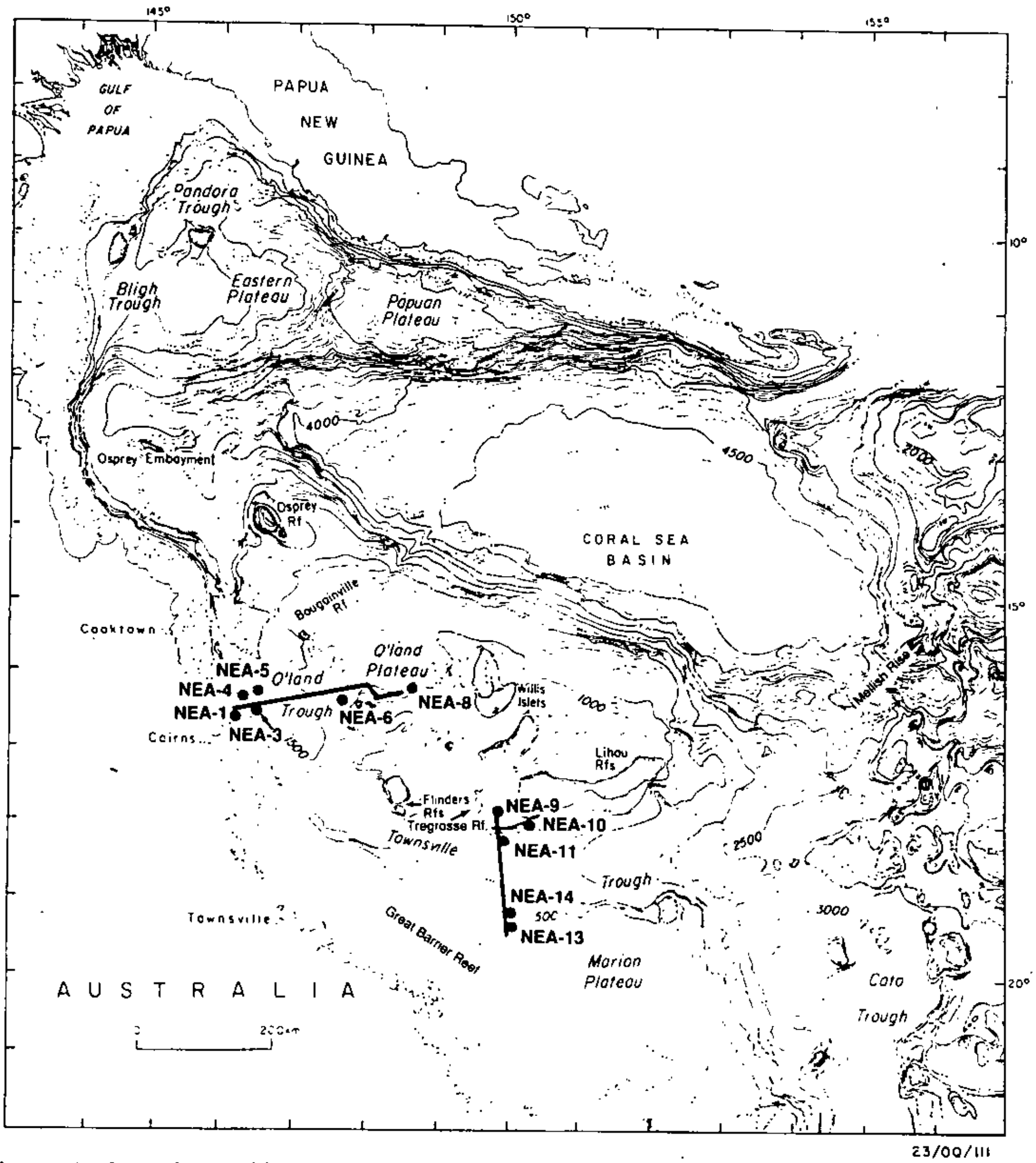


Figure 1. Locations of Leg 133 Northeast Australia proposed drill sites.

Beneath the eastern flank of the Queensland Trough (CDP 1400-1700), the dip of the faults bounding the tilt blocks switches to the east, and the corresponding syn- and pre-rift sections dip to the west. Complex faulting beneath the eastern part of the trough (CDP 1700-2000) may be related to wrenching and indicates that strike-slip movement probably played an important part in the development of the trough. A large planated basement block in the center of the trough (CDP 20002300) appears to be bounded by a major near-vertical fault on its eastern flank and a series of smaller high-angle normal faults on its western flank that progressively down-step basement to the west. This high can be identified on seismic data both north and south along the strike of the trough. West of this high, sediment thickness could be as much as 3000 m. In the center of the trough (CDP 2600-2900) another major half graben containing Cretaceous (?) pre- and syn-rift sections occurs at a depth of 3.1 s TWT. Both this section and the underlying basement tilt block are planated by the Paleocene "breakup" unconformity. The westem flank of the

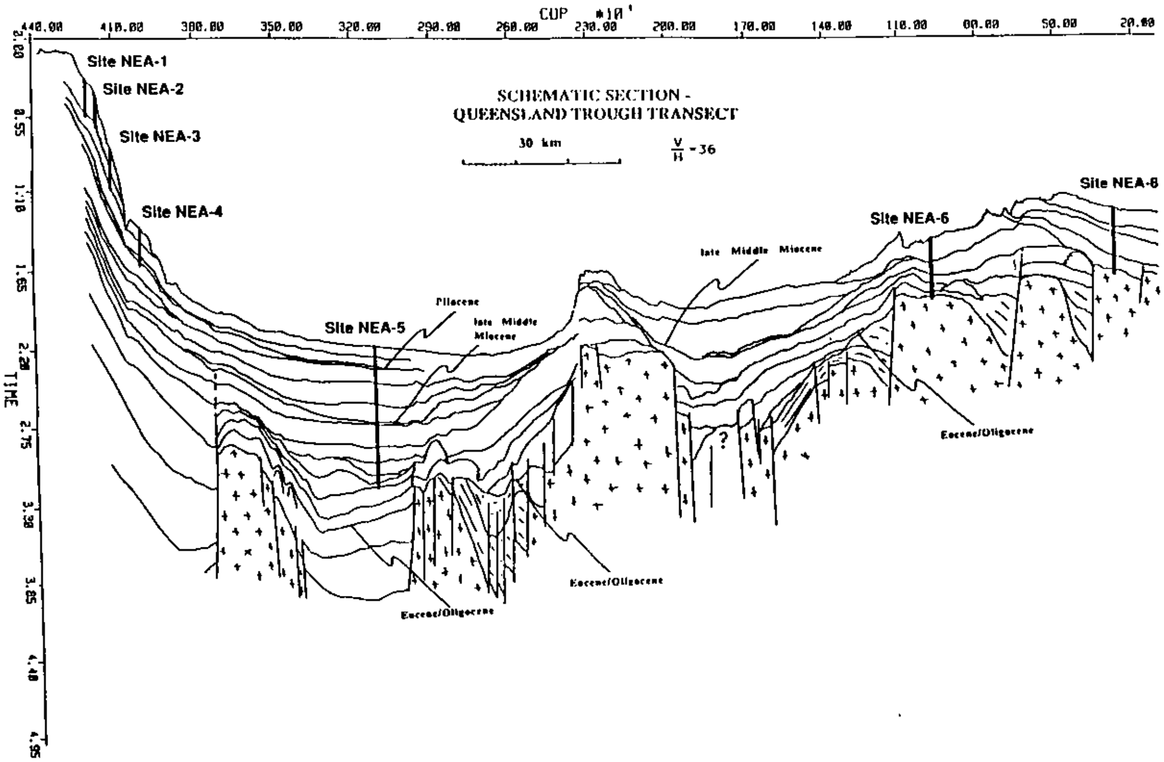


Figure 2.

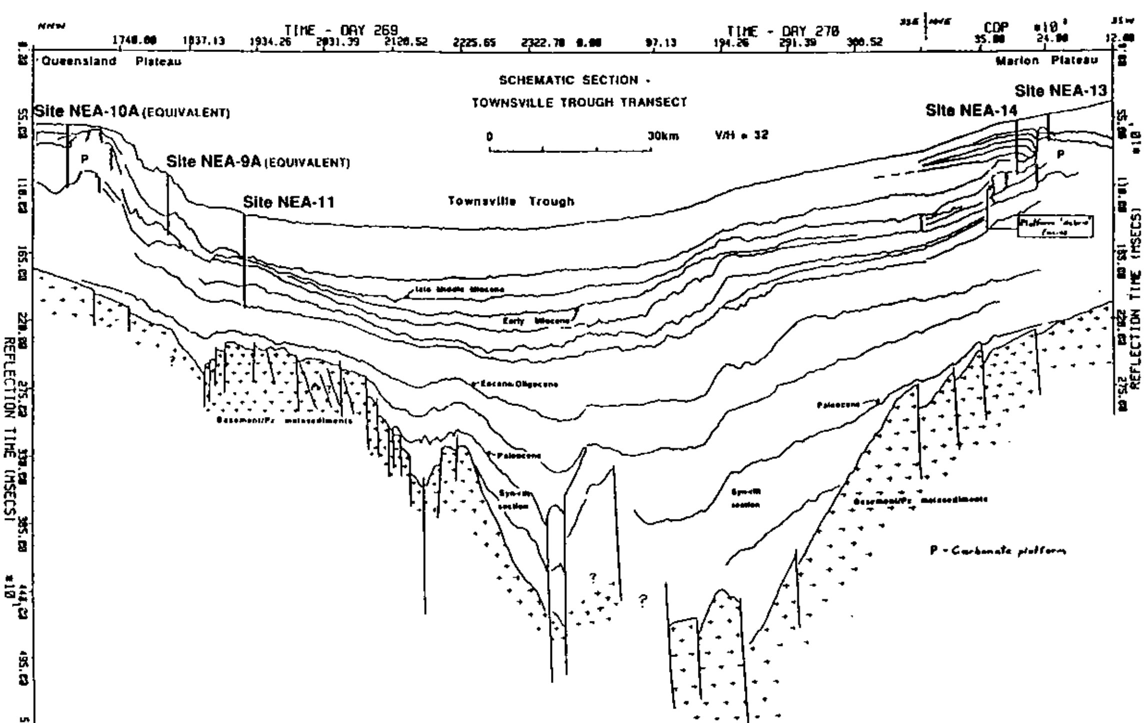


Figure 3.

high is formed by a complex vertical fault system. Another planated basement high occurs beneath the western flank of the trough (CDP 3600-3800) at a depth of 2.9 s TWT, and is bounded by high-angle faults. A broad anticline formed by flexural and compaction drape over this block extends to quite high levels (upper Miocene) within the section. The thickest sedimentary section within the trough occurs beneath its western flank, where it may be over 4000 m thick.

Pre-Oligocene mounds or buildups occur on the flanks of highs beneath the western part of the Queensland Trough, and are draped by the overlying Oligocene and upper Miocene section. Similar buildups also occur on basement highs on the western margin of the Queensland Plateau between proposed Sites NEA-6 and -8. A major lower middle Miocene buildup occurs on top of the large basement high in the center of the trough (CDP 2000-2300), associated with a substantial debris apron extending westward into the deeper part of the trough. There is a marked change in depositional style across the upper middle Miocene unconformity from essentially conformable sequences to onlapping basin-fill sequences. On the western flank of the trough the PliocenePleistocene section displays strong downlapping character and thins eastward. The thickest part of this section occurs in the prograding wedge beneath the slope of the Great Barrier Reef at Sites NEA-l to-3.

The relatively thin Miocene and younger section covering the westem Queensland Plateau (Site NEA-8) thins dramatically westward. The complexity of the sequence stratigraphy in the vicinity of Site NEA-6 is apparently a result of the interaction between trough and plateau depositional processes.

TOWNSVILLE TROUGH TRANSECT

Most of the schematic section in Figure 3 is based on two tied seismic profiles that extend across the Townsville Trough from the Queensland Plateau in the north to the Marion Plateau in the south. The northernmost part of the section in the vicinity of Site NEA-10A is entirely schematic, and is based on a combination of seismic profiles. The section illustrates the general structural style of the Townsville Trough and places sites NEA-10A, -11, -13, and -14 within a regional structural and stratigraphic framework.

The northern margin of the Townsville Trough is underlain by a relatively flat "basement" platform, which exhibits small-throw, down-to-the-north normal faults beneath the southern Queensland Plateau. In places, southward-dipping reflectors occur within the "basement" platform and may represent Paleozoic metasediments or pre-rift Mesozoic section. On this section the southern edge of the platform is basically a hinged margin that dips into the Townsville Trough and is associated only with minor down-to-basin faulting (time 269.2100-2200). Large tilt blocks, some with eroded and planated corners, occur beneath the main depocenter of the trough, which is about 70 km wide. Beneath the northern part of the trough a large tilt block up to 12 km across (time 269.2150-2330) is bounded by several relatively steep northward-dipping rotational normal faults. The half graben to the south of this block contains a southward-dipping Upper Cretaceous (?) syn-rift section up to about 1500 m thick. A switch in the direction of faulting occurs about a complex fault zone (transfer fault/accommodation zone) beneath the center of the trough (time 269.2330-2340). Fault blocks to the south of this zone are bounded by southward-dipping normal faults, and this style extends beneath the northern flank of the Marion Plateau. Thus on this schematic section the southern margin of the Townsville Trough is also a hinged or dip-slope margin formed by northward-tilted "basement" blocks bounded by southward-dipping rotational normal faults. The Upper Cretaceous (?) syn-rift section is considerably thicker beneath the southern part of the trough - up to 3000 m (1.6 s TWT) thick. Broad anticlines related to flexural and compaction drape over tilt blocks, and the edges of the bounding "basement" platforms, particularly on the Queensland Plateau side, can in places extend to quite high levels (lower Miocene) within the section (e.g., time 269.2150-2230).

The sedimentary fill within the Townsville Trough can be broadly divided into three main units: (1) an Upper Cretaceous (?) syn-rift section, which is restricted to the half grabens (as described above); (2) a Paleocene-Eocene post-breakup section, which generally onlaps the syn-rift section and the flanks of the bounding "basement" platforms; and (3) an upper Oligocene to Holocene section, which covers both the trough and the adjacent platforms. The Paleocene-Eocene section is basically a basin-fill unit, which has a relatively uniform, conformable reflection character throughout the trough. It can be up to about 2000 m thick beneath the center of the trough. The overlying upper Oligocene (?) to Holocene unit is much more variable in reflection character, both across the trough and up through the section. In the center of the trough, where it can be up to 2000 m thick, this unit commonly contains chaotic, mounded, and channeled facies, particularly toward its base, suggesting that along-trough depositional processes have been important during post-late Oligocene time. A possible lower Miocene shelf edge is evident beneath the southern part of the Townsville Trough (day 270 194.26), and the top of the main shelf edge sequence appears to correspond to the base of the "debris" facies in front of the carbonate platform at Site NEA-14. That is, the carbonate platform beneath the northern Marion Plateau (~ CDP 24 on section) appears to have built up on the inner edge of a lower Miocene shelf. The post-platform facies in this area have a prominent downlapping character and may correspond to a late Miocene-Pliocene period of current-controlled contourite deposition. An apparently older phase (late Oligocene-early Miocene) of carbonate platform development is evident beneath the southern slope of the Queensland Plateau on the northern flank of the Townsville Trough (time 269.1740-1840), and Site NEA-11 should intersect the distal facies shed into the trough in front of this platform. On the schematic section, the southern edge of the oldest part of the carbonate platform that forms the base to the modern Tregrosse reefal platform is shown. The back-platform facies east of the western edge of a younger portion of this platform will be drilled at Site NEA-10A. This is illustrated conceptionally on the northern end of the schematic profile (Fig. 3).

SITE OBJECTIVES

NEA-l

To determine the composition and origin of the most landward of the prograding and aggrading units beneath the upper slope terrace, and to define the sea-level signal within them.

NEA-2

To determine the composition and origin of the prograding and aggrading units beneath the outer part of the upper slope. This hole, in conjunction with NEA- 1, will calibrate the abrupt seismic facies variations evident on the seismic lines.

NEA-3

To determine the nature of the most distal portions of the progradational and aggradational units beneath the upper slope terrace. To determine the age and origin of the eight seismic sequences at this site. This hole, in conjunction with NEA-1 and NEA-2, will allow the investigation of a complete shelf-margin series of prograding units.

NEA-4

To define and evaluate the relationship between lower slope carbonate/silici-clastic fan facies and the more proximal facies found at Sites NEA-1 to -3, and to relate that to the sea-level signature extracted from Sites NEA-1 to -3.

NEA-5

To obtain a complete basinal section for paleoceanographic history and to correlate basin-fill response between the continental margin and the Queensland Plateau.

NEA-6

To understand slope processes in an exclusively carbonate system and to determine the age of the reef platform and timing of the onset of pelagic sedimentation. To determine the sea level, oceanographic, and climatic control in the Pliocene-Pleistocene periplatform sediments shedding from the western margin of the Queensland Plateau.

NEA-8

To sample the periplatform sequence and to determine the sea level and climatic signals for comparison with Sites NEA-l to NEA-3. To determine the timing and mode of origin of the uppermost reef horizons.

NEA-9A

To determine the composition and origin of the slope units immediately seaward of the Neogene carbonates of the southern margin of the Queensland Plateau. To compare the history and processes operative on the mixed carbonate/siliciclastic continental margin sites.

NEA-10A/1 and -10A/2

To determine the origin of platform-top carbonates, the history of drowning, and the paleoclimatic signal in the overlying periplatform ooze.

NEA- 11

To obtain stratigraphic and age data to tie event stratigraphy in the Townsville Trough. Furthermore, to obtain paleoclimatic data on the change from temperate to tropical climates as Australia drifted north in the Neogene. To determine the age and origin of carbonate deposition on the Queensland Plateau.

NEA- 13

To determine the nature and age of the buildups on the northern edge of the Marion Plateau, the minimum position and timing of the middle Miocene sea-level fall, and to determine the cause(s) of demise of these buildups.

NEA- 14

To establish the composition and age of the forereef, the downlapping and onlapping sediments that overlie the platform, and to establish the cause and timing of the demise of the platform. To establish the paleoclimatic history and the facies response to climatic variation and the initiation of boundary-current activity. To determine the composition and age of the pre-reef sediments.

DRILLING PLAN

Sites approved by the JOIDES Pollution Prevention and Safety Panel for drilling on Leg 133 are shown in Table 1. The drilling schedule was designed noting: (1) the need to drill the platform sequences before the basin sequence in the Townsville Trough, and (2) the logistical advantage of coring the western slope of the Queensland Trough at the end of the cruise, thus reducing the transit time to Townsville.

Leg 133 is scheduled to depart from Guam on 10 August 1990. Drilling operations will begin on 16 August at NEA-8. From there the ship will proceed to NEA-10A/1, -10A/2, -13, -6, -5, -4, -2, and -3. In accordance with JOIDES policy, logging (i.e., the standard Schlumberger logs plus the formation microscanner, or FMS) is currently planned for all sites drilled to 400 mbsf or deeper; in addition, logging is planned for other (shallower penetration) sites of interest. A vertical seismic profile (VSP) is scheduled for Site NEA-2, and the wireline packer will be run at Site NEA-10A/1 (and possibly also at Site NEA-13). However, this program may need to be revised if more vertical seismic profiling is considered necessary, drilling difficulties are encountered, and/or additional water samples are required. In addition, a prototype of the Vibra Percussive Corer (VPC) system, currently under development by the ODP Engineering and Drilling Operations Department, will also be tested at one or more sites. The ship will arrive in Townsville on October 11.

TABLE 1. LEG 133 NORTHEAST AUSTRALIA

Site	Latitude (°S)	Longitude (°E)	Water Depth (m)	Drilling Depth (mbsf)	Drilling Time (days)	Logging Time (days)	Total Time (days)
NEA-1	16°38.6'	146°17.3'	206	400	1.8	0.9	2.7
NEA-2	16°38.3'	146°18.3'	272	400	2.2	1.2	3.4
NEA-3	16°37.3'	146°19.6'	555	400	2.0	0.9	2.9
NEA-4	16°25.3'	146°12.7'	960	400	2.4	0.9	3.3
NEA-5	16°36.9'	146°47.1'	1638	1011	7.7	1.3	9.0
NEA-6	16°26.7'	147°45.8'	1000	390	3.1	0.8	3.9
NEA-8	16°31.1'	148°09.4'	934	400	2.9	0.8	3.7
NEA-9A	18°03.7'	150°02.6'	739	500	3.5	0.9	4.4
NEA-10A/1	17°48.8'	149°36.3'	455	500	23.1	1.2	4.3
NEA-10A/2	17°50.0'	149°30.9'	505	300	2.4	0.0	2.4
NEA-11	18°09.5'	149°45.5'	1005	700	5.4	1.0	6.4
NEA-13	19°12.0'	150°00.6'	426	250	2.2	0.7	2.9
NEA-14	19°12.0'	149°59.5'	456	400	28	09	3.7

ODP SITE SURVEY DATA BANK REPORT

The JOIDES/ODP Data Bank received the following data between August 1, 1989 and March 31, 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 E. Davis and B. Sawyer (PGC, Canada): SeaBeam bathymetry, SeaMARC II images, seismic reflection profiles, and navigation, magnetics, sediment thickness and heat flow charts, Middle Valley area of the "Sedimented Ridges" drilling proposal.
- From A. Taira (ORI, Japan): SeaMARC mosaic image of the Nankai Trough area.
- From B. Bornhold (PGC, Canada): Piston core locations and descriptions in the Patton-Murray Seamount area.
- From R. Larson (URI): Unprocessed seismic profiles collected by SUROIT in the Pigafetta and East Marianas Basins in support of Leg 129 ("Old Pacific") drilling.
- From U. Albright (SIO): Magnetic tape of digital underway geophysics merged with navigation for VENTURE Leg 1 (THOMAS WASHINGTON Site Survey of the Eastern Equatorial Pacific).
- From S. Cande (LDGO): Preliminary processings of CONRAD 2901 multichannel seismic profiles in the Chile Triple Junction area, along with preliminary SeaBeam charts and digital underway geophysics merged with navigation.
- From G. Westbrook (U. of Birmingham, UK): Cruise report of CHARLES DARWIN 36/88 GLORIA cruise in the Chile Triple Junction area.
- From D. Fornari (LDGO): Videotapes of ARGO data collected during VENTURE 3 site survey of the East Pacific Rise (9°-10°N) area.
- From E. Winterer (SIO): Processed single channel seismic profiles from ROUNDABOUT cruise 11 in the M.I.T. Guyot area, for Engineering Leg II site ENG-7.
- From D. Fornari (LDGO): Charts showing locations of hydrothermal features in the East Pacific Rise area, from survey work carried out by VENTURE cruise 3.
- From K. Crane (LDGO): Atlas of East Pacific Rise thermal data, consisting of folio sheets showing depths to particular isotherms and isopychnals.
- From J. Hawkins (SIO): Seismic reflection profiles from ROUNDABOUT 14 site survey of Lau Basin.

PLANNING COMMITTEE MEETING SUMMARY

The Planning Committee meeting of 24-26 April 1990 was hosted by the Société Géologique de France at the Université Pierre et Marie Curie in Paris, France. Adjustments to the FY91 Program Plan, the 4-year general plan, and long-range planning were the focus of the discussions.

FY91 PROGRAM PLAN

PCOM adjusted this plan after hearing about trans-Pacific transits and the meeting of the EPR-DPG. It is virtually the same through Leg 135, Lau Basin, ending at Suva about 12 February 1991; the vessel will, however, transit east *via* Honolulu. Inserted is a leg of about 2 weeks (Honolulu to Honolulu) to drill and case to basement a re-entry hole north of Oahu for eventual emplacement of a digital seismograph. The next leg is for engineering operations to log and attempt to mill the junk from 504B. Next is the Eastern Equatorial Pacific Neogene Transect leg, ending in earliest summer, 1991; then Sedimented Ridges I, followed by either deepening of 504B, if that hole is cleared, or by a joint Engineering-Science leg on the East Pacific Rise. The Program Plan tentatively ends in Panama on 30 October, 1991. If the last FY91 leg is to deepen 504B, then the first FY92 leg will be the joint Engineering-Science leg on the East Pacific Rise.

THE 4-YEAR GENERAL PLAN

After examining how the four thematic panels ranked the programs, and seeing how those programs were distributed around the globe, PCOM approved the following motion: *Recognizing the thematic priorities of the advisory panels, the Planning Committee has decided that the JOIDES RESOLUTION will operate in two areas in the four years beginning April 1990, i.e., the Atlantic Ocean north of the equator and the Pacific Ocean. A preferred scenario is that the ship will continue in the Pacific until October 1992 and transit then to the Atlantic for a program that will continue through the completion of this 4-year plan.*

This means that beyond the legs in the current FY90 and 91 Program Plans, FY92 will be in the Pacific, and FY93 and at least the first half of FY94 will be in the North Atlantic.

Preparation for FY92 Program Plan

PCOM will decide on its FY92 plan at the Annual Meeting in Hawaii in late November 1990. Essentially, that will mean selecting six legs in the Pacific from among those ranked highest by the thematic panels (that will be either six science legs, or one engineering-science leg followed by five science legs if deepening 504B ends FY91).

A FY92 Prospectus assembled by the JOIDES Office for FY92 Pacific drilling will include 9 programs (Table 1). The appropriate components of the third and final CEPAC Prospectus will be the basis of the FY92 Prospectus. Also the prospectus will hold the reports from the East Pacific Rise DPG (which just met) and the Cascadia Margin DPG (which meets in early August), and any update from the proponents of the Hess Deep and Peru Gas Hydrates proposals.

In July SSP will scrutinize the data for the 9 programs. The thematic panels, at their fall meetings, will rank the programs in the prospectus; that probably will resemble the just-completed ranking, but may differ depending on DPG reports, SSP analysis of data, number of legs and their sequence, tool development, or newly reviewed proposals from any ocean. PCOM will determine the FY92 Program Plan in November.

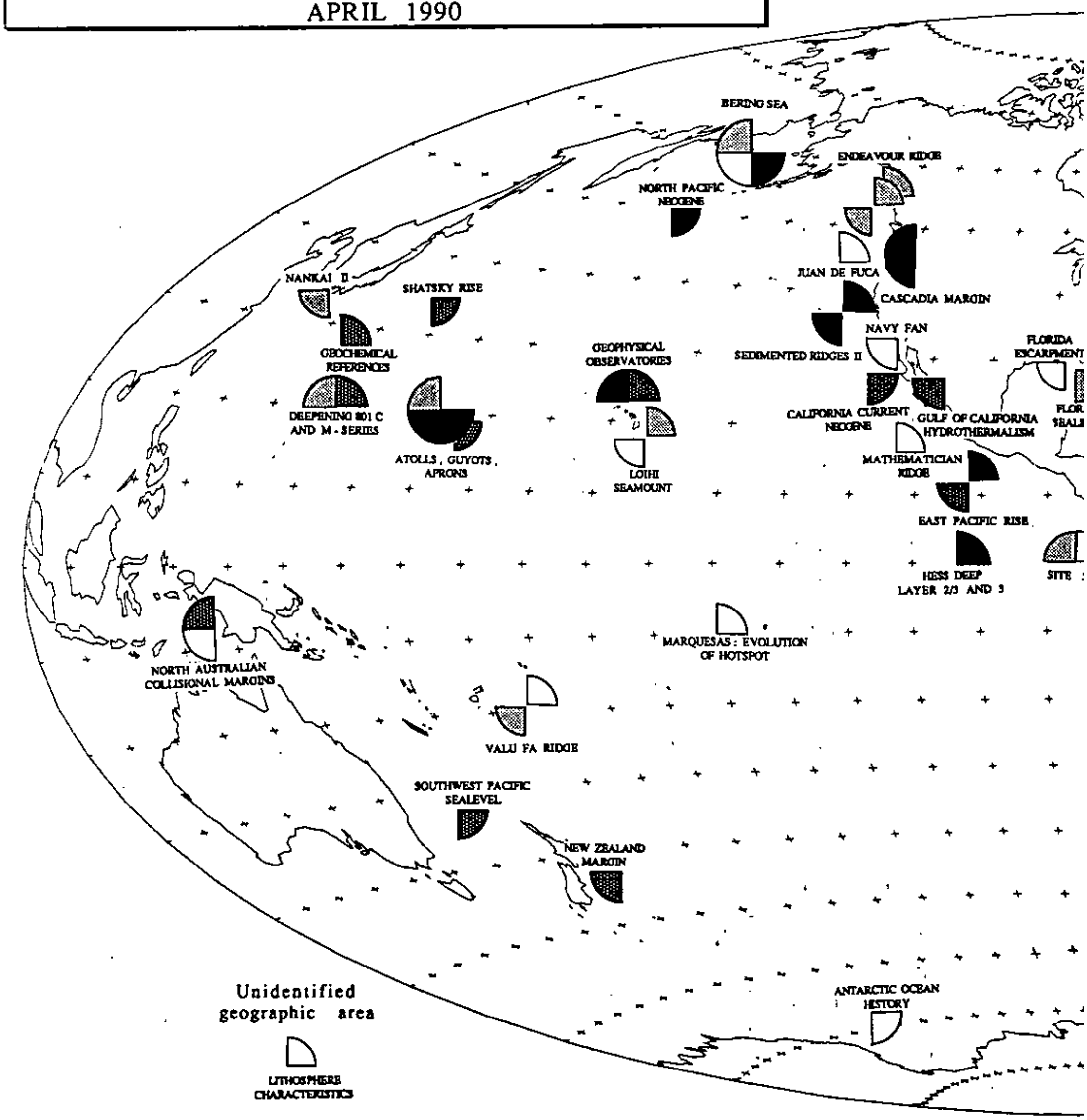
Preparation for Atlantic Drilling in FY93 and early FY94

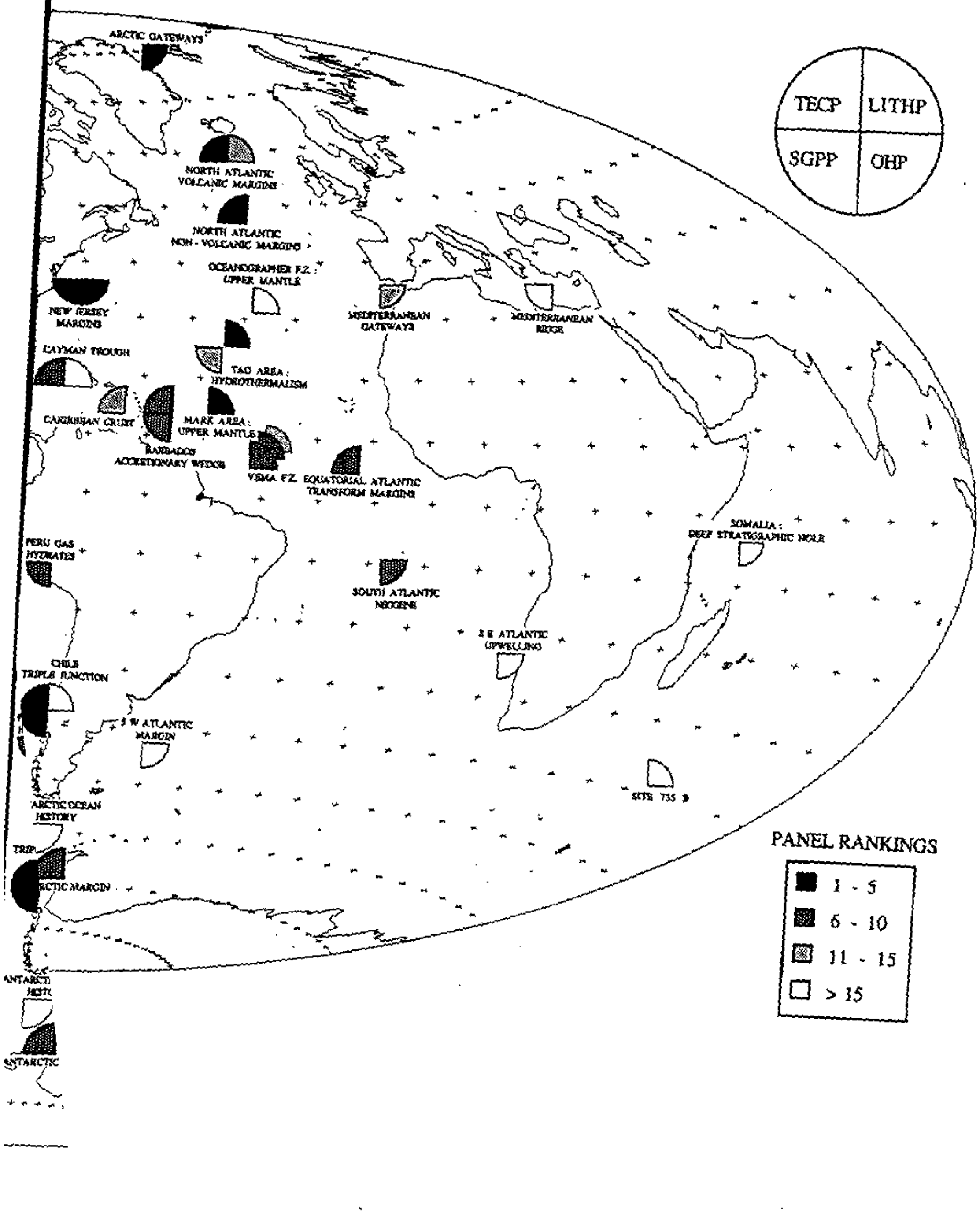
PCOM approved two DGPs, the North Atlantic Rifted Margins DPG and the North Atlantic Arctic Paleoceanographic Gateway DPG, and will establish their memberships and mandates at the August PCOM meeting. Chairmen of the thematic panels will be consulted about possible members. The rifted margins panel is to consider both volcanic and nonvolcanic margins.

PCOM did not come to a decision about forming a "North Atlantic DPG." Proponents of the top five North Atlantic

LOCATION OF PROGRAMS RANKED THEMATICALLY,

APRIL 1990





ARCTIC GATEWAYS
NORTH ATLANTIC VOLCANIC MARGINS
NORTH ATLANTIC NON-VOLCANIC MARGINS
OCEANOGRAPHER F.Z. : UPPER MANTLE
NEW JERSEY MARGINS
CAYMAN TROUGH
TAG AREA : HYDROTHERMALISM
CARIBBEAN CRUST
MARK AREA : UPPER MANTLE
BARBADOS ACCRETIONARY WEDGE
VEMA F.Z.
EQUATORIAL ATLANTIC TRANSFORM MARGINS
MEDITERRANEAN GATEWAYS
MEDITERRANEAN RIDGE
SOMALIA : DEEP STRATIGRAPHIC HOLE
PERU GAS HYDRATES
SOUTH ATLANTIC NEOGENE
S E ATLANTIC UPWELLING
CHILE TRIPLE JUNCTION
S W ATLANTIC MARGIN
SITE 735 B
TECP
LITHP
SGPP
OHP
PANEL RANKINGS
1 - 5
6 - 10
11 - 15
> 15

programs of each thematic panel should be endeavoring to bring their proposals to maturity so that they will be ready if chosen for drilling (Table 2). A Sea Level working group may be formed after results of the El Paso workshop are examined. Each thematic panel should have some interest in such a working group, and should have nominees ready; some panels have already done so.

LONG-RANGE PLANNING

Deep Drilling

The problems of drilling deeper than 1.5-2 km concerns PCOM and each of the thematic panels, some moreso than others. Reports were received from the recent TEDCOM meeting, to which thematic panels sent scientists, and from the recent joint LITHP/TECP meeting, which was attended by engineers. As a result of extensive conversation with Charles Sparks, Chair of TEDCOM, and Mike Storms, TAMU Engineer, PCOM will form a Working Group on Deep Drilling. The PCOM Chairman is to consult with TEDCOM and thematic panel chairmen to formulate an appropriate membership and mandate, for presentation to PCOM at its August 1990 meeting. The group will look at ways to proceed towards planning for deep drilling, including systems for coring and bore-hole control, platform requirements, estimated costs, time, and advisory and operational structures in parallel or within JOIDES-ODP.

Renewal Process

PCOM decided to form an *ad hoc* commitee to consider ways to aid the renewal process, by developing strategies for generating excitement and publicity about the scientific advancements and technological achievements of ODP, coordinating presentations of partner countries, countering criticism, identifying and strengthening weak points, and improving the image that ODP projects outside of the marine geoscience community. Jamie Austin will chair the committee; members are Margaret Leinen, John Malpas, Ralph Moberly, and Nick Pisias. Comments or suggestions from within the advisory structure should be directed to the above members.

TABLE 1. PANEL THEMATIC RANKINGS, APRIL 1990
For Fiscal Year 1992 Consideration: Highest-ranking Programs

Abbreviated Title	LITHP	OHP	SGPP	TECP
Atolls, Guyots & Aprons		4 & 6	3	15
Bering Sea		5	m	13
Cascadia Margin			1	3
Chile Triple Junction	24.5		2	1
East Pacific Rise: Bare-rock	2.5		7	
Hess Deep: Layer 2/3 transition and layer 3	1			
North Pacific Neogene and older		2		
Peru: Gas hydrates			6	
Sedimented Ridges II	5		4	

TABLE 2. PANEL THEMATIC RANKINGS, APRIL 1990
Highest Ranking North Atlantic Programs

Abbreviated Title	LITHP	OHP	SGPP	TECP
Barbados Accretionary Wedge			10	6
Cayman Trough	24.5			10
Equatorial Atlantic Transform Margins				7
MARK area: Long section of upper mantle	2.5			
Mediterranean Gateways		11		
New Jersey Margin sealevel		3	5	
North Atlantic: Non-volcanic rifted margins				2
North Atlantic: Volcanic rifted margins	11			5
Northernmost Atlantic paleocean.: Arctic gateway		1		
TAG area: High-temperature hydrothermalism	4		11	
Vema FZ: Layer 2/3 transition	7			
Vema FZ: Layer 3-mantle transition	6			
West Florida Margin sealevel		12		

TECTONICS PANEL MEETING SUMMARY

The JOIDES Tectonics Panel met March 5-7, 1990, in New Orleans, Lousianna. Foremost on the agenda were a joint meeting with the Lithosphere panel and the prioritization of TECP programs.

JOINT TECTONICS/LITHOSPHERE PANEL MEETING

The joint meeting of the Lithosphere and Tectonics panels was convened by I. Dalziel and R. Batiza. The minutes for this portion of the meeting are identical for both LITHP and TECP, and are not reproduced in the LITHP Meeting Summary.

Very Deep Drilling

The ODP Long-Range Plan discusses the importance and rationale of very deep (>2 km) drillholes in the ocean. Such deep drilling is of obvious importance for a variety of scientific goals, including some important scientific priorities of LITHP, TECP and SGPP. However, at present, the capability to achieve such deep objectives does not exist; a purpose of the joint meeting was to discuss the future prospects of very deep drilling and to begin a discussion aimed at assessing the technical feasibility and costs of such drilling.

This discussion was initiated at the mid-February TEDCOM meeting in Utah, and two participants in the meeting, Jim Natland and Keith Millheim, reviewed the early findings. As an example for discussion, Natland showed that to penetrate normal oceanic crust with normal rotary drilling would require an 11.5-km-long drill string, new heavy duty casing, and a great deal of drill time. Millheim emphasized that extrapolation of needs and costs from past ODP experience was probably not the correct approach. Instead, he suggested that very deep holes would have to be "custom-designed" and the tools would have to be tailored accordingly. Such a procedure throws open such questions as platform capabilities, development of entirely new drilling technologies and hardware, and the need for careful long-term planning.

Drilling very deep holes is a great technical challenge and is not a trivial extension of existing ODP drilling. It should be approached in a carefully phased manner. For this, Millheim considers it essential that the experience of experts in very deep on-land drilling (the Soviet Union and W. Germany) be brought to bear on the problem. The Japanese apparently also are planning for a very deep drilling capability at sea, so the task of deep drilling is clearly international in scope and interest. The difficulty, estimated costs and development time for such a capability appear to go beyond what is possible within the present ODP program. However, ODP can play an extremely important role by initiating the planning, engineering development and tests that are needed. If such a capability is to exist in the time frame of the ODP Long-Range Plan (next 10-12 years), the planning must begin very soon. This joint meeting strongly endorsed the notion that planning efforts for deep drilling should go forward.

A closely related issue is the possibility of using the new DCS system as a mini-riser for drilling 2-to-3-km-deep holes. Such a capability requires further development, but probably can be achieved within the next 2-4 years within ODP. This capability would make it possible to achieve a variety of very high-priority goals of TECP, LITHP and SGPP, and thus is of very great interest. The joint panels strongly encourage the continued development of the DCS system for this purpose.

Volcanic Rifted Margins (VRM)

LITHP and TECP have a strong interest in learning more about early continental rifting and the reasons why passive continental margins commonly have very thick sections of rift-related volcanic rocks. A better understanding is needed of mantle processes that occur before, during and after rifting, as well as effects on the style of continental breakage. Scientific ocean drilling provides a very important tool for investigating this problem. As amply demonstrated by COSOD II, the ODP Long-Range Plan, and the large number of proposals received, this problem is of first-order importance in the modern geosciences.

Partly because the volcanic sections at many VRMs are very thick (>5 km), an integrated strategy for study needs to be developed. Establishing the strategy and defining the role for drilling is not only essential for further progress, but also is very urgent. PCOM was urged to establish a working group on volcanic rifted margins at its April meeting.

Status and Developments of the Diamond Coring System (DCS)

The TAMU engineering group provided a summary of the latest improvements to the DCS. The on-land tests are proceeding as planned and the system has undergone numerous design improvements. The rate of progress on the DCS system has been phenomenally good and both panels eagerly anticipate full-scale tests during Leg 132.

Tectonics of Mid-Ocean Ridges

Both TECP and LITHP have a strong interest in the nature of mid-ocean ridges. Traditionally, LITHP has emphasized the magmatic and hydrothermal aspects of ridges, but clearly the origin of oceanic crust involves stretching, faulting and other tectonic processes. The joint meeting provided a good forum for discussing the tectonic activity at ridge crests. Progress on understanding the activity of mid-ocean ridges requires a multidisciplinary effort, and future ODP drilling is a very important component of this effort.

Global Seismic Arrays

The establishment of an array of 15-20 broad-band ocean seismic stations is an important initiative in the geosciences and ODP is vitally necessary in the initial stages of the program in order to help complete critical pilot studies. LITHP has provided strong support for this initiative. The joint panels reaffirm the importance of establishing global seismic coverage and strongly urge that the Hawaii pilot hole be drilled as soon as possible.

PRIORITIZATION OF TECP PROGRAMS

Tectonics Panel considered all existing programs for drilling tectonic targets in all the world's oceans over the four years following the program in the Pacific already approved by PCOM. The proposals were considered in terms of potential programs to address the five principal themes set out by TECP in its White Paper published in the October 1989 *JOIDES Journal*. Technical and political feasibility were also taken into account. The ranking below includes relevant proposal numbers and recommended number of drilling legs within the four-year time period. An asterisk indicates that a DPG or Working Group has been established or requested to plan this program.

1) *Chile Triple Junction*; proposal 362; 2 legs of a 2 leg program.
2) *North Atlantic non-volcanic rifted margins*; proposals 334, 365, 366; 2 legs of an approximately 6-leg program.
3) *Cascadia convergent margin**; proposals 233 and 317; 1-2 legs of a 1-2 leg program.
4) *Oahu geophysical observatory pilot project*; proposal 315; 10 days (could be first of approximately 15 stations).
5) *North Atlantic volcanic rifted margins**; proposals 310, 311, 328, 358 and 363; 2 legs of a 4 leg program.
6) *Barbados accretionary wedge*; proposal 342; 2 legs of a 4 leg program.
7) *Equatorial Atlantic transform margins*; proposals 313 and 346; 1 leg of a 1 leg program.
8) *North Australian collisional margin*; proposal 340; 2 legs of a 2 leg program.
9) *Antarctic Peninsula margin*; proposals 297 and 351; 2 legs of a 2 leg program.
10) *Cayman Trough*; proposal 333; 1 leg of a 1 leg program.
11) *M-series anomalies in Western Pacific*; proposals 287, etc.; 1 leg of a 1 leg program.
12) *Stress measurements at Site 505*; proposal 373; 1-2 legs of a 1-2 leg program.

13) *Bering Sea*; proposals 34, 182, 207, 225, 229 and 234; 1 leg of a 1 leg program.

14) *Caribbean crust*; proposal 343; 1 leg of a 1 leg program.

15) *Cretaceous sea mounts in Western Pacific*; proposal 280, etc.; 2 legs of a 2 leg program.

OCEAN HISTORY PANEL MEETING SUMMARY

The Ocean History Panel met in Honolulu, Hawaii during 29-31 March, 1990.

PROGRAM RANKINGS

OHP reaffirmed that the Eastern Equatorial Pacific program scheduled for Leg 138 remains its highest priority undrilled program.

OHP generated the following list of prioritized programs:

1) *Northernmost Atlantic Paleoceanography*; proposals 320, 336 and 305.

2) *North Pacific Neogene*; from the package created by CEPAC at the request of SOHP/OHP from proposals 259, 247, etc.

3) *New Jersey margin (sea level)*; proposal 349.

4) *Guyots*; proposal 203.

5) *Bering Sea*; CEPAC prospectus from proposals 182 and 195.

6) *Atolls*; proposal 335.

7) *South equatorial Atlantic*; proposal 347.

8) *California Current*; proposal 271.

9) *Southwest Pacific (sea level)*; proposals 337 and/or 338 and/or 367.

10) *Shatsky Rise*; CEPAC Prospectus from proposal 253.

11) *Mediterranean gateways*; proposals 323 and 372.

12) *West Florida margin (sea level)*; proposal 345.

PUBLICATIONS

OHP accepts the present publication targets with two reservations: (1) Up to the final make-up deadline, flexibility must be exercised with involvement of the Editorial Board and NOT left solely in the hands of production staff who may make inappropriate judgements; and (2) Every effort must be made to ensure that authors whose manuscripts are accepted for review are not turned down through delays in the review process. This is especially important since a member of the Editorial Board may be, or may be perceived to be, the cause of the delay. ODP should find a means of publishing late papers, since they often contain important data that are not published elsewhere.

ORGANIC-RICH SEDIMENTS

OHP remains interested in the ability to recover organic-rich sediments on the continental margins because of their importance for paleo-productivity studies. Efforts should be made to refine the methods by which safety is established so as to extend the working range in such areas.

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LITHOSPHERE PANEL MEETING SUMMARY

The JOIDES Lithosphere Panel Meeting was held in New Orleans, Louisianna, during 5-7 March, 1990.

NEAR-TERM PLANNING

Engineering Leg 3A at Site 504B

At its April meeting, PCOM firmly scheduled Engineering 3A and 3B (Leg 136) for 504B and the EPR respectively. Of the following legs, Leg 137 is Sedimented Ridges I, Leg 138 is the East Pacific Neogene transect and Leg 139 is either continued deepening of 504B or EPR-1, depending on whether 504B can be cleared of junk.

The question of whether Engineering 3A and 3B need be contiguous has recently arisen. Leg 3A at 504B is presently scheduled for 37-38 days. With transit time (~17 days), there is sufficient time for milling junk (and/or fishing, as required) and a modest program of downhole measurements. LITHP feels it is important to complete 2-3 days of downhole logs (temperature, fluid sampling and permeability) prior to milling. The remaining time should be devoted to milling the junk and, if the hole is cleared with time remaining, an effort should be made to drill ahead. It is for this reason that at least a small scientific party should be present on Engineering 3A.

If milling and fishing operations are unable to clear the hole after 19 or so days, than an evaluation for a best course of action can be made later. If it is clear very early in the leg that 504 cannot be cleared (for whatever reason), LITHP recommends that the remaining time of Engineering 3A be used to carry out a full logging program including: FMS, wire-line packer, flow meter, geochemical logging and sidewall coring. If the hole can be cleared, then this logging program (1 week or so) could be carried out at the beginning of Leg 139. If 504B cannot be deepened during Engineering 3A, a possibility may be to drill a new hole nearby without coring. Assessing this option from a scientific point of view, however, would require a new proposal and considerable discussion of alternative sites for a deep hole. In any case, this decision can be made after Engineering 3A is complete.

Engineering 3B at the EPR

Engineering half-leg 5B need not follow immediately after 5A, however, LITHP feels that it should be scheduled as soon as possible thereafter, consistent with possible additional engineering needs after Leg 132. From previous discussion with the TAMU engineering group, LITHP views the purpose of Engineering Leg 3B as being much more important than simply deploying two or more old-style large guidebases. Instead, the purpose of the engineering half-leg is to fully establish one or more drill sites at the EPR. Several possible options for doing this have been discussed, and one attractive possibility is to use pogo mini-guidebases and drill-in casing. With this technique, established holes (> 50 m deep) could be sealed and be ready for further deepening during later drilling. If these new techniques are unsuccessful, Engineering 3B could be used to try an array of others. In either case, one or more EPR sites could be established and perhaps significant penetration could occur during Engineering 3B. In this case also, it would be useful to have a small scientific party aboard to handle the samples and to help make scientific decisions during the leg.

LONG-TERM PLANNING: GENERAL TRACK OF THE VESSEL 1992-1994

The LITHP ranking is as follows:

1) *Layer 2/3 transition*, Hess Deep; proposal 375.
2.5) *East Pacific Rise magmatic and hydrothermal*; proposals 321, 357.
2.5) *Upper mantle, MARK area of the Mid-Atlantic Ridge*; proposal 369.
4) *Hydrothermalism and metallogenesis, TAG area*; proposal 361.
5) *Magmatic and hydrothermal, Middle Valley and Escanaba*; SRDPG drilling prospectus.
6) *Layer 3 - mantle transition, Vema Fracture Zone*; proposal 376.
7) *Layer 2/3 transition, Vema Fracture Zone*; proposal 376.
8) *Global Seismic Network, N.E. of*

Oahu, Hawaii; proposal 315.
9.5)*Element and mass fluxes, West Pacific*; proposal 267.
9.5)*Old ocean crust, Site 801-C*; proposal 368.
11)*North Atlantic margins*; program to be designed by proposed WG.
12)*Hydrothermalism and metallogenesis, Endeavour Ridge*; proposal 325.
13)*Layer 3, Vema Fracture Zone*; proposal 376.
14)*Loihi Seamount*; proposal 252.
15)*Sulfides, Endeavour Ridge*; proposal 325.
16)*Axial Seamount*; proposal 290.
17.5)*Hydrothermal processes, Valu Fa Ridge-Lau Basin*; proposal 360.
17.5)*Layer 3 - mantle transition, Site 735-B*; proposal 300.
19.5)*State of stress in the lithosphere, Site 505*; proposal 373.
19.5)*Lithosphere characteristics*; DMP initiative-specific sites not yet chosen.
21)*Upper mantle, Oceanographer Fracture Zone*; proposal 374.
22)*Extinct ridges, Mathematician Ridge*; proposal 352.
23)*Temporal evolution of hot spots, Marquesas*; proposal 291.
24.5)*Chile Triple Junction*; proposal 362.
24.5)*Transform dominated ridges, Cayman Trough*; proposal 333.

OTHER BUSINESS

"Rumor" Proposals

It was noted that not all proposals considered by LITHP in its discussion and ranking were equally mature or even of equal status in some sense. For example, some documents with JOIDES office numbers (official proposals) are little more than letters of intent. LITHP considers it important that the international community recognize that such letter proposals are acceptable for long-range planning. LITHP encourages all investigators with ideas for possible drilling targets to send such letters to the JOIDES office.

Suggestions for IHP on Data Bank Entries

In response to IHP's solicitation for input on the information for the computerized data bank, LITHP recommends that the following be added, if a convenient form can be found: (1) X-ray diffractometer and (2) downhole information collected with non-Borehole-Research Group tools, e.g. TAMU downhole tools.

LITHP Chairmanship

As its new chair, LITHP unanimously nominates Dr. Susan Humphris (WHOI).

CO-CHIEF SCIENTISTS ON UPCOMING CRUISES

Leg 133 will depar Guam on August 10, 1990, to drill on the NE Australian Margin, ending the leg in Townsville on October 11. Co-Chief Scientists are Dr. Peter J. Davies (Bureau of Mineral Resources, Canberra, Australia) and Dr. Judith A. McKenzie (Geological Institute, ETH, Zurich, Switzerland).

Leg 134 will visit the Vanuatu region from October 16 to December 17, 1990. Co-Chief Scientists are Dr. Jean-Yves Collot (Geodynamics Laboratory, Villefranche-sur-Mer, France) and Dr. Gary Greene (USGS, Menlo Park, CA).

Leg 135 will travel to the Lau Basin from port in Fiji (December 22, 1990 - February 16, 1991). Co-Chief Scientists are Dr. Jim Hawkins (Scripps Institution of Oceanography, CA) and Dr. Lindsay Parson (Institute of Oceanographic Sciences, U.K.).

More detailed information and applications for participation are available from the Manager of Science Operations, Ocean Drilling Program, Texas A&M University Research Park, 1000 Discovery Drive, College Station, 77845-9547. Telephone: (409) 845-7209. Bitnet: AUDREYM@TAMODP.

SEDIMENTARY AND GEOCHEMICAL PROCESSES PANEL MEETING SUMMARY

SGPP met at the University of California, Santa Cruz, during 14-16 January, 1990. The main focus of the meeting was the ranking of all proposals received by SGPP towards a post-1991 drilling schedule. Secondary tasks were revision and expansion of the SGPP White Paper and the status of position papers on technology and sampling issues.

RANKING OF DRILLING PROPOSALS

SGPP considered more than 50 proposals for post-1991 drilling; these were grouped into and prioritized within the five SGPP themes: (1) Sea Level; (2) Fluids and gases; (3) Metallogenesis and hydrothermalism; (4) Sediment and mass balances; and (5) Paleocean-chemistry/paleoceanography. Fourteen proposals remained for the final discussion. They were ranked by comparing the thematic objectives of the top proposals among each of the five themes while maintaining the priority within each theme. This procedure resulted in the following ranking:

1) *Cascadia margin*; proposals 233, 237 and 317.
2) *Chile Triple Junction*; proposals 318 and 362.
3) *Atolls and guyots*; proposals 203 and 335.
4) *Sedimented ridges II*; proposals 272, 284 and 290.
5) *New Jersey margin*; proposal 348.
6) *Peru gas hydrates*; proposal 355.
7) *East Pacific Rise bare-rock*; proposals 321 and 357.
8) *Gulf of California hydrothermalism*; proposal 275.
9) *New Zealand margin*; proposal 337.
10) *Barbados accretion*; proposal 342.
11) *TAG area hydrothermalism*; proposal 361.
12) *Northern Juan de Fuca bare-rock*; proposal 325.
13) *Nankai II*; proposal 314.
14) *Valu Fa Ridge*; proposal 360.

SGPP WHITE PAPER

The White Paper received extensive discussion which ended with the conclusion that much of what the present version contains represents mandate and priorities.

TECHNOLOGY ISSUES

Improved sand recovery affects many groups and hence commands a great deal of interest. Fluid sampling is a high priority; SGPP needs needs to assure optimal analytical and sampling procedures. Sampling of high-temperature fluids and use of instrumented holes should be addressed without further delay. The pressurized core barrel and avoidance of artifacts during porewater recovery require further attention; options include controlled sampling, P-T stability, microbial experimentation capability, titanium construction, record of thermal history, self-squeezer, and internal imaging.

JOI/USSAC Ocean Drilling Graduate Fellowship

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 $18,000 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	Application Schedule
Leg 139: East Pacific Rise or 504B	September 1, 1990
Shorebased work	January 1, 1991

For more information, please contact Robin Smith at JOI, Inc., Suite 800, 1755 Massachusetts Avenue, NW, Washington, DC 20036-2102; Tel: (202)232-3900; Telemail: R.Smith.JOI

SEDIMENTARY AND GEOCHEMICAL PROCESSES PANEL: WHITE PAPER

INTRODUCTION

The ocean can be regarded as a major component of the complex system of interacting fluids, gases and solids forming the Earth's surface layers. The ocean is the largest fluid reservoir in terms of both the mass of water and of dissolved materials. Seen as the central component of the Earth's surface system, the ocean receives inputs from land and the atmosphere as well as from fluids circulating through the underlaying oceanic crustal rocks and expelled from the sediments deposited on the ocean floor and margins. Material entering the ocean in particulate or dissolved form is processed and removed from the water as either a component of sediment or alteration product of crustal rocks. Both the composition and depositional architecture of the sediments record the processes that have acted on the ocean system. Ultimately, material deposited on the ocean floor is subducted to return to the mantle or become volcanics, or is accreted and obducted onto the continents to become continental crust. The Ocean Drilling Program provides the information needed to treat the Earth as a closed system and the processes shaping its surface.

The goal of the JOIDES Sedimentary and Geochemcial Processes Panel (SGPP) is to encourage investigation of processes affecting inputs, interior processing of materials, and outputs from the ocean. These studies would include, but not be limited to, the aging of the Earth's crust, fluid circulation and geochemcial budgets, mass balances of the sediments and elements, organic and inorganic geochemistry and diagenesis, and sedimentary processes, facies and physical processes. Hence, this White Paper, identifies five themes under which the overall goal may be attained and which should be addressed by future ocean drilling:

1. SEA LEVEL: Record of eustatic change
2. SEDIMENTS: Material cycling and sediment distribution processes
3. FLUIDS: Circulation through the crust and geochemical balances
4. METALLOGENESIS: Control by tectonics and host material
5. PALEOCEAN: Fluctuations in chemistry and geochemcial budgets

These themes encompass the mandate of SGPP as envisioned by the JOIDES Planning Committee (PCOM), the recommendations of the 2nd Conference on Scientific Ocean Drilling (COSOD-II, 1987), and the highlights of the first five years of the Ocean Drilling Program (ODP). The themes also reflect a consensus on high priority topics gleaned from the proposals submitted for drilling by the international scientific community. The order in which the themes appear here does not reflect a prioritization but rather is a sequence that follows the material transport pathways and processing mechanisms through the changing global ocean system. It is intended as a source for the scientific community to draw information and inspiration on utilizing the unique opportunities for scientific discovery provided by ODP.

NEW TECHNOLOGIES

These technological developments are scientifically critical and operationally extensive. They must be implemented so as to ensure optimum scientific returns while being orchestrated with on-going drilling objectives. New technologies are of such crucial importance to the future of ocean drilling that they are grouped and summarized here as goals to be fulfilled within the next decade:

<u>I. Phased improvements of present drilling capabilities:</u>

1. Solve problems of sampling and stabilizing sandy strata

2. Stabilize re-entry in sediment holes

3. Drill deep holes into sediment and into basement

4. Deal with "hot holes" through gradual improvements of logging and sampling capabilities

5. Re-seal holes to arrest vertical flow and allow return to equilibrium

6. Complete development of continuous recovery of undisturbed sediments and rocks of all lithologies for studies of diagenesis and metamorphism, characterization of *in situ* sediment structure, strain measurements, and continuous core logging

<u>II. Developments of sampling and *in situ* profile measurements of physical properties and chemical compositions:</u>

1. Assure closely-spaced *in situ* sampling of truly representative, uncontaminated fluids and gases, coupled with temperature measurements

2. Approach this essential capability by perfecting the pressure core sampler system; i.e. initiate PCB-phase II; this device should be capable of recovering sediment at *in situ* temperatures and pressures for analyses of clathrates, pore fluids, gases and microbial activity; it must also preserve sediment structures for fabric analyses and physical properties measurements, allow through-wall imaging of internal structures, have transfer capabilities through pressure ports for shipboard separation of gases, fluids, and solids, and provide for the calibration of logging tools

3. Augment this capability by the use of a wire-line side-wall corer with an *in situ* pore water sensor and sampler; this device is to be used to recover sediment and pore waters in coring gaps or where recovery is poor, to satisfy the demand for additional material for high-resolution studies, to recover pore fluids under *in situ* conditions without risk of jeopardizing further drilling of a hole, and to measure *in situ* temperature, pore pressure, pH, and other constituents by specific ion-electrodes

4. Develop *in situ* permeability, porosity, electrical resistivity, seismic velocity and pore fluid pressure measurements for successively higher bore hole temperatures; then adapt the capabilities of the chemical logging tools for the same temperature environment

5. Be aware that for "hot holes" such chemical logging tools will not be available in the short-term; therefore, devote efforts to develop a bore hole water sampler or sensor package which should either be used during packer deployment or as a separate, self-contained, wire-line instrument.

6. Develop in parallel near *in situ* pore fluid and gas sampler for frequent and multiple samples per deployment plus appropriate packer; for this to be useful, better hole isolation has to be achieved

7. Think about insulating the pressure core sampler for it to be used at high temperatures and making it resistant to corrosive chemicals.

8. Decide which logging tools should be slim-lined, if the diamond coring system (DCS) becomes the favored alternative drilling method, since not all tools are suitable for adaptation to enter the smaller DCS bore holes.

<u>III. Long-term experiments for steady state versus episodicity of fluid flow:</u>

1. Monitor *in situ* temperature and pressure gradients

2. Monitor fluid pressure, temperature, fluid and gas chemistry, and strain in sealed holes

3. Obtain repeated samples from sealed holes via alternate platform

<u>IV. Other technological developments and considerations:</u>

1. Consider drilling atolls and guyots using alternate platforms or on-land drilling

2. Emplace and recover long-term and short-term sea-floor monitoring experiments

3. Conduct extended site surveys

4. Explore alternate platforms to complement the drilling vessel *JOIDES Resolution*

SEA LEVEL: Record and Causes of Eustatic Change

<u>Overview</u>

It is generally recognized that eustatic fluctuations constitute one of the most important controls on the stratigraphic record. Yet, neither the timing and amplitudes nor causes of eustatic change are well known. Possible relations between eustasy and tectonics, climate, the origin and deposition of siliciclastic and carbonate sediment, ocean chemistry and circulation, and organic evolution are largely a matter of educated speculation. Little is known about feedbacks between these phenomena or about the possible leads and lags that may be involved. It is for these reasons that the history of eustatic change has been identified as a first-order problem to be addressed by the Ocean Drilling Program.

Advances during the past fifteen years in elucidating the eustatic record can be traced to the development of seismic stratigraphy, and more generally, sequence stratigraphy. The basis of this approach is to identify depositional sequences bounded by unconformities and their correlative conformities. Unlike transgressions or regressions of the shoreline or changes in paleo-bathymetry, the development of prominent sequence boundaries is relatively insensitive to sediment supply, and major sequence boundaries of eustatic origin should be of very nearly the same age in all marine basins. Sequence stratigraphy should be the basis of all attempts to gauge eustasy directly from the stratigraphic record. The problem of estimating amplitudes and rates of change is difficult, and cannot be achieved by seismic or sequence stratigraphy alone, but requires a quantitative assessment of the tectonic forces that drive subsidence and uplift at any depositional site.

No single technique or single site can be expected to provide a realistic picture of sea-level change on a global scale. In support of the recommendations of the Second Conference on Scientific Ocean Drilling (COSOD II), we propose three approaches: the drilling of both terrigenous and carbonate-dominated successions in transects across passive continental margins, the drilling of atolls, and the establishment of a complete high-resolution benthic and planktonic foraminiferal $\partial 18O$ record from pelagic sediments. Oxygen isotopic variations reflect a combination of ice-volume and temperature fluctuations, and they are a useful proxy for one of the most important components of the eustatic signal in post-Eocene time.

Drilling to establish the record of eustatic change must be supported by high-resolution geophysical surveys, high quality logging, and complete core recovery. Also, the recommendation of transects presupposes that alternative platforms will be available for drilling in shallow water, and that, where appropriate, it may be useful to sample outcrop sections onshore.

Scientific opportunities for future drilling

The principal objective of drilling is to establish the timing and amplitudes of eustatic change on timescales of 1-10 m.y. in late Paleogene and Neogene time. The temporal focus is justified for three reasons: (1) the late Paleogene and Neogene are times of substantial continental ice cover, and this allows the stratigraphic record of eustatic change to be compared directly with the oxygen isotopic record of sea-level change; (2) strata of this age are relatively easily dated by means of biostratigraphy, magneto-stratigraphy and Sr-isotopic stratigraphy; and (3) strata of late Paleogene and Neogene age are preserved at shallow depths on numerous continental margins and atolls, and in many cases can be reached easily by drilling. For Plio-Pleistocene time, very high-resolution seismic surveys and drilling in areas of rapid sediment accumulation has potential for relating the record of sea-level change to high-frequency climatic oscillations.

Mesozoic targets are also of some interest. The evaluation of eustasy in Cretaceous time is one of the main goals of the Global Sedimentary Geology Program on Cretaceous Resources, Events and Rhythms. That program is primarily land-based but might usefully interface with ODP. The Cretaceous offers the opportunity of investigating sea-level change during an interval of minimal continental ice, and hence to investigate non-glacial mechanisms of sea-level change.

When the eustatic record has been established, subsidiary objectives of anticipated drilling are to evaluate the mechanisms that may be responsible for the observed variations in sea level, as well as to determine the consequences of sea-level change for sedimentation along the margins of the continents and in the deep sea.

Drilling strategy

Three independent approaches are proposed to address these objectives: (1) drilling of passive-margin transects (terrigenous and carbonate-dominated successions); (2) atoll drilling; and (3) the recovery of continuous pelagic carbonate sections to establish oxygen isotopic records. By combining these different approaches, it may be possible to overcome the limitations inherent in each of them individually, and to place constraints on the global sea-level signal.

Transects across passive continental margins will improve the likelihood of dating unconformities at or near regions of conformity, and we emphasize the need for a concentrated effort to improve dating by a combination of all available tools, where possible in the same samples (e.g., biostratigraphy, magneto-stratigraphy, Sr-isotopic stratigraphy). High-resolution dating will also require improved core recovery through critical intervals, as well as appropriate logging so that boreholes can be tied precisely to seismic reflection profiles.

Criteria for the selection of appropriate passive margins include: (1) relatively simple or predictable subsidence history; (2) high-quality, publicly available seismic coverage; (3) suitable existing well data to calibrate seismic interpretation; (4) exposures of equivalent stratigraphy in nearby on-shore areas; (5) laterally persistent depositional sequences that allow one or more transects from the inner part of the continental shelf to the deep sea; (6) a relatively complete section in the target interval; (7) relatively high sedimentation rate and well defined sequence boundaries that can be traced to correlative conformities; (8) stacked sequences boundaries that can be investigated with a relatively small number of holes; (9) stratigraphic objectives that are within reach of the drill string; (10) high quality correlation/calibration potential; and (11) a well-established age for the onset of sea-floor spreading. Potential areas for the Paleogene-Neogene record include the margins off the eastern United States, New Zealand, northwestern Australia, the South China Sea, the Maldive archipelago, and the Gulf of Mexico. Transects across the margins off the eastern United States, western Africa, eastern Africa, and the Exmouth Plateau are suggested for obtaining information about Mesozoic sea-level change.

To ensure success, for a given geological interval it will be necessary to select a minimum of three suitable margins in widely separated areas, with at least one transect per margin, and at least five drill sites per transect. The purpose of these sites is not only to provide information about the ages of sequence boundaries, but also to permit quantitative analysis of the subsidence history of a particular margin. Calculations of amplitudes of sea-level change require assumptions about the tectonic or driving subsidence, and achievable precision is also limited by uncertainties in paleobathymetric change through time, and the effect on basin subsidence of compaction and isostatic compensation due to the emplaced sediment load. Estimates for each of these factors are needed at the same age resolution as the eustatic signal to be estimated. While ages of unconformities are best constrained in deep water, amplitudes are best measured in shallow-water facies.

Sr-isotope stratigraphy now permits the dating of previously undatable atoll carbonate successions. This approach uses the stratigraphic record of atoll carbonates as dipsticks in areas thought to have comparatively simple subsidence history. Although this strategy yields discontinuous records with variable resolution, it may offer the best chance of obtaining reliable, quantitative, low-frequency (greater than 2 m.y.) information on the amplitude of post-Eocene eustatic variations. It is important to locate sites in areas where uncertainties in modelling subsidence history are minimal. These conditions appear to be met in the Marshall-Gilbert Islands. Because these islands lie on crust that is locally compensated, it is probable that they have undergone a straightforward subsidence history since Eocene time. Paired depth transects off currently forming atolls and drowned atolls along a major atoll chain that extends over a wide latitude and age range are preferable drilling targets.The early sea-level record would be encountered on the drowned atoll and the more recent record on the currently forming atoll. The transects should also include atoll apron, rim and lagoon sites. It is recommended that lagoon sites be drilled on a current atoll to provide a tie to the platform top. The USGS Eniwetak and the French Mururoa sites may provide this information. One problem with atoll drilling is the difficulty of relating shallow-water and deep-sea records. In this respect, prograding margins of carbonate platforms offer certain advantages.

A third approach to the sea-level problem depends on the oceanic oxygen isotope record, which is one of the components of the recommended multiple strategies, and perhaps more important, can provide insight about the mechanism of sea-level change. The oxygen isotope approach infers changes in global ice volume from the isotopic composition of benthic and planktonic foraminifera. Proper use of this approach requires the compilation and validation of records of both benthic and planktonic low-latitude foraminifera, with sufficiently high resolution and stratigraphic calibration to ensure that each sea-level event registered by other indicators can be matched against the correlative oxygen isotope record.

Technology

Technical developments are required to be able to address the topic of global sea-level fluctuations. In the short term these should be devoted to: continuous core recovery in all types of sediments, including sands, chert and especially shallow-water carbonate sediment; and continuous core logging. Intermediate-range objectives will require drilling within atoll lagoons and on atoll rims. It is probably not feasible to use the *JOIDES Resolution* for such a task, and alternative platforms should be sought. Long-term developments should be aimed at the ability to drill deep (2500-3000 m), stable holes required for continental-margin transects, and to provide the pre-Neogene sea-level record.

SEDIMENTS: Material cycling and sediment distribution processes

Overview

One goal of the SGPP is to promote investigation of the sedimentological and geochemical budgets of the ocean system. These investigations would include studies of processes that alter inputs to the ocean, the interior processing of materials, and the output from the ocean.

Material cycling

Sedimentary mass balance requires a closed system. With respect to materials carried to the sea in solution, the system is global; input and output sites may be widely separated. However, with respect to material introduced in particulate form, a region may be effectively a closed system. An alternative to a truly closed system is a defined system, in which the gains to and losses from the region under study are specified. Elements of the mass balance equation that have major potential for change and hence are of particular interest are:

(1) Sediment inputs, including materials transported from land to the ocean by (a) rivers, (b) glaciers, (c) wind, and (d) groundwater, and material introduced by (e) volcanic activity, (f) hydrothermal activity, (g) dewatering of sediment wedges, and (h) diagenetic processes.
(2) Deposition, movement, redeposition and recycling of sediment within the ocean system, including (a) alternate storage and erosion of material on the continental shelves, (b) mass wasting of material on the slopes of continental margins and oceanic platforms, (c) downslope re-sedimentation, (d) sedimentation of biogenic material, (e) deposition of evaporites, and (f) reworking and recycling of sediments by bottom currents and corrosive waters and the relation of these processes to regional deep-water unconformities.

(3) Residence times of sedimentary materials in different tectonic and environmental settings.
(4) Sediment output, largely comprising return of materials including solids and fluids to the mantle by subduction but also estimates on accreted and obducted material.

Depositional processes, facies and architecture

Although we understand in general how sediment is eroded, transported and deposited in the oceans, our knowledge in most cases falls far short of specific mechanics and physical parameters of the processes involved. We must understand about the way these processes change in space and time to form sedimentary units on seismic profiles.

Major processes about which a greater understanding is required include: (1) turbidity currents, (2) bottom currents, (3) volcanic sedimentary processes, (4) ice margin processes, and (5) mass-movement processes. In order to read a given sedimentary succession as a record of change in the past environmental conditions, we need to know more about the detailed characteristics of the range of sediment facies and how they vary laterally and vertically, i. e. their depositional architecture or geometry. One major objective of this aspect of drilling will be to relate facies distinctions based either on seismic-stratigraphic analyses or on morphometric characters of surface sediment distribution to the *in situ* character of the sediment bodies. A second objective achievable only through drilling is to relate detailed chronostratigraphy to the rates of growth and migrations of sedimentary facies units and thus help to establish depositional processes and architecture. Efforts must be made to relate the ocurrence, cycling, and geometries of these systems to both allocyclic and autocyclic controls.

Scientific opportunities for future drilling

Bottom current sedimentation

Bottom currents play a major role in reworking and redistributing sediments in the world ocean basins. These bottom currents can have two sources: the thermohaline circulation system which results from sinking and lateral flow of dense waters and benthic storms which result from the contact of the wind-driven surficial eddies with the bottom. The form of the resulting sediment deposits is controlled mainly by the nature of bottom current present in any given area and the availability of sediment. The history of thermohaline bottom current processes is preserved in sediment drifts and sediment waves moulded under relatively steady currents. The role of benthic storms in creating strata is less clean, but sediment accumulation beneath regions of benthic storms may be reduced. Drilling transects will test sedimentation models for sediment structure and bottom current depositonal processes and use these models to determine past variations in the bottom flow regime of the ocean.

Re-sedimented systems

Future drilling must attempt to document the three-dimensional geometries of a range of sedimentary facies and environments and to relate these geometries to images recorded by seismic profiling and other techniques. Facies variations occur over an area of a few square kilometers and less in the oceans, and this information is crucial to our understanding of the sediments and their depositional processes, as well as to their use in any models for fluid flow or for global sediment budgets. Drilling to date has barely addressed this aspect.

Type-localities are needed for distinctive facies and environments. Two particular examples are re-sedimented systems (carbonate and siliciclastic), including overbank (with and without levee relief), channel floor, depositional lobe, channel/lobe transition zone, basin plain, mass-wasted intervals and base-of-slope ramps and contourite systems, including drift margins, drift axes, open-ocean drifts, interbedded marginal contourites and deep-water passageway drifts.

Of equal importance is an effort to relate processes and facies within different parts of sedimentary systems to the major external and internal factors that control their formation and distribution (geometry):

(1) Allocyclic controls. Drilling in the main types of margins can address several important problems: (a) the influence of sea level changes on the nature (type, source area, rate and transport path) of sediment provided to the basin; (b) the influence of the source-area gradients (tectonism) on the sediment supply to the margins; (c) the influence of shelf characteristics, including width, intra-basinal sediment generation (e.g., carbonate), and storage potential (providing a staging area for sediment eventually moved to the deep-sea) on various sedimentary systems beyond the shelf break; (d) relationships between sea level and other factors that affect sediment distribution.

(2) Autocyclic controls. Tests are necessary to address growth patterns of rapidly accumulating clastic systems where the allocyclic controls outlined above remain relatively constant. This includes determination of rates of aggradation and shifts in depocenter position of critical morphologic features formed by deposition along the margin, including the influence of channel avulsion, lobe switching and the effects of clogging bottom current strengths and positions. It is also important to determine the deformational behavior with respect to diapirism, tectonic deformation and the timing and mechanics of slumping and associated mass-wasting processes.

Ice margin processes

Todays most unknown depositional environments are beneath the permanently ice-covered Arctic Ocean. Clearly, Arctic Ocean drilling must be a prime future objective. More achievable and equally important targets lie at the ice margin where both bottom-current and turbidite sedimentation may occur and within the oceanographic gateways that connect the Arctic with adjacent seas. These gateways have a profound affect on both surface and deep-water circulation and hence also on deposition and erosion within the adjacent seas. Variation of sedimentary facies and architecture in these ice-margin environments and associated gateways and their influence on global budgets require special attention.

Volcanic sedimentary processes

Volcanic sediments are one of the major component sediment types in active plate margins, oceanic ridges, and oceanic islands. Variation of depositional facies and architecture of pyroclastic and volcaniclastic sediments, including the transformation from pyroclastic processes to normal marine settling and subaqeuos sediment gravity flow, should be tested in response to tectonic activities, eruption types, and nature of magmas. Volcaniclastic sediments are chemically unstable and play an important role in controlling early diagenesis and geochemical mass balance in oceanic environments.

Physical properties

Sediment physical properties change through time and space in response to environmental processes. Fluid circulation through the sea floor, consolidation of sediments, diagenesis and generation of gas are the most important processes that cause change in sediment physical property in ocean basins. The determination of the regional distribution of diagenetic patterns in basal sediments in ocean basins will greatly aid in the development of coherent models of mass, fluid and heat transfer in the oceanic regime. Ultimately, it should lead to a more complete understanding of geothermal and hydrothermal oceanic systems.

Drilling strategy

Deposition by bottom currents

Both the North and South Atlantic Oceans contain well-documented examples of large current deposits; modern examples have formed from flow of bottom, deep and intermediate water masses. The primary drilling targets are sediment drifts, including at least one site up-current from the drift deposit to evaluate the contribution of sediment by erosion of the deep-sea floor. Large-scale sediment-wave fields constitute the other major type of target. Special technological requirements include oriented cores and logging, especially dip determinations. Site-survey data should include SeaBeam and high-resolution seismic-reflection profiles.

Re-sedimented systems

There are two major classes of re-sedimented systems: Those formed in basins on continental crust, and those on oceanic crust along passive margins. The North Pacific Ocean has the best examples of margin-basin deposits that can provide the information on architectural elements needed for modeling fluid flow in accreted margin wedges. Drilling these margin deposits will also provide the closest tie to the geoscience community at large. The Atlantic Ocean provides the best targets for drilling large, continental-rise deposits fed by major rivers; drilling of these systems will be critical to determining global sediment budgets and autocyclic controls on sedimentation. Special technology requirements include recovery of unconsolidated sediment, logging, and casing the hole if VSP-experiments are to be conducted. High-resolution seismic-reflection profiles are recommended as part of the site-survey data set.

Physical properties

Physcial-property studies of sediment types should be conducted at sites selected for the biogenic end-members and from sites selected for re-sedimented systems and bottom-current deposits for terriginous supply. The full range of logging measurements are of prime importance for physical-property studies. For ice-margin processes the Arctic Ocean is one of the prime areas. Site-survey data should include high-resolution seismic-reflection profiles.

Volcanic sedimentary processes

The prime target areas are in the western Pacific and northeastern Indian Oceans for arc-related volcanism, and oceanic islands such as Hawaii and Iceland. No supplemental work is required. Special technological considerations are the recovery of loose sediment and probable requirement for diamond drilling or Navidrill. Site-survey data should include high-resolution seismic-reflection profiles and, for the oceanic island sites, SEABEAM bathymetry.

Technology

Past problems with sand recovery has resulted in a serious bias toward mud-rich system, in both our understanding of margin sedimentation and the selection of future drill sites. Discussion of recovery problems at two scientific meetings that included industry participants (SEPM mid-year meeting in 1987 and COMFAN II in 1988) indicated that the technology for drilling unconsolidated sand exists and may be transferable to ODP. We recommend immediate investigation of the possibility to adapt such technology. Simultaneously and if existing techniques cannot be adapted, we also request development in house.

Logging of sites on continental margins is a high priority to adequately address many of the objectives described in this section. There is a special need to log the upper portions of the holes to tie facies distinction to morphologic controls available only in the upper tens of meters of many depositional environments.

FLUIDS: Circulation Through the Crust and Geochemical Balances

Overview

Large-scale circulation of fluids within the oceanic lithosphere is of fundamental importance to global geochemical budgets. It is now clear that fluid circulation and the transport of solutes and gases by fluids are of major importance. The interaction of fluids with oceanic sediment and basalt is a first-order process affecting the cycles of elements and determining the transfer between geochemical reservoirs.

The SGPP believes that continental margins, both active and passive, are of the highest priority for drilling during the period through 1994. One of the major achievements of the first four years of the ODP, as also identified in the COSOD II documents and recently in the ODP Long Range Planning Document, was the demonstration for the first time that fluids moving through and flowing out of margins are major contributors to the geochemical fluxes in the lithosphere and hydrosphere. Because the discharge regions at all margins are submerged, ocean drilling is essential. The emphasis by SGPP of drilling in continental margins is complemented by the emphasis of LITHP for drilling the ridge axes (JOIDES Journal XIV No.1, 24-36, 1989) and hence the latter will not be repeated here.

Scientific opportunities for future ocean drilling

Through studies of submarine fluid circulation, we are at the threshold of gaining new understanding of how margins are dewatered, lithified and how they respond to tectonic stress. Ocean drilling permits investigation of fluid circulation in different geologic environments and the possibility of long-term experiments in re-entry holes. A consensus among a large portion of the scientific community holds that this frontier of research should be exploited as the target of future drilling efforts in which tectonic, lithosphere, and geochemical objectives become intertwined (see for example: TECP White Paper, *JOIDES Journal*, 1989, XV (3), 41-60 and LITHP White Paper, *JOIDES Journal*, 1989, XIV (1), 24-36). Specifically, drilling must be used to define: (1) geologic settings; (2) physical characteristics and chemical composition of fluids; and (3) existing pore pressures and rates of flow and solute transport. Fluid pore pressures, chemistries, and temperatures indicate fluid sources and the nature of chemical reactions affecting both the fluids and host rocks. These parameters, along with *in situ* permeability measurements and theoretical analyses, will permit rates of fluid flow and chemical transport to be estimated in different tectonic settings and on a global scale. Long-term experiments in re-entry holes will provide transient *in situ* measurements of fluid and sediment properties and can be used to determine the importance of time-varying fluid and matrix stress states. These objectives are:

Geological environment of the fluid circulation:

1) Large scale plate tectonic setting: ridges, flanks, basins, active margins, passive margins.
2) Local geological setting: bare rock ridges vs. sedimented ridges; continental vs. marine subduction zones; ridge crest subduction and similar configurations; scale and nature of fluid flow boundaries.

Characteristics of fluids:

1) Sources of the fluids: terrestrial vs. marine dewatering; membrane controlled vs. dewatering by mineral dehydration.
2) Physical state of the fluids: one phase vs. two phase liquid states; gas phase formation and phase separation.
3) Chemical changes affecting the fluids: crustal alteration, cementation gas hydrate formation.

Magnitude of flow regimes

1) Constraints on the fluid flow: temperature gradient, pressure gradient, initial permeability and diagenesis-introduced permeability changes of porous media.
2) Location and extent of recharge and discharge areas.
3) Three-dimensional circulation pattern.
4) Time scale and modulation of the fluid flow regimes.

These objectives will also provide answers to questions regarding the complexities of material balances of the total Earth system; those questions are:

- Can the mass transport of certain elements be quantified that are critical to the mass balance?
- What are the driving forces of fluid flow?
- What changes in mass transport rates have occurred over the last 100 My?
- What are the reaction dynamics and rates of alteration?
- What are the mode and location of deposition of base metals as well as gas and petroleum migration and emplacement?
- How do fluids and their migration pathways affect styles of tectonic deformation?

The major advantage of ODP and its unique role with respect to these SGPP objectives are that ocean drilling is the only means by which to gain direct access to:

•Material properties and tectonic settings within active submarine fluid regimes
•Long-term experiments in re-entry holes
•Critical space and time scales of fluid processes
•Three-dimensional pattern of circulation
•Environments with controlled sources and gradual evolution of fluids between sources.

Of the submarine fluid regimes, the SGPP believes that those on active margins are highest priority for drilling in the immediate future. Hence, the scene is set for the design of a major drilling experiment on active margins, that will complement the LITHP- priorities of the ridge axis (*JOIDES Journal*, 1989, XIV (1), 24-36).

Drilling on passive margins and the sedimented ridge axes is the next priority for the SGPP in this context. The SGPP recognizes that the flow regimes on ridge flanks and their relationship to basin-wide flow patterns may well be of major importance too, but anticipates that drilling proposals addressing this theme will require longer to achieve maturity.

<u>Drilling strategy</u>

The overall strategy calls for drilling in tectonic environments that represent contrasts in convergence rate and sediment type, accumulation rates and sediment thickness. Such a strategy provides key data which can then be used to extrapolate to global fluxes. Drill hole locations and depths should be designed to delineate the overall hydrogeologic setting and provide detailed data on depth variations in the critical parameters. Deep drilling beyond the accreted or subducted sediment packages into underlying basement is essential. Models of fluid flow and chemical transport combined with physical convergence and compaction models should be used in planning these transects. Tracers for source depths of fluids and other criteria for sources need to be developed. A drilling strategy for margins should take into account the following considerations:

1) Fluid flow at active margins is driven by tectonic and gravitational stresses. As sediments are incorporated into an accretionary complex, they are either off-scrapped into an accretionary prism or carried downward with the subducting plate. In both cases, the sediments compact in response to increasing stress and water is driven from the complex laterally seaward and toward the ocean floor. Mechanical deformation of accreting and subducting sediments controls: (a) rates of compaction and amount of fluid driven from the complex; (b) rates of tectonic transport of pore waters; and (c) permeabilities and dispersion properties of the sediments.

2) At passive continental margins, meteoric water may enter relatively permeable strata that extend beneath the continental shelf. This water may migrate long-distances, vertically and horizontally, and mix with pore waters of different origin. Both fluid chemistries and temperatures alter fluid densities, thus modifying fluid flow, driving forces and circulation rates and patterns. To understand these processes at a specific location, it is essential to: (a) delineate the regional hydrogeologic setting; (b) obtain point measurements of pore pressures and hydraulic properties (e.g.,permeability, porosity) of the geologic material; and (c) measure temporal and spatial variations in pore pressure, fluid chemistry and fluid temperatures.

3) For ridge crest and flank environments, transects on the flanks of both fast and slow spreading ridges will provide information on the crustal and sedimentary chemical exchange due to free convection of fluid.

<u>Technology</u>

For a complete characterization of the fluid regimes in active and passive margin settings extensive technological developments will be required. As in the recent past important insights and great scientific leaps in understanding these fluids regimes will be achieved by continued drilling and parallel development of technologies. Extensive surveying of both regional and detailed targeting of sites will be needed; most of the required technologies for surveying exist.

Drilling developments should be directed to:
1) Stabilize re-entry sediment holes;
2) Drill deep holes into sediment and into basement;
3) Solve problems of sampling and stabilizing in sandy horizons;
4) Re-seal holes to arrest vertical flow and allow to return to equilibrium;
5) Core ahead of drill bit, providing less chemical and vertical disturbances.

Developments of sampling and *in situ* profile measurements of physical and chemical properties should be directed to:
1) Recover undisturbed sediment cores for chemical and physical properties;
2) Correct closely spaced *in situ* sampling of truly representative, uncontaminated fluids and gases, coupled with temperature measurements
3) Develop near *in situ* pore fluid and gas sampler (for frequent and multiple samples per deployment), plus appropriate packers; for this to succeed better hole isolation will have to be developed;
4) Measure *in situ* permeability, porosity, electrical resistivity, seismic velocity and pore fluid pressure;
5) Develop pressure core system and procedures for on-board sampling of fluids, gases and gas hydrates at *in situ* pressure and temperature; e.g. PCB-phases II and III;
6) Recover continuous undisturbed sediments and rocks for lithology, diagenesis and metamorphic characterization, *in situ* sediment structure analysis and strain measurements.

Developments in long-term monitoring experiments should address:
1) steady versus episodic fluid flow by instrumentation;
2) temperature and pressure gradients (and strain ?) on the seafloor;
3) fluid pressure, temperature, fluid and gas chemistry, and strain in sealed holes.

METALLOGENESIS: Control by Tectonics and Host Material

<u>Overview</u>

A major manifestation of the thermally-driven migration of fluids through oceanic sediment and underlying oceanic crust is the mobilization and concentration of metals, locally to economically important levels. In this sense, metallogenesis represents a special case in which an otherwise diffuse fluid flow field is highly focussed to yield considerable amounts of metal precipitation. All stages of the "Wilson orogenic cycle" involving initial hot spot magmatism/intra-cratonic rifting, creation of oceanic crust, ocean floor subduction-back-arc spreading as well as continent-continent and continent-arc collision are known to be capable of driving fluid migration. Hence metal enrichments are associated with the full spectrum of tectonic environments. Ocean drilling can be employed as a means to access all hydrologic/metallogenic processes in these settings. "Extinct" ore deposits are overprinted and the result of integrated, complex tectonic, hydrologic, magmatic, sedimentary, thermal and geochemical processes. From these alone it is difficult to unravel the hydrologic/metallogenic history.

A spectrum of modern settings should be investigated in order to fully appreciate the possible range of controls on ore formation. Furthermore, this same broad approach may contribute significantly to the understanding of oceanic rifts, which are now recognized as potential source and/or host environments for Ag, Co, Ni, As, Bi ores and as sites of hydrothermal petroleum formation.

Special opportunities in studying these processes through ocean drilling arise from the ability to examine in three dimensions the active fluid flow field together with changes in metal and sulfur concentrations within the fluids and their interaction with the parent rock during active metallogenesis. The final product, that is, the accumulation of metals, contains the fingerprint of fluid flow paths, fluid geochemistry, and processes of deposition. Although metal accumulation occurs in a spectrum of marine environments, interest focuses on the so-called "volcanic massive sulfide deposits". These are now recognized to have formed as a result of oceanic-based tectonism and comprise over a thousand deposits including some of world's major sources of Cu, Pb, Zn, Ag, and Au. Massive sulfides can be divided into those formed at ocean ridge spreading centers and those associated with felsic volcanism in island arc settings or active marginal basins. Metallogenesis in the former setting has received somewhat more attention in the Ocean Drilling Program but among the presently recognized ore districts, perhaps 70%, are associated with felsic volcanism of convergent margins.

Scientific opportunities for drilling

A number of oceanic settings are known for their potential to yield significant data for the understanding of metallogenesis. Targets include those with proven ore deposition and 'frontier' areas. Studies of these environments complement each other to contribute to a more complete picture of metallogenesis. Oceanic environments with proven ore deposition are targets in the following settings: bare rock mid-ocean ridges, sedimented mid-ocean ridge crests, spreading ridges in back-arc basins and intra-continental young ocean basins. They share a suite of common drilling objectives and, conversely, each poses a set of environment-specific questions; these common questions are :

•What are the sources of the metals, of sulfur, of the gangue (non-ore) constituents?

•What are the primary controls of the three-dimensional hydrologic flow paths?

•What specific conditions focus the fluids sufficiently to produce a significant metal accumulation?

• What is the nature and scope of rock alteration along hydrothermal flow paths?

•What are the physio-chemical and -perhaps- microbiological conditions of metal precipitation?

•How do these processes evolve through the life of a hydrothermal system?

For mid ocean bare ridge settings a detailed understanding of the deeper part of the sulfide system, confined within oceanic layer 2, is needed. Access to these systems cannot be attained by any other means except by drilling. Further questions address the scale and extent of metallogenesis in these settings –why have some massive sulfides evolved to giant size while others are limited in scope? Finally, how have such deposits been preserved in different settings under a variety of post-emplacement histories? Within sedimented ridge environments and back-arc basins, the varying composition of the sediment cover and facies modify hydrologic flow paths and thermal evolution and influences metal sources, sulfur sources, and overall fluid evolution.

SGPP encourages for sedimented environments studies of the geometry and chemical composition of the sulfides in the sediments as well as within the basaltic sections. Many of the objectives associated with metallogenesis in intra-continental young ocean basins and back-arc basins are similar to those for sedimented ocean ridges because of the controlling role of the sedimentary cover. However, boundary conditions for hydrologic flow in young ocean basins are distinct from those in mature rifting systems. Furthermore, the influence of underlying red-bed clastics, rift evaporite deposits, and organic matter accumulations needs to be considered. These same constraints may apply in more evolved -and more deeply buried-rift settings. The marine-based thermal regime in young rifts may also influence ore deposition in adjacent continental blocks. Hence an understanding the ocean-based hydrothermal flow regime provides significant constraints on ore genesis in continental settings.

Three additional tectonic environments provide new frontiers for the understanding of metallogenesis: (1) Ore formation has clearly occurred in sub-environments of island arc settings in addition to back-arc basins; drilling these can potentially open up exciting opportunities to understand metal deposition. (2) Carbonate reefs are known to host significant Pb-Zn (Cu, Co, Ni) ores of the so-called Mississippi-Valley type (MVT). This type of mineralization is believed related to oceanic-based tectonic events, but ore emplacement occurred long after host-rock deposition. Nonetheless, early diagenesis may control the initial host-rock permeability and porosity structure, which would ultimately influence the ore deposition. Drilling provides the opportunity to study these controls on secondary ore deposition. (3) Intra-plate volcanoes can provide locations for ore genesis. They are characterized by localized thermal sources and fluid conduits and are potential sites to study the phenomenon of fluid phase separation (boiling) because of their shallow depths. Again, drilling provides the only access to sample these actively forming ore bodies and their precipitating fluids.

Drilling strategy

Quite well known and well-surveyed drilling targets exist for the mid-ocean ridge and early rift-basin settings. For bare ridges these include the Endeavour segment of the Juan de Fuca Ridge, 21°N of the East Pacific Rise, the Galapagos Ridge segment, and the TAG area of the Mid-Atlantic Ridge. Sedimented ridges that are well surveyed include the Middle Valley, the Escanaba Trough, and the Guaymas Basin. The ridge Valu Fa is a back-arc spreading center with volcano-clastic sediment cover. The Red Sea is an example of an early rift basin, while Guaymas Basin also shares affinities to this type of setting. Site characterization prior to drilling should address the hydrologic regime, the composition of fluids vented at the seafloor, and the regional extent of alteration (e.g. models based upon magnetization of the crust). Effective drilling also must contain programmatic elements designed to understand fluid flow and evolution of hydrothermal fluids. Both these requirements necessitate a three-dimensional approach and thereby converge towards the strategy outlined in the previous chapter on Fluids: Circulation through the Crust and Geochemical Balances.

Technology

Radically new technologies are needed for characterizing the "hot" hydrologic regime, including ways to measure *in situ* permeability, porosity, thermal structure, and fluid flow. These are the same as those discussed in more detail in the previous chapter. However, drilling technology specifically required for metallogenesis studies is in the context of access and sampling of "very high temperature" environments and "improved drilling recovery" of: (1) sulfides and associated sediments and rocks, including sandy sediments and coarse rubble zones; (2) uncontaminated pore fluids, with specific precautions for sampling trace metals; (3) volatile and ephemeral constituents, particularly H2S, CO2, He and CH4.

PALEOCEANS: Fluctuations in Chemistry and Geochemical Budget

Overview

Major and minor perturbation in the global sedimentary record document that the chemistry of ancient oceans was not constant throughout geologic time but deviated from the composition of modern oceans considerably. For example, evaporite deposits are a primary sink, as well as a source, for the major ions (Na, Ca, Mg, Cl and SO4) in sea water, but evaporite giants are not equally distributed throughout geologic time. Thus, ocean salinity has probably fluctuated sporadically with sequestering of salt into evaporite deposition and release from evaporite erosion. Knowledge of the chemical budget of paleoceans has implications for understanding changes in the chemical material balances as well as for evaluating changes in the global environment.

Another example is the cycle of carbon. The variation in the burial of biogenic forms of oxidized (calcium carbonate) and reduced (organic matter) carbon in the marine sedimentary record plays a role in regulating the pCO_2 and pO_2 in the atmosphere. Spatial patterns of preservation for these different forms of carbon has fluctuated back and forth over geologic time. The causes are a complex interplay between marine primary production, sediment influx, sedimentation rate and ocean circulation. Detailed knowledge of spatial patterns and mechanisms of carbon preservation in key areas of the ocean throughout the geologic past is essential to the formulation of accurate models for paleoproductivity and defining causal relationships between bio-production and climate change and hence regulating atmospheric pCO_2 and pO_2. Developing such models of the paleocean environment is central to our attempt in predicting how human influence will impact future, otherwise, naturally controlled, climate fluctuations.

Fluctuations in the biogeochemical processes of the Earth's ocean and atmosphere during the Mesozoic and Cenozoic eras are recorded in the biogenic and authigenic components of deep-sea sediments. Understanding the controls on the distributions of geochemical indicators of global environmental change in time and space allows detailed reconstruction of past oceanographic conditions and key events related to global change. This leads to an understanding of the interactions between terrestrial, atmospheric and oceanic systems. Examples of environmental information accessible through ocean drilling include changes in the: (1) patterns of oceanic thermohaline and surface water circulation, shifts in the locations, strengths and ecology of equatorial and high latitude fronts and upwelling zones; (2) rates and locations of continental weathering and erosion due to uplift and tectonics or to changes in rainfall patterns; (3) rates of sea-floor spreading and hydrothermal circulation through mid-ocean ridges; (4) the redox state and corrosiveness of bottom and interstitial waters; (5) patterns of delivery of wind-blow and fluvial material to the oceans; and (6) the climate change linked to radiative forcing, ice volume, atmospheric CO2 and other greenhouse gases, and biologic recycling of nutrients.

The sedimentary biogenic record contains two types of historical information: *paleochemical tracers and accumulation rates.* High-resolution chemostratigraphies in biogenic material document isotope or trace element perturbations of the paleoceans and, in conjunction with bio- and magneto-stratigraphies, can be used to evaluate the timing, causes, and consequences of these geochemical events. Within and beyond the next decade the application of paleochemical tracers will include not only the traditional paleoceanographic foraminiferal tools (∂18O, ∂13C, 87Sr/86Sr, Cd/Ca) but also new ones under development for plankton (Ba), for calcitic microfossils (Sr/Ca, Li/Ca, ∂34S {in sulfate}, ∂15N {in calcified protein}, REE, 143Nd/144Nd), for siliceous microfossils (∂18O, Ge/Si, REE), and for organic matter (biomarkers such as unsaturated alkenones and ∂13C and ∂15N in isolated biomarkers). Biogenic components, such as marine organic carbon, calcite, opal, and detritial organic carbon (introduced to the oceans erosionally from land sources) record changes in the global balance of dissolved fluxes to and from the sea, changes in global climate (as a response to Milankovitch forcing), continental aridity, ecology of surface water production, local front migration, bottom water sources and chemistry of the paleocean. Global rates of accumulation of biogenic material on the seafloor are fundamental information for quantifying global geochemical balances and thus the fluxes of elements through the ocean-atmosphere system. Recent oceanographic observations suggest that the flux of iron may provide an important control on marine biogenic accumulations in large expanses of past oceans.

The climate controls air-sea interactions, oceanic circulation and ultimately the deposition of biogenic as well as eolian sediment. Except for the central oceanic areas the climate is strongly influenced by the extent and relief of adjacent lands. Hence the reconstruction of paleotopography is critical to understanding the distribution of sediments in the ocean.

The sedimentary authigenic record results from post-depositional changes in the mineral components due to diagenetic alteration, the influx of new material by diffusion across the sediment/water interface or hydrothermally-driven circulation. Authigenic components, such as clays, zeolites (and other silicates), iron and manganese minerals, diagenetic carbonates, phosphorites, and cherts, reflect geochemical conditions at the time of depositon and yield clues to fluid movements and material fluxes. The importance of evaluating the distribution and occurrences of authigenic minerals to global geochemical balances has been emphasized with the recent discovery of new oceanic source terms, such as the expulsion of pore fluids from subducting and accreting sediments on active margins, free convection of seawater through low-temperature ridge flanks, and leakage of continental fresh and saline groundwater from passive margins. Also, metallogenesis as controlled by fluid migration at active margins leaves a lasting sedimentary imprint of chemical exchange among reservoirs.

Scientific opportunities for future drilling

Important questions to be addressed by future deep ocean drilling include the following:
1) What are the global removal rates of elements in biogenic and authigenic sediments?
2) How do oceanic processes, affecting these removal fluxes, impact atmospheric and oceanic chemistry and climate?
3) What are the locations, accumulation rates and nature of biogenic sediments deposited under high latitude frontal zones, and how important is Southern Ocean ventilation-nutrient removal on atmospheric CO2 and climate?
4) What is the timing and state of diagenetic alteration or removal from the sediment column of the bio-calcareous, bio-siliceous and bio-organic components and how does this affect the internal long-term cycling of nutrients, Ca, Sr, alkalinity, CO2 and volatiles in the ocean, as well as the integrity of paleochemical signals derived from biogenic microfossils and bulk sediments?
5) What are the most promising proxy indicators for water mass properties and where are the key areas and critical time periods for which paleocean hydrography (Paleo Geosecs) should be reconstructed?

Recovery of the paleochemical and accumulation record will require a detailed global inventory of continuous high resolution sections, including coverage of the biogenic sediment facies (calcareous, siliceous, and organic carbon rich) and paleolatitude and paleodepth transects in all oceans. A systematic documentation of the state of *in situ* diagenetic alteration, including key boundary sections containing evidence of dramatic environmental changes, will also be required. Assessment of global fluxes into the ocean on ridge flanks and active and passive margins will require site -and process-specific experiments.

Drilling strategy

In order to meet the overall objectives of SGPP in evaluating geochemical fluxes, balances and the water mass properties of paleoceans, the following strategy should be adopted:
1) Drill the "missing" ages and poorly-recovered time intervals in existing DSDP and ODP sites, including re-occupation of some sites with APC/XCB to core continuous Neogene and Paleogene sections. Complete geochemical logging will be required to ensure the best possible "recovery" of continuous chemical information to complement the core-derived date. This strategy is identical to that driving Neogene and Paleogene paleoceanography (OHP White Paper; *JOIDES Journal* 1989, XV (1), 40-58), with the exception that biosiliceous sediments must not be ignored. Sites to be considered include the condensed biogenic sections on the flanks of the Southeast Pacific-Antarctic Ridge, the topographic features associated with the Southwest Indian-Antarctic Ridge, and re-occupation of older DSDP sites between Australia and Antarctica. In the northern high latitudes drilling must include the Arctic Ocean, the Bering Sea and the Sea of Ochotsk. Also, drilling of paleochemical events recorded in Mesozoic sediments should be emphasized

2) Co-ordinate a drilling program with LITHP on both fast- and slow-spreading ridge flanks to obtain information on both

crustal and sedimentary chemical exchange due to forced and free-convection of fluids. This must include a modern pore water chemical program, and new technology to measure *in situ* pore pressure, temperature, pH and other dissolved constituents with specific ion-electrodes, perhaps with a top hole packer that contains passive (diffusive) tracers to monitor up-hole and/or down-hole advection.

3) Augment the drilling strategy for fluid flow through both active and passive margins; or where there is mineralogic evidence from authigenics for flux of material through the sediment package. Proposed drill sites should include accretionary wedges, the boundary zone between continental and oceanic crusts, and continent-continent collision zones.

4) Extend the existing logging program to allow for logging of more holes with the Geochemical Logging Tool (GLT) that yields continuous down-hole elemental compositions, and development of other tools for rapid real-time analog analyses of both recovered cores and holes drilled. This provides a complete, rapid and inexpensive global evaluation of paleogeochemical signals contained within the sediment column and permit identification of missing core sections.

5) Initiate deep micro-biological and shipboard organic geochemical studies which would distinguish between recent chemoautotrophic and heterotrophic processes operating within sediments and hydrothermal processes acting upon organic matter transported by fluid, sedimentary and tectonic mechanisms. Studies of deep microbial activity is a new research frontier of enormous importance that helps define the lower boundary of the Earth's biosphere.

Technology

New technology is needed to accomplish these drilling objectives, including ways to recover sediments, fluids and gases at *in situ* temperatures and pressures as well as a wireline side-wall corer with *in situ* sensor and sampling capabilities. The pressure core sampler and side-wall corer are discussed in greater detail in the chapter on fluids, however, a specific requirement to advance paleocean objectives are enhanced drilling capabilities in areas with thin sediment cover (< 50 m on upper ridge flanks) and in areas with alternating sediment types. The ability to recover variable lithologies, such as carbonate-siliciclastic sediments, their diagenetic equivalents: chert-limestone sequences, intervals of hard-soft interlayers, such as reefal limestones and carbonate sands and muds without severe disturbance or loss of material is essential.

JOI/USSAC Booth at the Circum-Pacific Energy and Mineral Resources Conference

Don't forget to drop by Booth #25 at the Circum-Pacific Energy and Mineral Conference, July 29 - August 3, 1990, at the Hilton Hawaiian Village in Honolulu, Hawaii. Information and brochures about ODP and the JOI/U.S. Science Support Program will be available.

JOIDES/ODP BULLETIN BOARD

JOIDES MEETING SCHEDULE (05/05/90)

Date	Place	Committee/Panel
11-12 June, 1990	Iceland	PPSP
20-22 June, 1990	Washington, DC	EXCOM & ODPC
28-29 June, 1990	Seattle, WA	DMP
10-11 July, 1990	Palisades, NY	SSP
9-11 August, 1990	Quinault, Washington	Cascadia DPG
8-9 August, 1990	LaJolla, CA	USSAC
14-16 August, 1990	LaJolla, CA	PCOM
26-27 Sept., 1990	College Station, TX	TEDCOM
2-4 October, 1990	France	EXCOM
8-10 October, 1990*	Basel, Switzerland	IHP
9-12 October, 1990*	Brisbane, Australia	DMP
9-12 October, 1990*	Brisbane, Australia	SMP
11-13 October, 1990*	Tokyo, Japan	LITHP
19-21 October, 1990*	Canberra, Australia	OHP
1-3 November, 1990*	Paris, France	TECP
2-3 November, 1990*	Paris, France	SGPP
27 November, 1990*	Kona, Hawaii	Panel Chairmen
28 Nov.-1 Dec., 1990*	Kona, Hawaii	PCOM
23-25 April, 1991*	Austin, TX	PCOM
June, 1991*	Cardiff, Wales	ex-IOP & Co-Chiefs
20-22 August, 1991*	Hannover, FRG	PCOM
3 December, 1991*	Univ. Rhode Island	Panel Chairmen
4-7 December, 1991*	Univ. Rhode Island	PCOM

* Tentative meeting; not yet formally requested and/or approved.

ODP/TAMU PANEL LIAISONS:

Downhole Measurements Panel - ANDREW FISHER
Information Handling Panel -RUSS MERRILL
Pollution Prevention & Safety Panel - LOUIS GARRISON
Site Survey Panel - AUDREY MEYER
Technology & Engineering Development Committee - BARRY HARDING
Executive Committee - PHILIP RABINOWITZ
Planning Committee - LOUIS GARRISON
Shipboard Measurements Panel - JACK BALDAUF & DENNIS GRAHAM
Sedimentary and Geochemical Processes Panel - MARTA VON BREYMANN
Ocean History Panel - TOM JANECEK
Tectonics Panel - LAURA STOKKING
Lithosphere Panel - JAMIE ALLAN

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. Please contact Ellen Kappel at the JOI office for further information and proposal guidelines: (202) 232-3900.

CALL FOR PAPERS:

EVOLUTION OF UPWELLING SYSTEMS SINCE THE EARLY MIOCENE

September 3-4, 1990

The Geological Society
Burlington House, London, United Kingdom

The central aim is to consolidate the growing body of knowledge on the evolution of upwelling systems and to examine the consequences emerging from a wealth of studies on upwelling sedimentation performed in the framework of scientific ocean drilling.
If you wish to contribute a paper please inform Dr. Warren L. Prell, Geology Department, Brown University, 324 Brook Street, Providence, RI, 02912, and send an abstract of not more than 100 words.

The proceedings will be published as a Special Publication of The Geological Society. A limited amount of travel funds have been made available to U.S. participants through the JOI/U.S. Science Support Program. If you are interested in attending, please contact Warren Prell immediately.

TAKE NOTICE

ODP has a new 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. Write to Karen Riedel, ODP Public Relations, for copies.

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.

WORKSHOP REPORTS AVAILABLE

The following reports are available. For copies please write to JOI/USSAC Workshop Report, 1755 Massachusetts Ave. NW, Suite 800, Washington, D.C. 20036-2102.

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.

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

ODP OPEN DISCUSSION LIST *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 (ANNIE@TAMODP) requesting that you be added to the ODP-L subscription list.

NEW OPPORTUNITIES FOR ODP THEMATIC PUBLICATIONS

The Ocean Drilling Program is now seeking scientists worldwide who are interested in serving as conveners or leading editors for ODP thematic volumes. The Joint Oceanographic Institutions has seed money available to defray out-of-pocket costs such as postage, telephone, copying, travel to consult with colleagues or potential publishers, etc. These thematic volumes would be published by outside firms or societies, rather than ODP. For more information, write or call Ellen Kappel at the JOI Office.

1991 NSF/ODP FIELD PROGRAMS

The Ocean Drilling Program of the National Science Foundation, in its continuing effort to encourage the development of mature drilling proposals, is accepting proposals for regional geological and geophysical studies well in advance of drilling from US scientists and institutions. In keeping with the thematic emphasis of the international Ocean Drilling Program, the Foundation will accept proposals for work in any ocean. However, as the international planning effort focuses drilling plans on a particular region of the world, proposals for work in that region will receive special attention.

Proposals are evaluated primarily on their intrinsic scientific merit in the general context of marine geology and geophysics. ODP proposals, however, are also judged on their value to the drilling program. Thus these proposals should also contain a separate section (two or three pages) that specifically addresses the potential of the proposed research to enhance the effectiveness of and scientific return to the drilling program. This section should discuss both long-term ODP goals as outlined in the report of the Conference on Scientific Drilling (COSOD) as well as the specific scientific problems to be addressed. The COSOD report is available from the JOI office.

The target date for submission of proposals for marine field work in 1991 is June 1, 1990. Field programs that were funded for 1989 included a video and acoustic side-scan survey of the East Pacific Rise using ARGO, a combined multichannel seismic and SeaMARC survey of the Oregon margin, and a seismic and coring program in the East Pacific.

NEWS! From an ODP Liaison Group

There will be a SEPM Research Conference, co-sponsored by the Global Sedimentary Geology Program (GSGP) entitled:

CRETACEOUS RESOURCES, EVENTS, AND RHYTHMS
August 20-24, 1990
Denver, Colorado

Interested researchers should apply to SEPM directly at the following address to register for the conference: S.E.P.M., P.O. Box 4756, Tulsa, OK, 74159-0756. Call Susan Green at (918) 743-9765 for further information.

BIBLIOGRAPHY OF THE OCEAN DRILLING PROGRAM

The publications below are available from ODP Subcontractors. Items from ODP/TAMU are available at 1000 Discovery Drive, College Station, TX 77840. Items from LDGO can be obtained from the Borehole Research Group, LGDO, Palisades, NY 10964.

ODP/TAMU, Texas A & M University

1. Proceedings of the Ocean Drilling Program, Initial Reports

   Volumes 101/102 (combined) Dec 86
   Volume 103 published Apr 87
   Volume 104 published July 87
   Volume 105 published Aug 87
   Volume 107 published Oct 87
   Volume 108 published Jan 88
   Volumes 106/109/111 (combined) Feb 88
   Volume 110 published Apr 88
   Volume 112 published Aug 88
   Volume 113 published Sept 88
   Volume 114 published Nov 88
   Volume 115 published Nov 88
   Volume 116 published Jan 89
   Volume 117 published June 89
   Volume 118 published May 89
   Volume 119 published Sept 89
   Volume 120 published Nov 89
   Volume 121 published Nov 89
   Volume 122 published Jan 90
   Volume 123 published June 90
   Volume 124E published June 90

2. Proceedings of the Ocean Drilling Program, Scientific Results

   Volumes 101/102 (combined) Dec 88
   Volume 103 published Dec 88
   Volume 104 published Oct 89
   Volume 105 published Oct 89
   Volume 108 published Dec 89
   Volume 111 published Dec 89
   Volume 106/109 published Jan 90
   Volume 110 published May 90
   Volume 112 published May 90

3. Technical Notes

   #1 Preliminary time estimates for coring operations (Revised Dec 86)
   #3 Shipboard Scientist's Handbook (Revised 1990)
   #5 Water Chemistry Procedures aboard the *JOIDES RESOLUTION* (Sept 86)
   #6 Organic Geochemistry aboard *JOIDES RESOLUTION* - An Assay (Sept 86)
   #7 Shipboard Organic Geochemistry on *JOIDES RESOLUTION* (Sept 86)
   #8 Handbook for Shipboard Sedimentologists (Aug 88)
   #9 Deep Sea Drilling Project data file documents (Jan 88)
   #10 A Guide to ODP Tools for Downhole Measurement (June 88)
   #11 Introduction to the Ocean Drilling Program (Dec 88)
   #12 Handbook for Shipboard Paleontologists (June 89)

4. Scientific Prospectuses

#25/26	(Dec 88)	Legs 125 & 126
#27/28	(April 89)	Legs 127 & 128
#29	(Aug 89)	Leg 129
#30	(Oct 89)	Leg 130
#31	(Oct 89)	Leg 131

5. Preliminary Reports

#25	(June 89)	Leg 125
#26	(Aug 89)	Leg 126
#27	(Sept 89)	Leg 127
#28	(Oct 89)	Leg 128
#29	(Feb 90)	Leg 129

6. Engineering Prospectuses

   #2 (Nov 89) Leg 132

7. Other Items Available
   - Brochure: The Data Collection of the ODP - Database Information
   - Ocean Drilling Program brochure (English, French, Spanish, German or Japanese)

Bibliography of the Ocean Drilling Program, continued

- Onboard *JOIDES RESOLUTION* (new edition, 24 pp.)
- ODP Sample Distribution Policy
- Micropaleontology Reference Center brochure
- Instructions for Contributors to ODP Proceedings (Revised Apr 88)
- ODP Engineering and Drilling Operations
- Multilingual brochure with a synopsis of ODP (English, French, Spanish, German and Japanese)
- ODP Poster
- ODP Scientific Highlights: Legs 101-123, January, 1985-December, 1988 (12 pp.)
- Western Pacific Cruises (Objectives of Legs 129-135)
- Four years of Scientific Ocean Drilling (Reprinted from *Sea Technology*, June, 1989)

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

- Wireline Logging Manual (3rd Edition, 1988)

DATA AVAILABLE FROM THE NATIONAL 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.

Data are also available on magnetic tape, floppy diskette, or as computer listings. Costs for services are: $90/2-disc CD-ROM data set, $90/magnetic tape, $30/floppy diskette, $25/microfilm reel. Costs for computer listings and custom graphics vary. Prepayment is requires by check or money order (drawn on a U.S. bank), or by charge to VISA, Mastercard, or American Express. A $10 handling fee is added to all shipments ($20 for non-U.S. shipments), rush orders are extra. 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, call (303)497-6339 or write to: Marine Geology and Geophysics Division, NOAA/NGDC E/GC3, Dept. 334, 325 Broadway, Boulder CO 80303 (Fax 303-497-6513). Internet address cjm@ngdc1.colorado.edu.

DSDP AND ODP DATA AVAILABLE

ODP Data Available

ODP databases currently available include all DSDP data files (Legs 1-96), geological and geophysical data from ODP Legs 101-124E, and all DSDP/ODP core photos (Legs 1-124E). More data are available as paper and microfilm copies of original data collected aboard the *JOIDES Resolution*. Underway geophysical 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 #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 77840, 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 National Geophysical Data Center (NGDC)

DSDP data files can be provided on magnetic tape according to user specifications (see table below). 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/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 surcharge 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. For details, call (303) 497-6339 or write to: Marine Geology and Geophysics Div., Natl. Geophys. Data Center, NOAA E/GC3 Dept. 334, 325 Broadway, Boulder, CO 80303.

AVAILABLE DATA

Data Available	Data Source	Description	Comments
1. LITHOLOGIC and STRATIGRAPHIC DATA			
Visual Core Descriptions			
-Sediment/sedimentary rock	Shipboard data	Information about core solor, sedimentary structures, disturbance, large minerals and fossils, etc.	
-Igneous/metamorphic rock	Shipboard data	Information about lithology, texture, structure, mineralogy, alteration, etc.	
Smear slide descriptions	Shipboard data	Nature and abundance of sedimentary components.	
Thin section descriptions	Shipboard data	Petrographic descriptions of igneous and metamorphic rock. Includes information on mineralogy, texture, alteration, vesicles, etc.	
Paleontology	*Initial Reports, Proceedings*	Abundance, preservation and location for 26 fossil groups The "dictionary" consists of more than 12,000 fossil names.	
Screen	Processed data	Computer-generated lithologic classifications. Basic composition data, average density, and age of layer.	
2. PHYSICAL PROPERTIES			
G.R.A.P.E. (gamma ray attentuation porosity evaluator)	Shipboard data	Continuous whole-core density measurements.	
Grain Size	Shore laboratory	Sand-silt-clay content of a sample.	Legs 1-79 only
Index properties: bulk and grain density, water content, and porosity	Shipboard data	Gravimetric and volumetric measurements from a known volume of sediment	
Liquid and plastic limits	Shipboard data	Atterberg limits of sediment samples.	
Shear-strength measurements	Shipboard data	Sediment shear-strength measurements using motorized and Torvane instruments.	
Thermal conductivity	Shipboard data	Thermal conductivity measurements of sediments using a thermal probe.	
Velocity measurements	Shipboard data	Compressional and shear-wave velocity measurements.	
Downhole measurements			
-Heatflow	Shipboard data	*In-situ* formation temperature measurements.	
-Pressure	Shipboard data	*In-situ* formation and hydrostatic pressure.	
3. SEDIMENT CHEMICAL ANALYSES			
Carbon-carbonate	Shipboard data, shore laboratory	Percent by weight of the total carbon, organic carbon, and carbonate content of a sample.	Hydrogen percents for Legs 101,103, 104, 106-108; nitrogen percents for Legs 101, 103, 104, 107, 108.
Interstitial water chemistry	Shipboard data, shore laboratory	Quantitative ion, pH, salinity, and alkalinity analyses of interstitial water.	
Gas chromatography	Shipboard data	Hydrocarbon levels in core gases.	
Rock evaluation	Shipboard data	Hydrocarbon content of a sample.	
4. IGNEOUS AND METAMORPHIC CHEMICAL ANALYSES			
Major element analyses	Shipboard data, shore laboratory	Major element chemical analyses of igneous, metamorphic, and some sedimentary rocks composed of volcanic material.	
Minor element analyses	Shipboard data,	Minor element chemical analyses of igneous, metamorphic, and	

AVAILABLE DATA (Continued)

Data Available	Data Source	Description	Comments
4. IGNEOUS AND METAMORPHIC CHEMICAL ANALYSES, CONT'D.			
	shore laboratory	some sedimentary rocks composed of volcanic material.	
5. X-RAY MINERALOGY			
X-ray mineralogy	Shore laboratory	X-ray diffraction	Legs 1-37 only
6. PALEOMAGNETICS			
Paleomagnetics	Shipboard data, shore laboratory	Declination, inclination, and intensity of magnetization for discrete samples and continuous whole core. Includes NRM and alternating field demagnetization.	
Susceptibility	Shipboard data	Discrete sample and continuous whole-core measurements.	
7. UNDERWAY GEOPHYSICS			
Bathymetry	Shipboard data	Analog records of water-depth profile	Available on 35-mm continuous microfilm
Magnetics	Shipboard data	Analog records and digital data.	Available on 35-mm continuous microfilm
Navigation	Shipboard data	Satellite fixes and course and speed changes that have been run through a navigation smoothing program, edited on the basis of reasonable ship and drift velocities, and later merged with the depth and magnetic data.	Available in MGD77 exchange format
Seismics	Shipboard data	Analog records of sub-bottom profiles and unprocessed signal on magnetic tape	Available on 35-mm continuous microfilm
8. SPECIAL REFERENCE FILES			
Leg, site, hole summaries	Shipboard data initial core descriptions	Information on general leg, site, and hole characteristics (i.e. cruise objectives, location, water depth, sediment nature, drilling statistics).	
DSDP Guide to Core Material	*Initial Reports,* prime data files	Summary data for each core: depth of core, general paleontology, sediment type and structures, carbonate, grain size, x-ray, etc.	Legs 1-85 only
AGEPROFILE	*Initial Reports,* hole summaries	Definition of age layers downhole.	
COREDEPTH	Shipboard summaries	Depth of each core. Allows determination of precise depth (in m) of a particular sample.	
9. AIDS TO RESEARCH			
ODASI	A file of ODP-affiliated scientists and institutions. Can be cross-referenced and is searchable.		
Keyword Index	A computer-searchable bibliography of DSDP- and ODP-related papers and studies in progress.		
Sample Records	Inventory of all shipboard samples taken.		
Site Location Map	DSDP and ODP site positions on a world map of ocean topography.		
Thin Section Inventory	Inventory of all shipboard thin sections taken.		

New ODP Offprint Policy

Current ODP policy calls for 50 offprints of every paper published in the "Scientific Results" volumes of the Proceedings of the Ocean Drilling Program to be made available without charge to the authors of these papers. If a paper has more than one author, the 50 offprints will be sent to the first author unless an alternative distribution is requested.

It is possible, however, for an author who wants more than 50 offprints of a paper to order these additional copies through the Chief Production Editor at ODP headquarters. Authors must initiate such requests well before the volume is printed and be prepared to pay for the extra offprints ordered, which are provided at cost.

Anyone having questions about this policy should contact Russell B. Merrill, Manager of Science Services, or William D. Rose, Supervisor of Publications.

ODP EDITORIAL REVIEW BOARDS (ERB)

For each ODP cruise, an editorial board is established to handle review of the manuscripts intended for publication in the "Scientific Results" volume of the Proceedings of the Ocean Drilling Program. These boards consist of the Co-Chief Scientists and the ODP Staff Scientist for that cruise, one other scientist selected by the Manager of ODP Science Operations in consultation with the cruise Co-Chief Scientists, and an ODP Editor. These boards are responsible for obtaining adequate reviews and for making decisions concerning the acceptance or rejection of papers. The names of scientists serving on ERBs for Legs 116 through 127 are listed below. Please note that: *indicates Co-Chief Scientist; **indicates Staff Scientist; ***indicates Outside Scientist.

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Dr. Joseph R. Curray*** (SIO)

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Dr. Birger Larsen* (Technical Univ. of Denmark, Denmark)
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* indicates Co-Chief Scientist
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A chairman for each ERB, usually a Co-Chief Scientist, has been elected since Leg 120.

ODP SAMPLE DISTRIBUTION

The materials from ODP Leg 125 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 101-125. 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.

Preliminary sample record inventories for ODP Legs 101-128 are now in searchable database structures. The Sample Investigations database which contains records of all sample requests, the purpose for which the samples were used and the institute where the samples were sent, has reached a steady state. 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 April 1989 through March 1990:

Repository	Avg. No. Weeks Processing	Total No. Samples
ECR	8	14,033
GCR	8	9,173
WCR	4	6,730

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Golovchenko, X.	LOGO	(914)359-2900X336	7105762653/LAMONTGEO
Granger, J.	JOI	(202)232-3900	7401433/BAKE UC
Grassick, D.*	TEDCOM		
Green, A.	PPSP	(713)965-4172	9108813649/USEPR TEX HOU
Green, D.*	LITHP	(61) 2-202476	AA58150
Grout, R.	ODP/TAMU	(409)845-2144	62760290/ESL UD
Harding, B.	ODP/TAMU	(409)845-2024	62760290/ESL UD
Harrison, C.	EXCOM	(305)361-4610	317454/VOFM RSMAS MIA
Haseldonckx, P.	PPSP	(49)201-726-3911	8571141/DX D
Hay, W.*	SGPP	(303)492-7370	not available
Hayes, D.*	EXCOM	(914)359-2900X470	7105762653/LAMONTGEO
Heath, G.*	EXCOM	(206)543-6605	9104740096/UW UI
Hedberg, D.	IHP	(46)-8-151-580	13599/RESCOUN S
Hedberg, J.D.*	SSP	(713)973-3240	774169
Heinrichs, D.*	NSF,ODPC	(202)357-7837	7401424/NSFO UC
Hékinian, R.*	EPRDPG	(33) 98-22-40-40	940627/OCEAN F
Helsley, C.*	EXCOM	(808)956-6760	7238861/HIGCY HR
Hey, R.	SSP	(808)956-8972	7238861/HIGCY HR
Hinz, K.	TECP	(49)511-643-3244	923730/BGR HA D
Hirata, N.*	SSP	(81)0472-51-1111	not available

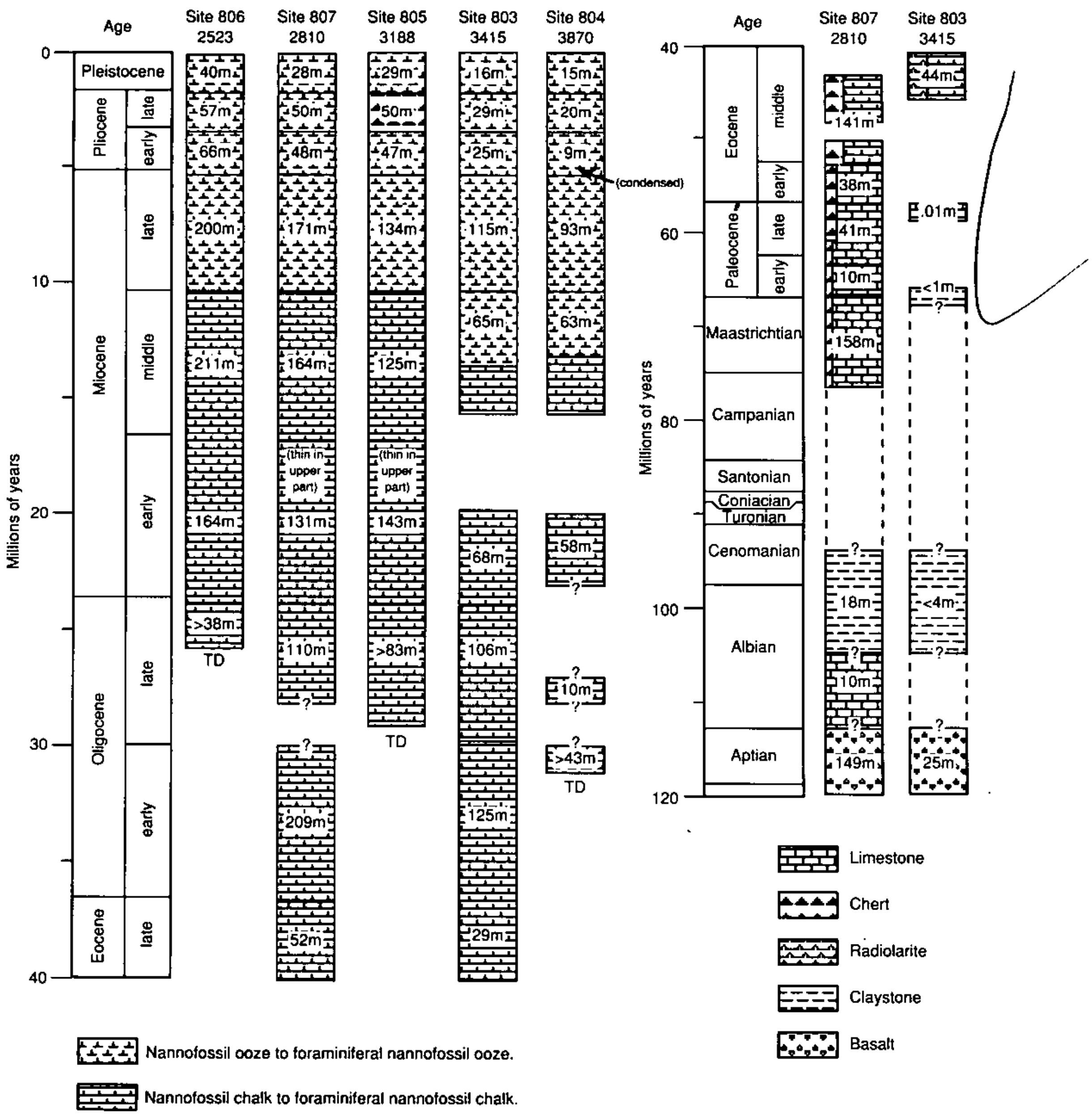
Horn, D.	PPSP	(49)201-726-3905	8571141/DX D
Hovland, M.	PPSP	(47) 4-80-71-30	73600/STAST N
Howell, E.	DMP	(214)422-6857	794784/ARCO PLNO
Humphris, S.*	LITHP	(508)548-1400X2523	951679/OCEANIST WOOH
Hutchinson, M.*	DMP	(405)767-3166	not available
Hyndman, R.*	CAPDPG	(604)356-6428	1497281/DFO PAT BAY
Ignatius, H.	ODPC	(358)0-469-31	123185/GEOLO SF
Ingersoll, R.*	IHP	(213)825-8634	3716012/UCLA LSA
Ito, M.*	SGPP	not available	25607/ ORIUT J
Iwamura, H.	JOIDES	(808)956-7939	7238861/HIGCY HR
Janecek, T.	ODP/TAMU	(409)845-0879	62760290/ESL UD
Jansen, E.*	OHP	(47)05-21-3491	8441023/UIBTA N
Jarrard, R.*	LDGO	(914)359-2900X343	7105762653/LAMONTGEO
Jenkyns, H.*	PCOM	(44)865-272023	83147 Attn. EARTH
JOIDES Office		(808)956-7939	7407498/JOID UC
Jones, M.*	IHP	(44)051-653-8633	628591/OCEANB G
Kappel, E.	JOI	(202)232-3900	7401433/BAKE UC
Karig, D.*	DMP	(607)255-3679	6713054/CORNELL ITCA
Kasahara, J.	TEDCOM	(81)3-812-2111X5713	not available
Kastens, K.*	SSP	(914)359-2900X236	7105762653/LAMONTGEO
Kastner, M.*	PCOM	(619)534-2065	9103371271/UCWWD SIO SDG,
Katz, B.*	PPSP	(713)954-6093	not available
Kent, D.*	EXCOM,OHP	(914)359-2900X544	7105762653/LAMONTGEO
Kidd, R.	SSP	(44)0792-295149	48358/UCSWAN G
King, J.	SMP	(401)792-6594	257580/KNAU UR
Kinoshita, H.*	DMP	(81)3-472-51-1111	25607/ORIUT J
Klitgord, K.	TECP	(508)548-8700x243	990739
Kobayashi, K.	EXCOM, PCOM	(81)3-376-1251	25607/ORIUT J
Korsch, R.*	CEPDPG	(61) 62-488178	not available
Kroenke, L.*	CEPDPG	(808)956-7845	7238861/HIGCY HR
Kulm, L.*	CAPDPG	(503)737-2296	5105960682/OSU COVS
Ladd, J.	NSF	(202)357-7543	7401424/NSFO UC
Lancelot, Y.	PCOM	(33)1-43-362525X5155	200145/UPMC SIX F
Langseth, M.*	PCOM	(914)359-2900X518	7105762653/LAMONTGEO
Larsen, B.*	SSP	(45)31106600	19999/DANGEO DK
Larsen, H-C.	TECP	(45)1-118866	19066/GGUTEL DK
Larson, R.*	PCOM	(401)792-6165	7400188/LARS UC
Laughton, A.*	EXCOM	(44)42-879-4141	858833/OCEANS G
Lee, C-S.	IHP	(61)062-499240	AA 62109
Leinen, M.*	PCOM	(401)792-6268	257580/KNAU UR
Levi, S.	PCOM	(503)737-2296	5105960682/OSU COVS
Lewis, B.	BCOM,EXCOM	(206)543-7419	9104740096/UW UI
Lewis, S.	SSP	(415)856-7096	171449/PCS USGS MNPK
Louden, K.*	SSP	(902)424-3557	01921863/DALUNIVLIB HFX
Loughridge, M.*	IHP	(303)497-6487	258169/WDCA UR
Loutit, T.*	OHP	(713)966-6114	not available
Lovell, M.*	DMP	(44)5533-522522	347250/LEICUN G
Lysne, P.*	DMP	(505)846-6328	169012/SANDIA LABS
MacKenzie, D.	PPSP	(303)794-4750	not available
Macko, S.*	SGPP	(514)987-4080	not available
Magnusson, M.*	ODPC	(354)1-10223	2307
Malfait, B.*	NSF	(202)357-9849	7401424/NSFO UC
Malpas, J.*	PCOM	(709)737-4708	0164101/MEMORIAL SNF
Manchester, K.*	TEDCOM	(902)426-3411	01931552/BIO DRT
Maronde, D.*	ODPC	(49)228-885-2328	17228312/DFG
Marx, C.	TEDCOM	(49)5323-722239	953813/TU ITE D
Maxwell, A.*	EXCOM	(512)471-4860	9108741380/UTIG AUS
Mayer, L.*	OHP	(902)424-2503	not available
McClain, J.*	LITHP	(916)752-7093,0350	9105310785/UCDAVIS
McGrath, K.	JOI	(202)232-3900	7401433/BAKE UC
McKenzie, J.*	SGPP	(41)1-256-38-28	817379/EHHG CH
Merrell, W.*	EXCOM	(409)740-4403	not available
Merrill, R.	ODP/TAMU	(409)845-9324	62760290/ESL UD

Mevel, C.*	LITHP	(33)1-43-36-25-25	200145/UPMC SIX F
Meyer, A.	ODP/TAMU	(409)845-7924	62760290/ESL UD
Meyer, H.	SSP	(511)643-3128	0923730/BGR HA D
Michot, J.	ODPC	(32)2-642-22-36	23069/BODPC
Mienert, J.*	SGPP	(49)431-720-0249	not available
Millheim, K.	TEDCOM	(918)660-3381	284255/CDFTU UR
Mix, A.*	OHP	(503)737-2296	5105960682/OSU COVS
Moberly, R.*	PCOM,EXCOM	(808)956-8765	7238861/HIGCY HR
Moore, J.C.*	TECP,CAPDPG	(408)429-2574	not available
Moore, T.C.*	IHP	(313)747-2742	not available
Moores, E.*	TECP	(916)752-0352	9105310765/UCDAVIS
Moran, K.*	SMP	(902)426-8159	1931552/BIO DRT
Morin, R.*	DMP	(303)236-5913	not available
Moss, M.*	EXCOM	(619)534-2836	not available
Mottl, M.*	SMP	(808)956-7006	7238861/HIGCY HR
Mutter, J.*	PCOM	(914)359-2900X525	258294/MCSP UR
Natland, J.*	PCOM	(619)534-5977	9103371271/UCWWD SIO SDG
Nicholls, P.	TEDCOM	(713)230-2650	9108814851/CHEVRON GT HOU
Nowell, A.	EXCOM	not available	9104740096/UW UI
Nowlin, W.	EXCOM	(409)845-3720	not available
NSF (ODP)		(202)357-9849	7401424/NSFO UC
ODP/TAMU		(409)845-2673	62760290/ESL UD
ODP Databank	LDGO	(914)359-2900X542	7105762653/LAMONTGEO
Ogawa, Y.*	TECP,SGPP	(81)92641-1101X4320	25607/ORIUT J
Okada, Hakuyu*	CEPDPG	(81)92641-1101X4301	25607/ORIUT J
Okada, Hisatake*	OHP	(81)23631-1421X2585	25607/ORIUT J
Ottosson, M-O.*	ODPC	(46)8-15-15-80	13599/RESCOUN S
Pascal, G.*	DMP	(33)98-46-25-21	940627/OCEAN F
Pautot, G.*	SSP	(33)98-22-40-40	940627/OCEAN F
Pearce, J.*	LITHP	(44)91-374-2528	537351/DURLIBG
Pedersen, T.*	OHP	(604)228-5984	not available
Perfit, M.*	LITHP	(904)392-2128	not available
Peters, P.	JOI	(202)232-3900	7401433/BAKE UC
Phipps-Morgan, J.*	LITHP	(617)253-5951	not available
Powell, T.*	PPSP	(61) 62-499397	not available
Prahl, F.*	SGPP	(503)737-4172	5105960682/OSU COVS
Premoli-Silva, I.	OHP	(39)2-23698248	320484/UNIMI I
Puchelt, H.	LITHP	not available	not available
Purdy, G.M.*	TECP,EPRDPG	(508)548-1400X2826	951679/OCEANINST.WOOH
Pyle, T.*	JOI	(202)232-3900	7401433/BAKE UC
Rabinowitz, P.*	ODP/TAMU	(409)845-8480	62760290/ESL UD
Rea, D.*	CEPDPG	(313)936-0521	not available
Renard, V.	SSP	(33)98-22-42-26	940627/OCEAN F
Reynolds, R.	LDGO	(914)359-2900X671	7105762653/LAMONTGEO
Rhodes, J.M.*	SMP	(213)545-2841	not available
Richards, A.	SMP	(31) 2977-40012	20000/MCC NL
Riddihough, R.*	CEPDPG,EXCOM,TECP	(613)995-4482	0533117/EMAR OTT
Riedel, K.	ODP/TAMU	(409)845-9322	62760290/ESL UD
Riedel, W.*	IHP	(619)534-4386	not available
Rischmüller, H.*	TEDCOM	(49)511-654-2669	923730/BGR HA D
Roberts, D.*	PPSP	(44)1-920-8474	888811/BPLDNA G G
Robertson, A.*	TECP	(44)31-667-1081	727442/UNIVED G
Rosendahl, B.*	EXCOM	(305)361-4000	317454/VOFM RSMAS MIA
Rowe, G.	EXCOM	not available	not available
Rutland, R.*	ODPC	(61) 062 499111	not available
Sager, W.*	IHP	(409)845-9828	258781/GRITUR
Sancetta, C.*	CEPDPG	(914)359-2900X412	7105762653/LAMONTGEO
Sartori, R.	SSP	(39)51-22-54-44	511350/ I
Sawyer, D.*	TECP	(713) 285-5106	62013673
Saunders, J.	IHP	(41) 61-295564	not available
Schaaf, A.*	IHP	(33)78-898124X3810	UCB 330 208
Schilling, J-G.	EXCOM	(401)792-6628	257580/KNAU UR
Schlanger, S.	CEPDPG	(708)491-5097	not available

Schrader, H.	CEPDPG	(47)5-21-35-00	42877/UBBRB N
Schuh, F.	TEDCOM	(214)380-0203	794784/ARCO PLNO
Searle, R.*	CEPDPG	(44)385-64971	537351/DURLIBG
Sengör, A.	CEPDPG, ODPC	(90)1-1433-100	23706/UTU TR
Shackleton, N.*	OHP	(44)223-334871	81240/CAMSPL G
Shanks, E.*	TEDCOM	(214)951-3271	730531/MOBINT
Shatto, H.*	TEDCOM	(713)467-8616	not available
Sinha, M.*	SSP	(44)223-333400	817297/ASTRON G
Skinner, A.*	TEDCOM	(44)31-667-1000	727343/SEISED G
Sliter, W.	CEPDPG	(415)329-4988	171449/PCS USGS MNPK
Small, L.	EXCOM	(503)737-4763	5105960682/OSU COVS
Smith, G.*	LITHP	(314)658-3128	550132/STL UNIV STL
Smith, R.	JOI	(202)232-3900	7401433/BAKE UC
Solheim, A.	SMP	(47)-2-123650	74745/POLAR N
Sondergeld, C.*	DMP	(918)660-3917	200654/AMOCO UR
Spall, H.*	IHP	(703)648-6078	160443/USGS UT
Sparks, C.*	TEDCOM	(33)1-47-52-63-95	203050/IFP A F
Spiess, V.*	IHP	(49)0421-218-3387	245811
Stanton, P.	TEDCOM	(713)940-3793	9108815579/USEPRTX HOU
Stein, R.	OHP	(49)641-702-8365	482956/GRIWOTY UNIGI D
Stel, J.*	ODPC	(31)370-440780	not available
Stephansson, O.	DMP	(920)91359	not available
Stokking, L.	ODP/TAMU	(409)845-5218	62760290/ESL UD
Storms, M.	ODP/TAMU	(409)845-2101	62760290/ESL UD
Strand, H.	TEDCOM	(47)-4-678066	not available
Stow, D.*	SGPP	(619)265-5498	not available
Suess, E.*	SGPP	(49)431-720-020	not available
Summerhayes, C.*	EXCOM	(44)42-879-4141	858833/OCEANS G
Svendsen, W.	TEDCOM	(612)331-1331	210685/LYHQ UR
Symonds, P.*	SSP	(61) 62-499490	not available
Taira, A.*	PCOM	(81)3-376-1251X256	25607/ORIUT J
Tamaki, K.*	IHP,CEPDPG LITHP,TECP	(81)3-376-1251	25607/ORIUT J
Tatsumi, Y.	LITHP	(81)075-753-4163	54223202/SCIKYU
Texier, M.	TEDCOM	not available	not available
Thomas, E.*	SMP	(203)347-9411	not available
Tokuyama, H.*	SMP	(81) 3-376-1251	25607/ORIUT J
Tucholke, B.*	PCOM	(508)548-1400X2494	951679/OCEANIST WOOH
Valet, J-P.*	SMP	(33) 1-43-362525x3566	202810/VOLSISM F
Veis, G.	ODPC	(30)1-777-36-13	215032/SATGEO GR
Villinger, H.*	DMP	(49)471-483-1215	238695/POLAR D
Vincent, E.	OHP	(33)1-43-362525X5162	200145/UPMC SIX F
von Breymann, M.	ODP/TAMU	(409)845-2522	62760290/ESL UD
Von Damm, K.*	EPRDPG	(615)576-0427	not available
von der Borch, C.*	SGPP	(61) 8-2752212	not available
Von Herzen, R.*	SSP,EPRDPG	(508) 548-1400	951679
von Rad, U.*	PCOM	(49)511-643-2785	923730/BGR HA D
Vorren, T.	SGPP	(47)83-44000	64251/N
Vrellis, G.	TEDCOM	(30)1-80-69-314	219415/DEP GR
Waggoner, G.	JOIDES	(808)956-7939	7407498/JOID UC
Watkins, J.*	PCOM	(409)845-8478	not available
Weaver, P. *	OHP	(44) 42879-4141	not available
Wefer, G.	OHP	(49)421-218-3389	245811/UNI D
Weigel, W.	SSP	(49)40-4123-2981	214732/UNI HH D
Westbrook, G.*	TECP,CAPDPG	(44)21-414-6153	333762/UOBHAM G
Westgaard, L.*	EXCOM,ODPC	(202) 333-6000	not available
Whitmarsh, R.*	SMP	(44) 42-879-4141	858833/OCEANS G
Wilkens, R.*	DMP	(808)944-0404	7238861/HIGCY HR
Wortel, R.	TECP	(31)30-53-50-86	40704/VMLRU NL
Worthington, P.*	DMP	(44)9327-63263	296041/BPSUNA G
Yamano, M.*	DMP	(81)3-812-2111 x5741	2722148/AERI TOK

BACK COVER

Sites drilled on Ontong Java Plateau, western equatorial Pacific, during ODP Leg 130. Sites are arranged according to depth. Recovered sediment is shown as a function of age, rather than depth below seafloor, to highlight hiatuses within drilled sections. Sediment thicknesses given in the columns are approximate values based on shipboard biostratigraphy. Note, for example, that the upper Miocene at Site 806 is approximately 200 m thick and thins downslope to approximately 93 m at Site 804. Age control through much of the Cretaceous is poor owing to dissolution of some calcareous microfossils.



Age
Site 806 2523
Site 807 2810
Site 805 3188
Site 803 3415
Site 804 3870
Pleistocene
Pliocene
Miocene
Oligocene
Eocene
early
middle
late
Millions of years
(thin in upper part)
TD
(condensed)
Paleocene
Maastrichtian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
Aptian
Limestone
Chert
Radiolarite
Claystone
Basalt
Nannofossil ooze to foraminiferal nannofossil ooze.
Nannofossil chalk to foraminiferal nannofossil chalk.